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Public Lighting Retrofitting Guidance Document

August 2020

RMO An Oifig um Bainistiú Bóithre Road Management Office
Údaráis Áitiúla Éireann Local Authorities Ireland
Horizon 2020
Rialtas na hÉireann Government of Ireland
Tionscadal Éireann Project Ireland 2040

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Section 1

Introduction

1 Introduction

1.1 Aims of the Guidance Document

The aim of this guidance document is to support local authorities in making informed decisions when carrying out replacement of existing exterior lighting in Ireland.

This document aims to provide best practice guidance in defining and delivering high-quality, energy-efficient systems that meet functional and budgetary environmental requirements.

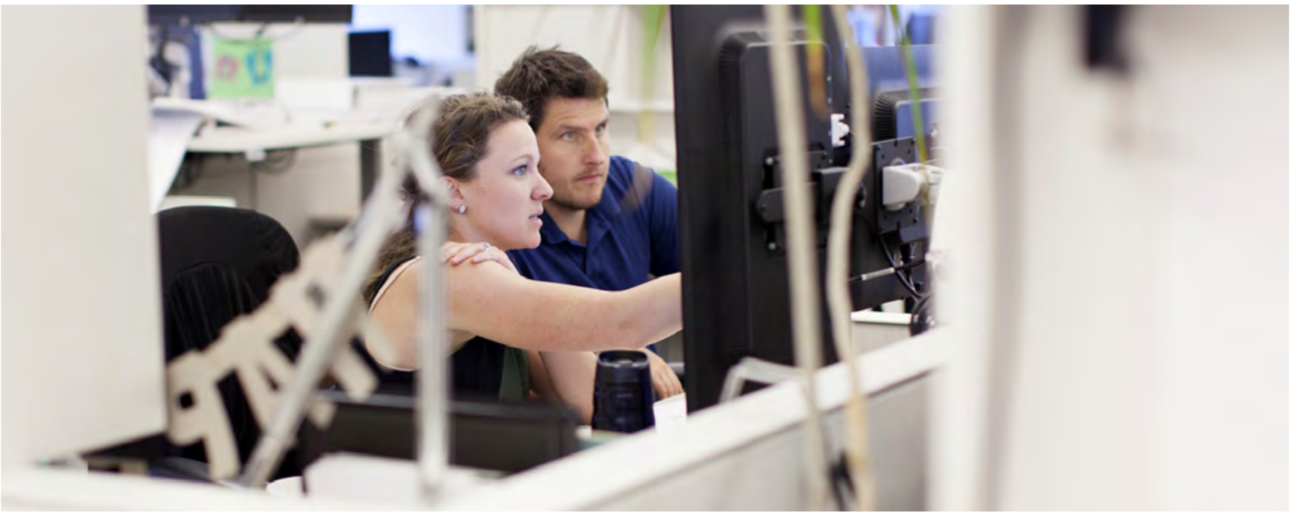
Light-emitting diode (LED) technologies are changing rapidly, and it is expected that further developments will take place as new data become available. This document will be updated and revised accordingly.

DN-LHT-03038: August 2018 - *Design of Road Lighting for the National Road Network* document shall be followed for the requirements and guidance for the design of a road lighting system on the national road network.

1.2 Intended Audience

This guidance document provides technical, performance and design advice to support lighting designers, contractors, planners, engineers and managers in local authorities to design effective and energy-efficient public lighting systems. This guidance can also be used to:

- inform procurement staff about energy-efficient public lighting retrofit design;
- communicate the benefits of effective energy-efficient public lighting to local authority managers, commissioners, engineers, planners and technicians;
- understand the important issues around effective energy-efficient public lighting retrofit design and gain the knowledge to make lighting procurement decisions; and
- complement existing public lighting design specifications.



1.3 Role of Public Lighting

1.3.1 Road Safety

People rely on public lighting for safety, security, guidance and recreation. Urban centres and public amenity areas are used during the hours of darkness by pedestrians, cyclists and vehicular traffic. Individuals and the surrounding environment need to be easily recognised. Public lighting reduces traffic accidents, thereby improving the safety of built-up areas. It should also be noted that the provision of lighting may not be the most cost-effective method of reducing night-time accident rates and that improvements to road alignment, carriageway markings, delineation of traffic and signage may offer a better solution.

1.3.2 Fear of Crime

A common reason given for the necessity of artificial lighting on streets and in public areas at night-time is to ensure that people are safer in towns, villages and cities. This is generally based on the belief that more light improves visibility, and that this visibility discourages criminals and gives a feeling of safety to the general public.

1.3.3 Night time Economy

Well-designed public lighting can enhance the quality of public realm areas and increases residents' and visitors' enjoyment of architecture and public realm spaces. In this way, high-quality public lighting design has a critical role in supporting economic growth by increasing the amount of time that people can spend participating in economic activities (such as entertainment and shopping) and improving the quality of public space for a community.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Section 2

Why Public Lighting LED Retrofit?

2 Why Public Lighting LED Retrofit?

From dusk until dawn, people rely on external lighting for safety, security, navigation and recreational activities, as outlined in Chapter 1.

While traditional technologies and lighting designs initially met these fundamental needs, recent years have seen improvements in the efficiencies, controls and design methods of light sources.
Advancements in exterior lighting technologies and changes in design standards provide the additional benefits of energy savings, reduced maintenance costs, improved visual environment, enhanced public safety and reduced light pollution.

Public lighting retrofits using modern LED technologies provide a challenging but excellent opportunity to lower energy usage, reduce operational costs and improve the quality of public lighting.

The main benefits of LED luminaire replacements are outlined below.

Table 1 - LED replacement comparison versus SON lighting

High-pressure sodium (SON) light nominal wattage	SON light circuit wattage (including ballast/driver)	Typical equivalent LED replacement	Typical energy savings
50W	80W	22W	72%
70W	85W	36W	57%
100W	114W	57W	50%
150W	171W	83W	52%
250W	275W	151W	46%

2.1 Reducing energy consumption

The Government has set a national target for Ireland to improve energy efficiency by 33% by 2020 under Ireland's National Energy Efficiency Action Plan (NEEAP). Furthermore, a greenhouse gas emission reduction target of at least 40% by 2030 has been agreed in accordance with Ireland's National Renewable Energy Action Plan (NREAP).

The amount of energy consumed for public lighting is directly related to the quantity of lanterns, lamp wattage, lantern type, and the lanterns' efficiency, efficacy and light distribution, as well as the lighting control strategy and maintenance regime.

Maximising the energy and economic performance of public lighting involves carefully balancing illumination needs with the available energy-efficient equipment.

LED light sources are now comparable with higher wattage SOX (low-pressure sodium) and SON (high-pressure sodium) lamps, as LED sources require less electricity than SON or SOX lamps. The efficacy of LED light sources is much more favourable than older technology and is typically around 100–150 lumens per watt (lm/W).

Tables 1 and 2 demonstrate the development of luminaire efficacy and typical energy saving percentages. This illustrates that developments in LED technology are able to provide a viable alternative to high-intensity discharge lamps and can help to reduce energy consumption and minimise maintenance intervention.

Table 2 - Public Lighting light source efficacy comparison

Public Lighting Luminaire Type	Typical Public lighting Luminaire efficacy (lm/W)
Low-pressure sodium luminaire (SOX)	39–140
High-pressure sodium luminaire (SON)	35–125
Metal halide luminaire (HID)	45–95
LED luminaire	100–165

2.2 Changes in Standards

Lighting standards have been updated in recent years to harmonise with European standards. These updates have permitted a greater selection of lighting classes that can be applied and have consequently resulted in opportunities for more targeted lighting schemes. As a result, some existing roads may already be lit to a higher level than necessary, following the current standards.

When carrying out LED retrofits, detailed design assessments should be undertaken by authorities following the principles of current European standards when selecting lighting classes; this could help in reducing energy consumption.

The latest version of Irish (IS), British (BS), European standards (EN), International Electrotechnical Commission (IEC), Institution of Lighting Professionals (ILP) and street lighting best practice documents are listed in Appendix E.

TII has published new versions of the following standards, which will apply for all national roads:

- DN-LHT-03038 (August 2018) – Design of Road Lighting for the National Road Network
- CC-GSW-01300 (May 2019) – Notes for Guidance on the Specification for Road Works Series 1300 - Road Lighting Columns and CCTV Masts
- CC-SPW-01300 (May 2019) – Specification for Road Works Series 1300 - Road Lighting Columns and CCTV Masts
- CC-RMP-01300 (January 2019) – Requirements for Measuring and Pricing of Road Lighting Columns and Brackets
- CC-GSW-01400 (May 2019) – Notes for Guidance on the Specification for Road Works Series NG 1400 – Electrical Work for Road Lighting and Traffic Signs
- CC-RMP-01400 (January 2019) – Requirements for Measuring and Pricing of Electrical Work for Road Lighting and Traffic Signs
- CC-SPW-01400 (May 2019) – Specification for Road Works Series 1400 - Electrical Work for Road Lighting and Traffic Signs.

"Lighting standards have been updated in recent years to harmonise with European standards."

2.3 Improved control opportunities

Traditionally, public lighting has been equipped with basic controls to operate street lighting between dusk and dawn using photocells, or from dusk to midnight using a combination of a photocell and a timer, with no opportunity to alter the output of the light source.

Modern LED public lighting products enable the implementation of several types of public lighting controls (as referenced in Appendix C) to reduce and increase light output, including:

- trimming;
- dimming;
- constant light output (CLO);
- central management system (CMS); and
- occupancy or motion sensors.

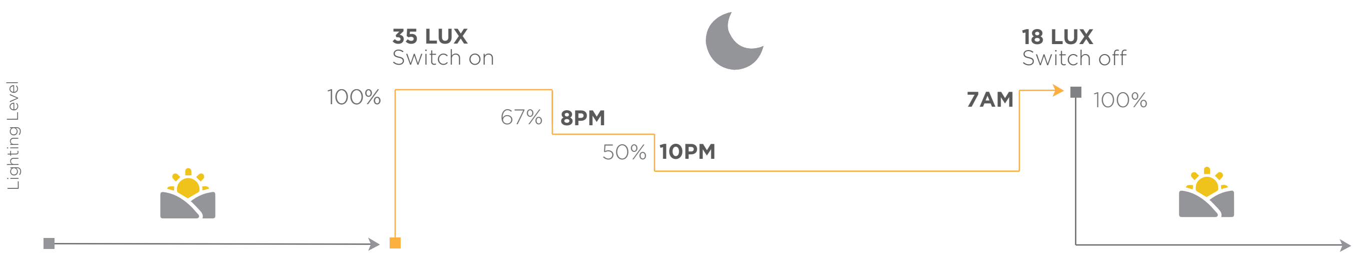
Lighting controls in LED public lighting systems can help reduce the number of operating hours, provide potentially longer service life, achieve lower maintenance costs, reduce light pollution and increase energy savings compared with conventional lighting technologies.

LEDs are suitable for dimming-based strategies as they can be dimmed smoothly with almost no technical complications by comparison to SON or SOX lamps. Dimming of SON or SOX types of fittings might result in drastic colour shifts, which will not provide sufficient illumination or appropriate colour rendering and, in some cases, dimming those lamps can cause the light to prematurely expire.

2.4 Reduction of light pollution

Compared with traditional light sources, LED luminaires provide a unique opportunity to reduce the negative environmental impacts of existing lighting systems. The use of a range of optics in LED outdoor lighting and lighting control technologies have made it possible to focus lighting only where and when it is needed, reducing light pollution. In addition, the combination of LED luminaires with adaptable monitoring and dimming control technologies can further minimise light pollution. For further guidance on reduction of light pollution refer to Appendix A.

Figure 1 - Programmable LED driver and multi-step dimming (Source: Sustainable Energy Authority of Ireland, public lighting burn profiles)



2.5 Reducing maintenance and increasing lamp lifetime

A longer lamp replacement interval can result in maintenance cost savings for local authorities.

Lamp replacements (bulbs) are typically required every two to five years (as shown in Table 3) for old lighting technologies and up to every 25 years for LED technologies.

A lighting retrofit can often deliver reduced maintenance costs over the life of the new lighting system, compared with the costs of maintaining existing old or outdated components.

For instance, improvements in lantern design and technologies have led to increased lifetimes for components in lighting systems. For example, many LEDs use a fin-type casing to dissipate the heat generated by the LEDs, and an integrated dimming function enables electronic components to run cooler. This not only extends the life of LEDs, but also increases the life of the phosphor coating that is used to produce white light. This, coupled with fewer failures, lengthens the time between maintenance activities which reduces labour and other maintenance costs.

Table 3 - Typical Rated lifetime of public lighting sources

Public Lighting Technology	Typical Lifetime (Hour/Year)
Low pressure sodium lamp (SOX)	10,000 – 18,000 / 3-5
High pressure sodium lamp (SON)	12,000 – 24,000 / 3-6
Metal Halide lamp (HID)	8,000 – 12,000 / 2-3
LED luminaire	70,000 – 100,000 / 20 - 25
Public Lighting Column	Minimum 25 years life expectancy

2.6 Improved colour rendering

SON or SOX lamps produce a yellow/yellow-orange light with poor or monochromatic colour-rendering properties. HID lamps are an alternative to SOX and SON in new installations due to better colour rendering and efficacy; however, HID lamps tend to have a shorter lamp life (some below 10,000 hours) and higher degradation of lighting levels over the lamp's lifespan as shown in Table 3.

On the other hand, LED lights are available in a range of colour temperatures (warm, neutral and cool) and provide a much better colour rendering index (CRI) (refer to Appendix A for further details).

As a result, LED lights provide true colours during night-time hours compared with traditional lamp technologies, and greatly improve the visibility of pedestrians to motorists, along with other previously outlined benefits. Table 4 shows typical colour rendering levels for different technologies used in public lighting.

Table 4 - Colour rendering index comparison among public lighting lamps

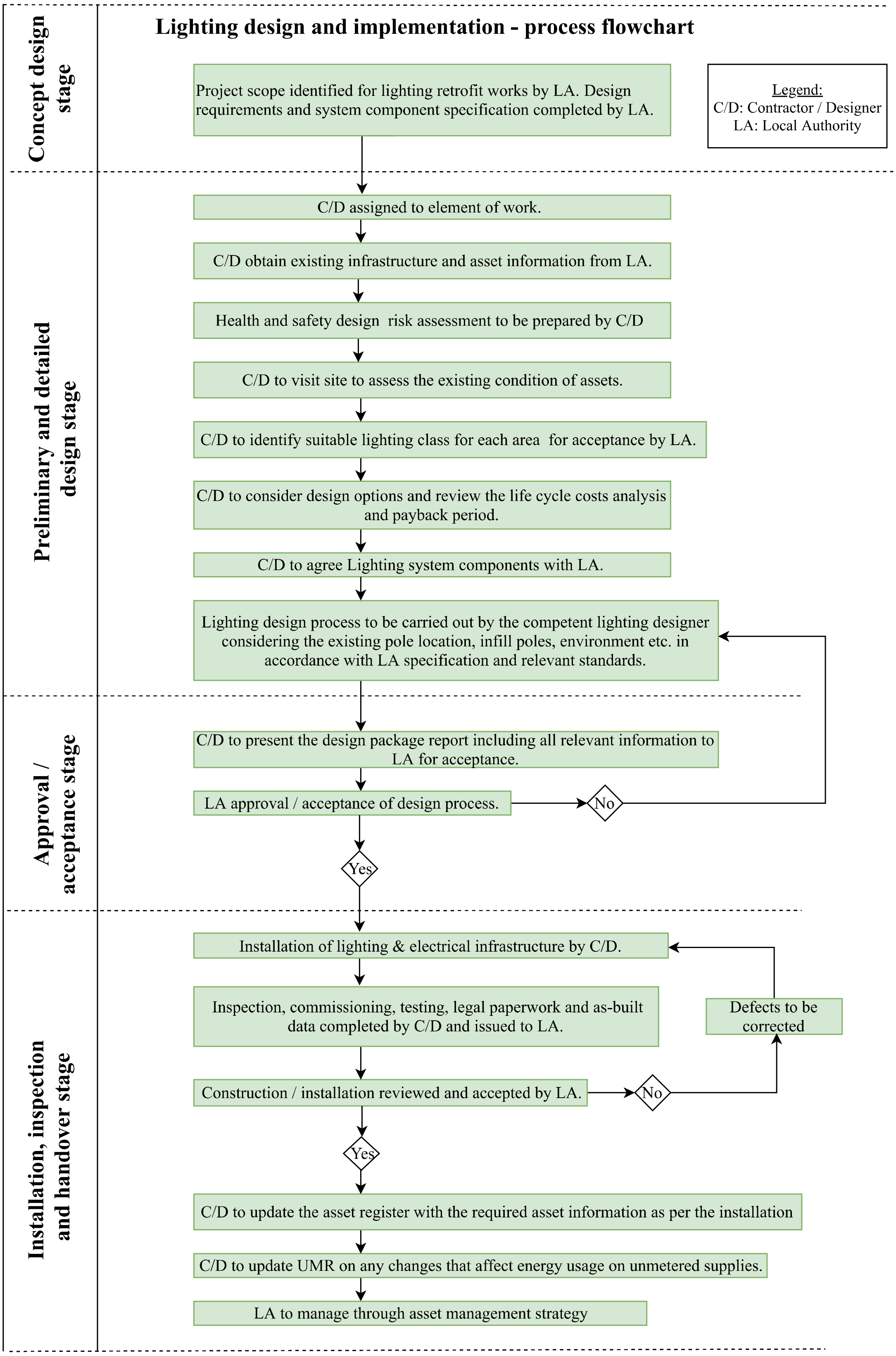
Public Lighting Technology	Colour Rendering Properties	CRI
Low pressure sodium luminaire (SOX)	Very Poor	Monochromatic
High pressure sodium luminaire (SON)	Fair	21
Metal Halide luminaire (HID)	Excellent	96
LED luminaire	Good	85

Section 3 **Lighting Design and Implementation Process**

Section 3

Lighting Design and Implementation Process

Figure 2 - Lighting Design and Implementation Process Flowchart



3 Lighting Design and Implementation Process

3.1 Context

Detailed below is a typical process carried out from project inception to implementation. This process is not intended to cover all specific technical or design issues, but rather to provide local authorities with a systematic approach to identifying the overall project goal. The steps outlined may differ between each authority and depending on the individual project.

These steps outline a typical approach to lighting design and dealing with process implementation issues. They also outline the constraints a local authority should address with a contractor/designer in order to ensure that public lighting needs are met with an effective and efficient quality design and installation.

This section shall be read in conjunction with the standards and best practice documents provided in Appendix E, which reference the required key standards and the best practice documents.

3.2 Identifying the overall project goal

The individual local authority should establish a clear overall project goal and identify the importance of key criteria driving the upgrade of the existing lighting system.

The quality and performance of public lighting designs also rely on appropriate specification, design and planning in addition to asset management and maintenance regimes for new and existing lighting installations. Local authorities should provide their public lighting and lantern specification for the project to the contractor for design, test and commissioning.

Specifications and requirements for the various individual components that make up a general lighting infrastructure are laid out in Appendices A through H.

3.3 Designer and client communication

It is vital that the contractor and designer gain a full understanding of the client's requirements and expectations.

During the design process, the contractor and their lighting design specialists shall engage with clients to obtain and understand the project scope and the client's requirement in order to ensure the delivery of high-quality, energy-efficient public lighting installations.

The design and installation of the lighting system shall be undertaken by a competent and experienced team who can demonstrate an appropriate understanding of road lighting design principles with adequate professional expertise to ensure that the retrofit/replacement works meet the overall goal and address design issues. The lighting designer shall be a qualified lighting designer through ILP, or similarly approved.

3.4 Access to infrastructure and asset information

Access to all relevant information on existing infrastructure and maintenance programmes should be established, and relevant records obtained.

Before any design process, the designers should also consider carrying out a design consultation process with all project stakeholders, including local authorities, specialists, security advisers, engineers, landscape architects, traffic and roads maintenance staff, etc.

3.5 Health and safety

The duties of Designers are set out in Section 15 of the Safety, Health and Welfare at Work (Construction) Regulations, 2013.

Under the Safety, Health and Welfare at Works (Construction) Regulations 2013 you are a designer if you are engaged in preparing drawings, particulars, specifications, calculations and bills of quantities in relation to a project.

Designers must:

- Identify any hazards that their design may present during construction and subsequent maintenance;
- Where possible, eliminate the hazards or reduce the risk;
- Communicate necessary control measures, design assumptions or remaining risks to the Project Supervisor Design Process (PSDP) so they can be dealt with in the safety and health plan;
- Co-operate with other designers, PSDP and Project Supervisor Construction Stage (PSCS);
- Take account of any existing safety and health plan or safety file;
- Comply with directions issued by the PSDP or PSCS;
- Where no PSDP has been appointed, inform the client that a PSDP must be appointed.

A designer should ensure, so far as is reasonably practicable, that their design can be constructed, maintained and decommissioned without risks to the health and safety of personnel who may be impacted during the assets lifecycle.

3.5.1 General Principles of Prevention

Designers must take account of the General Principles of Prevention as set out in schedule 3 of the Safety, Health and Welfare at Work Act 2005, when preparing designs.

The General Principles of Prevention (GPP) are:

1. The avoidance of risks;
2. The evaluation of unavoidable risks;
3. The combating of risks at source;
4. The adaptation of work to the individual, especially as regards the design of places of work, the choice of work equipment and the choice of systems of work, with a view, in particular, to alleviating monotonous work and work at a predetermined work rate and to reducing the effect of this work on health;
5. The adaptation of the place of work to technical progress;
6. The replacement of dangerous articles, substances or systems of work by safe or less dangerous articles, substances or systems of work;
7. The giving of priority to collective protective measures over individual protective measures;
8. The development of an adequate prevention policy in relation to safety, health and welfare at work, which takes account of technology, organisation of work, working conditions, social factors and the influence of factors related to the working environment;
9. The giving of appropriate training and instructions to employees;

Designers should systematically take account of the GPP. They should, as far as is reasonably practicable, include among the design considerations adequate regard to the need to:

- Identify any hazards in the proposed design
- Eliminate any hazards that can reasonably be eliminated (without introducing other higher risks)
- Evaluate and, where possible, reduce the risk associated with residual hazards, through the use of a risk assessment process of the design as referred to above giving preference to collective protection; and
- Provide necessary information so that the PSDP, other designers, and contractors are aware of identified residual hazards and can take account of them.

3.5.2 Providing and Obtaining Information

Designers have obligations to provide information about their design so that persons constructing, using, maintaining or decommissioning their design can fulfil their responsibility to manage risks and future users are protected from risks to their safety.

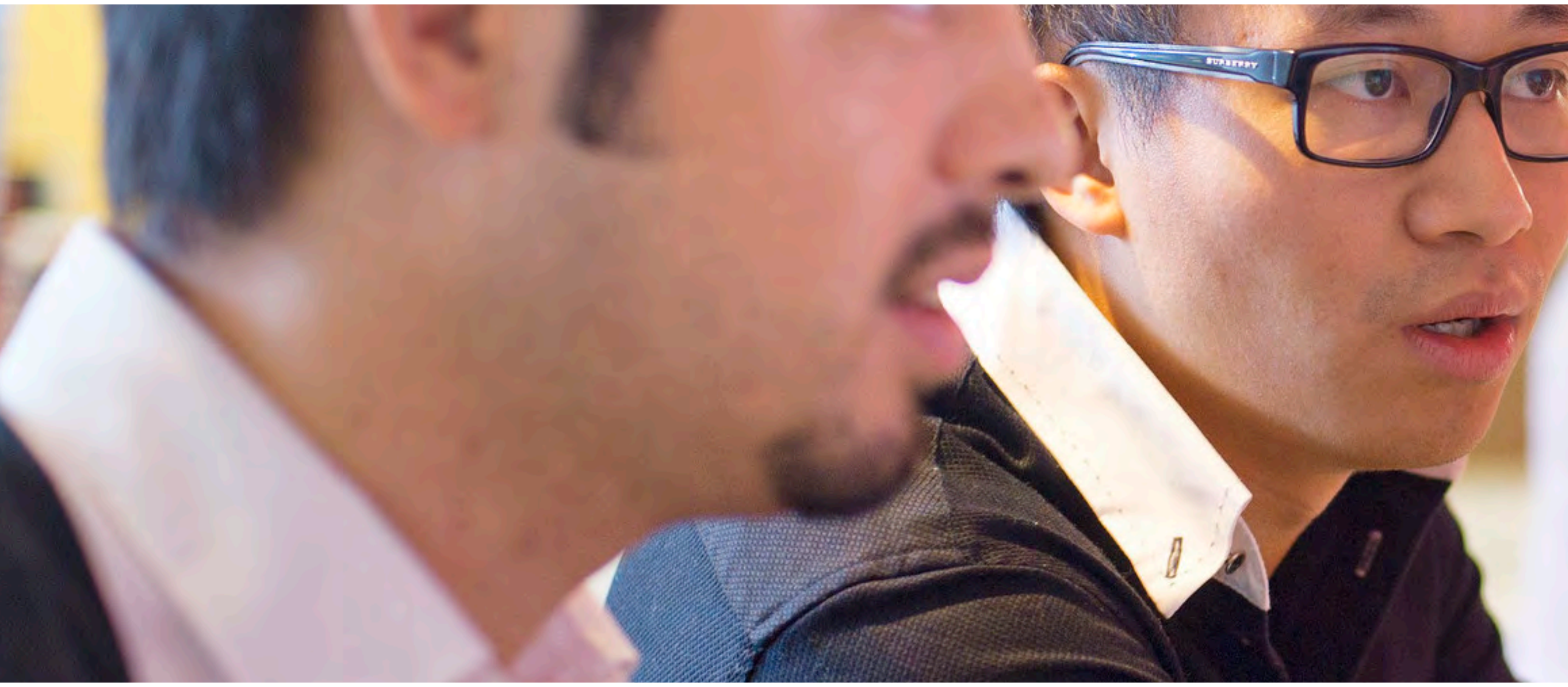
Information should be passed on from the designer through to parties responsible for constructing, managing and maintaining the design, this includes both the contractor and the client.

Designers should also ensure information regarding their design is communicated and coordinated with other designers to allow them to take account of each other's design and ensure all risks are addressed.

With regard to obtaining information a designer should be satisfied that they have all the required information to design safely for the whole lifecycle of a project this information includes but is not limited to:

- A defined design Scope;
- Environmental, Client and Planning restrictions;
- Location of existing services;
- Site Investigation information;
- Exiting Drawings;
- Existing Survey Information;
- Information regarding future use and maintenance.

Where a designer is not satisfied that they have the correct information to enable them to design safely, the design or element of the design should be paused until the safety critical information is obtained and furnished to the designer for consideration in their design.



3.5.3 Construction Hazards

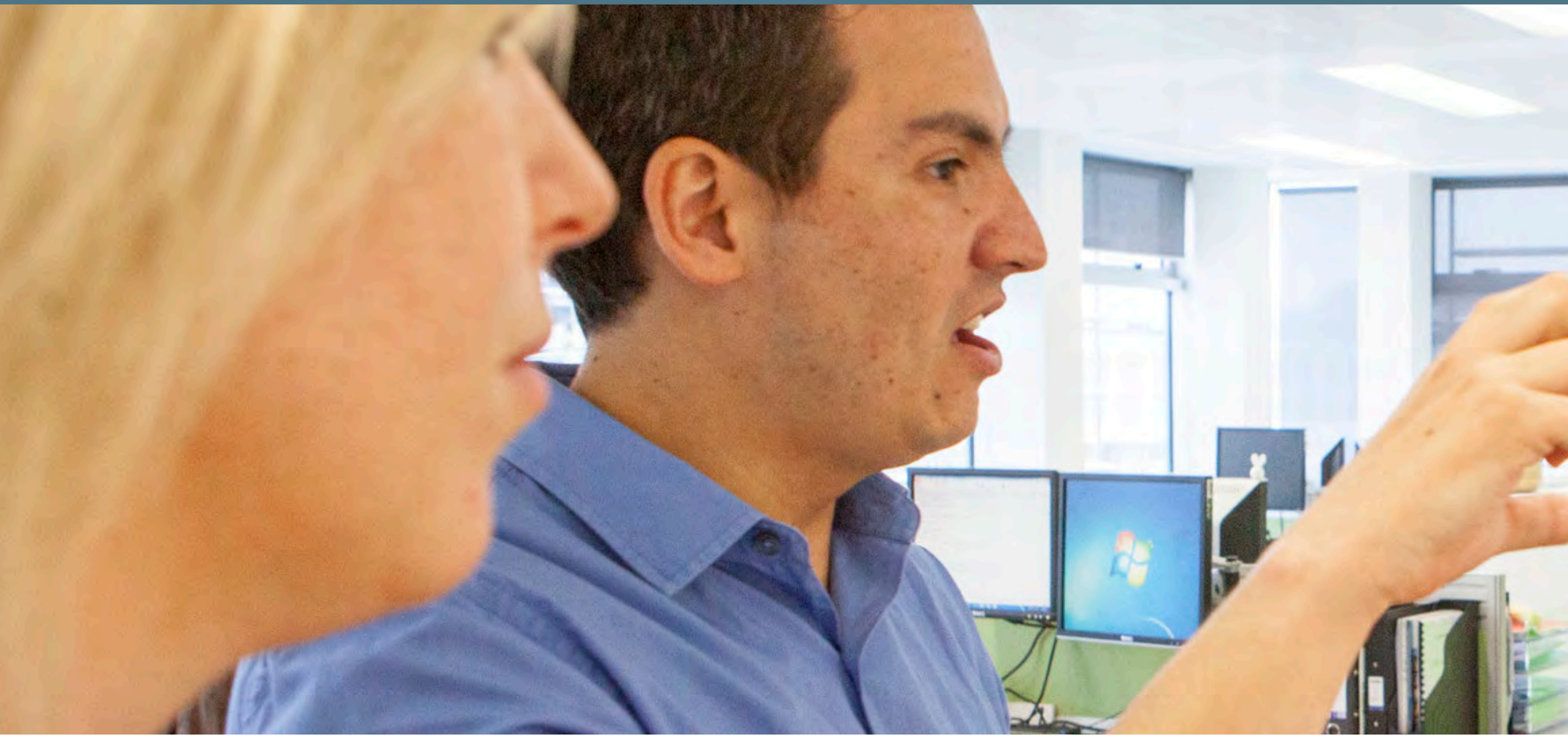
Designers should be aware of hazards likely to cause injury. The Health and Safety Authority (HSA) publishes annual statistics on the factors associated with construction injuries. In recent years most fatal injuries have been associated with (in descending order of frequency):

- Falling from a height;
- Being struck by moving, often reversing, vehicles;
- Being struck by falling objects or collapsing structures;
- Burial in a trench;
- Contact with overhead electric lines.

3.5.4 Legislation and Codes of Practice

Legislation and codes of practice (COP) pertaining to Design Health and Safety to be considered by the designer during the design, construction, future maintenance and decommissioning of road lighting schemes include, but are not limited to, the following:

- Safety, Health and Welfare at Work (Construction) Regulations 2013;
- Safety, Health and Welfare at Work Act 2005;
- Safety, Health and Welfare at Work (General Application) Regulations 2007, as amended 2016;
- HSA COP For Avoiding Danger From Underground Services, May 2016;
- ESB Networks COP for Avoiding Danger from Overhead Electricity Lines, September 2008;
- Department of Transport, Tourism and Sport, Traffic Signs Manual – Chapter 8, August 2019.



3.6 Site surveys and key design checks

The contractor should ensure that they get relevant information about a site, identify likely hazards, and carry out an initial risk assessment before visiting a site.

It is important to be familiar with and fully understand the site. Existing sites should be surveyed during both day and night in order to understand the ambient conditions, and photographic records of these site surveys should be kept.

In terms of helping to understand the local context and architectural style(s), exploring an area at pedestrian level also helps to establish and confirm several of the criteria which must be considered within the lighting retrofit area.

It is also important to have a clear understanding of existing problems, such as:

- Which areas are currently under/over lit?
- How much energy could be saved through the addition of controls and replacement of the light source?
- Will decorative and heritage lighting be retained?
- Are there any existing lighting pollution problems or potential for increased lighting pollution?
- Is there any shading by plants which will require foliage to be trimmed?
- In a case where the lantern is already attached to a building, has the owner agreed to attach a new interface/isolation box to safely isolate the power supply?

Where the project requires an upgrade to, or replacement of, the existing lighting system, initial questions must be asked, including:

- What lighting class is required?
- What ambient lighting level is required?
- Is there any safety or anti-social behaviour issues?
- How important is it to have colours appear naturally within the desired space?
- Is there a change to area usage/classification (e.g. a road downgraded from a national road to a regional road)?
- Is there a need to minimise the impact on bats or other wildlife?
- Will the existing light pollution be reduced?
- Are there any high level of pedestrian activity areas? Such as town/city centre, near train or bus stations, etc. – which might require maintaining the same road lighting classification from dusk to dawn.
- Where will the light fixture be located, and what measures should be taken to reduce glare issues?
- Are there any buildings, roadways or walkways that would require shielding from direct light?
- Is there a need for additional lighting?
- Is there a need for new column installation?
- How will the new columns be installed? Root mounted or flange plate?
- What will be type of new column?
- Where are the existing feeder pillar locations and distribution routes?
- What is the structural condition of existing assets including ESB Networks Pole, columns, brackets, service (supply) pillars, control equipment and conductors and ducts?
- Will the existing infrastructure (cabling and electrical supplies) and columns support the new lighting?
- Is there possible shading by plants or from the future growth of trees?
- Can the lights be configured to have multiple dimming levels as part of the lighting scheme?

3.6.1 Construction, structural and civil works

LED lantern retrofit works may also result in the replacement of the existing local authority lighting column. This would be due to either deterioration of the existing lighting columns or insufficient robustness of the existing column to safely accommodate the new lantern.

Installation of a new pole-mounted lantern may also be required where:

- the minimum lighting level or uniformity is not achieved with the existing pole arrangement, height, etc.;
- changes have occurred to the classification of an area, for example road widening, etc.; or
- existing ESB Networks pole condition is insufficient to accommodate the lantern.

In this case, where a new pole is required, the following should be considered:

- the location of existing utilities;
- the presence of available power supply points;
- new lighting pillar requirement;
- whether the area allows the erection of a new pole;
- foundation of the column;
- road opening license application;
- provision of ducting system and excavation works;
- temporary road closures and disruption;
- temporary public lighting and power supplies provision;
- the existing services in the proposed excavation areas; and
- visual impact of lighting on residents and other users of the public space, the location of entrances, etc;
- Provision of traffic management measures.

3.6.2 Lighting column retention/replacement

The use of existing lighting columns for LED retrofit schemes and the structural integrity of those existing columns should be assessed by the contractor. Refer to *RMO Public Lighting Asset Management Research Paper and RMO Asset Condition Survey Specification* for the audit process of existing columns and poles.

Where the reuse of existing lighting columns for LED retrofit schemes is considered, the structural integrity of those existing columns shall be assessed. Inspection and testing of columns shall follow the guidance and best practice detailed in *ILP Guidance Note GN22 - Asset-management Toolkit: Minor Structures and RMO Asset Condition Survey Specification.*

Local authorities can achieve substantial savings by replacing luminaires on the existing poles/columns.

However, lighting retrofits and associated design works might require column replacement due to deterioration of the existing column or infill column installation. The contractor should identify any infill columns and/or column replacements required.

Therefore, the investment and operational cost of column replacement options and infill pole requirements should be evaluated during the life cycle cost analysis (see Section 3.9.4).

The following should be considered for lighting replacements:

- the structural integrity of the column and any brackets;
- the difference in weight and wind area between existing and replacement luminaires (LED luminaires can be substantially heavier than existing old lantern technology);
- the adequacy, condition and nature of the existing cabling and circuit protection devices;
- the asset owner's aims, for example reduction of street clutter or a desire for increased accessibility;
- whether any retained columns will survive the predicted lifetime of the new luminaires, say up to 25 years; and
- access for future maintenance and whether a hinged column replacement is justified where access for a hoist is restricted.

3.6.3 Electrical power supply

There are two main installation procedures for power connection arrangements:

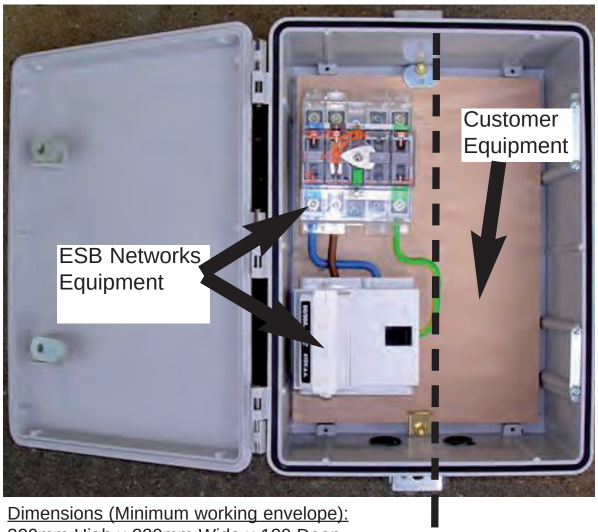
- ESB Networks overhead main cable; and
- underground mains cable.

3.6.3.1 Existing ESB Networks overhead main cable

Where the replacement of an existing lantern is carried out on an ESB Networks pole and directly connected to an ESB Networks low voltage line, an interface box (as per Figure 3) must be installed between the ESB Networks aerial service and the public lighting lantern. These isolator boxes should be approved for use by ESB Networks and shall meet the requirements set out in the *National Code of Practice for Customer Interface*, published by ESB Networks.

During the detail design stage, the contractor shall be responsible for coordinating with ESB Networks; this includes any application or further discussion wherever applicable.

Figure 3: Interface box detail (Source: ESB Networks National Code of Practice for Customer Interface 4th Edition, 2008)



Dimensions (Minimum working envelope):
320mm High x 220mm Wide x 120 Deep
Equipment shown:
ESB Networks Single Phase Cut Out
ESB Networks Single Phase Isolator

3.6.3.2 Underground mains cable

When the erection of new assets on ESB Networks is not possible or permitted, new public lighting column/pole installations may be required in order to ensure that the required lighting classes are achieved.

In such cases, a new micro-pillar and cable network will be required to service the lighting points.

This cable network shall be installed in a duct in accordance with the requirements of I.S. 10101: 2020 *- National Rules for Electrical Installations Edition 5.0* and as per the scheme design. Also, the ESB Networks design office must be consulted at the planning stage in order to determine the most suitable location for the ESB Networks connection.

The underground cabling design stage should include the following:

- schematic drawings detailing power and control cable types, circuiting, and network arrangement;
- distribution routes;
- micro-pillar location;
- civil works, including any duct and chamber requirements;
- connection from ducting to columns;
- detailed coordination exercise with other engineering disciplines;
- temporary road closures and required permission from the relevant road authority and provision of temporary traffic management measures; and
- RECI Cert (completion certificates) for the works.

The capital cost of underground-fed columns will be higher compared with the overhead cabling method due to required excavation works and new electrical infrastructure works.

3.6.3.3 Electrical service design requirement

The electrical services design for a scheme shall be undertaken to comply with the relevant sections of *I.S. 10101: 2020, National Rules for Electrical Installations Edition 5.0* and *ET 211:2003 Code of Practice for Public Lighting Installations in Residential Areas* or latest versions.

The electrical service design for the lighting system must consider the following points:

- circuit load;
- circuit length;
- cable type;
- cable cross section area;
- earth loop impedance;
- earthing type;
- circuit breaker type and rating;
- voltage drops;
- circuit disconnection time.

Table 5 - Lighting classes according to PD CEN/TR 13201-1:2014

Road Class	Description
M	For drivers of motorized vehicles on traffic routes medium to high driving speeds
C	For use in conflict areas on traffic routes where the traffic composition is mainly motorised. Conflict areas occur wherever vehicle streams intersect each other or run into areas frequented by pedestrians, cyclists, or other road users. Areas showing a change in road geometry, such as a reduced number of lanes or a reduced lane or carriageway width, are also regarded as conflict areas
P	For pedestrian traffic and cyclists for use on footways and cycleways, and drivers of motorised vehicles at low speed on residential roads, shoulder or parking lanes, and other road areas lying separately or along a carriageway of a traffic route or a residential road, etc.

3.7 Environmental impact assessment and other planning requirements

Where a scheme is subject to planning requirements such as an environmental impact assessment under Directive 2014/52/EU, then a lighting impact assessment may be required.

Lighting impact assessments shall only be undertaken by competent lighting professionals. The *ILP Professional Lighting Guide (PLG) 04: Guidance on Undertaking Environmental Lighting Impact Assessments* outlines a good practice approach for undertaking and assessing the impact of road lighting on surrounding land and on humans, flora and fauna.

3.8 How to select the lighting classes

Prior to commencing the lighting calculations, the contractor shall submit the proposed lighting classification to the local authority for acceptance.

It is important to understand the usage of the space being lit and to ensure that the lighting design provides the type of illumination and control that suits the needs of the expected users.

The lighting designer should determine the appropriate lighting performance parameters in accordance with the *PD CEN/TR 13201-1:2014* and *BS 5489-1:2013* standards for road, footway and cycle path lighting before commencing any lighting design. Appropriate classes are also to be specified for car parks and recreation areas by the lighting designer.

Liaison with road lighting, traffic planning, highway engineering and traffic safety experts might be required as appropriate. Maximum capacity values shall be obtained from traffic planning experts, as figures vary according to road and street classes.

Appendix G includes case studies for selecting the appropriate lighting classification for areas in city and town centres, and for urban and rural environments.

Table 6 - EN 13201-2 Road Classes and their required light levels

CEN/TR 13201-1	L, (minimum average maintained)	CEN/TR 13201-1	E, (minimum maintained)	CEN/TR 13201-1	E, (minimum average maintained)	E (minimum)
Class	**Cd/m²**	**class**	**lx**	**class**	**Lx**	**Lx**
		C0	50			
M1	2	C1	30			
M2	1,5	C2	20			
M3	1	C3	15	P1	15	3
M4	0,75	C4	10	P2	10	2
M5	0,5	C5	7,5	P3	7,5	1,5
M6	0,3			P4	5	1
				P5	3	0,6
				P6	2	0,4

3.8.1 Residential

This section discusses required lighting levels within residential areas. This includes heritage and standard lighting installations.

Residential areas use illuminance criteria (P). The most prominent lighting classes used in residential areas are typically P3 and P4 of BS 5489-1:2013 with a warm white colour temperature (3,000K) unless otherwise advised by the local authority. For the residential areas wherever more than 20% of the existing lighting fittings have been already replaced with 4000K LED, then the rest of the existing lighting lanterns shall be replaced with 4000K LED lanterns. Within a residential development, the requirement generally is to light the road, verge and footpath to the minimum level, as far as the boundary line of adjacent properties. In addition, the access roadway must be adequately lit. Walkways across green areas are generally not lit unless otherwise advised by the local authority.

If facial recognition is important, additional criteria for vertical plane illuminance (at a point) and minimum semi-cylindrical illuminance (on a plane above a road area) must be adhered to as indicated in Table 7.

For the lighting levels associated with lighting residential roads and minor roads to the P classes from IS EN 13201-2:2015, the target illuminance for a class can be adjusted according to the S/P ratio (refer to Appendix B.)

3.8.2 Access and distributor roads

This section discusses required lighting levels along access and distributor roads. This includes heritage and standard lighting installations.

Access and distributor roads use illuminance criteria (P or M). Lighting for access roads and local distributor roads shall be generally designed to the P2 or P3 standards of BS 5489-1:2013 with the parameters indicated in Table 7, with a warm white colour temperature (3,000K), unless otherwise advised by the local authority. The requirement generally is to light the road, verge and footpath to at least the minimum level, as far as the boundary line of the adjacent properties.

The main traffic routes should generally be designed to the M3 standard of BS 5489-1:2013 as indicated in Table 8; however, this shall be completed by a competent, qualified lighting engineer.

Table 7: Requirements for P lighting classes, taken from IS EN 13201-2:2015 (Source: CEN 2016, The National Standards Authority of Ireland (NSAI), IS EN 13201-2: 2015 - Road Lighting - Part 2 Performance requirements.)

Class	Horizontal illuminance		Additional requirement if facial recognition is necessary	
	$\bar{E}$ [a] [minimum maintained] lx	E_{min} [maintained] lx	$E_{v,min}$ [maintained] lx	$E_{sc,min}$ [maintained] lx
P1	15,0	3,00	5,0	5,0
P2	10,0	2,00	3,0	2,0
P3	7,50	1,50	2,5	1,5
P4	5,00	1,00	1,5	1,0
P5	3,00	0,60	1,0	0,6
P6	2,00	0,40	0,6	0,2
P7	performance not determined	performance not determined		

[a] To provide for uniformity, the actual value of the maintained average illuminance shall not exceed 1,5 times the minimum $\bar{E}$ value indicated for the class.

3.8.3 City/town centre and amenity areas

For city centre areas, lighting should generally be designed to either the C1, C2 or C3 class of IS EN 13201-2: 2015. The lighting designer/consultant shall advise on light levels to be achieved and the colour temperature should be with a warm white colour temperature (3,000K), unless otherwise advised by the local authority.

For city/town centre and amenity areas, lighting is generally intended for pedestrians, drivers of motorised vehicles, and other road users on conflict areas such as shopping streets, road intersections of some complexity, roundabouts, queuing areas, etc.

For security and for visual guidance purposes, the full street width shall be illuminated from building facade to building facade. Lighting classes for city and town centres as indicated in Table 9 according to BS 5489-1:2013.

Class	Luminance of the road surface of the carriageway for the dry and wet road surface condition				Disability glare	Lighting of surroundings
	Dry conditions			Wet	Dry conditions	Dry conditions
	$\overline{L}$ [minimum maintained] cd·m²	U_o [minimum]	U_l [a] [minimum]	U_{ow} [b] [minimum]	f_{TI} [c] [maximum] %	R_{EI} [d] [minimum]
M1	2,00	0,40	0,70	0,15	10	0,35
M2	1,50	0,40	0,70	0,15	10	0,35
M3	1,00	0,40	0,60	0,15	15	0,30
M4	0,75	0,40	0,60	0,15	15	0,30
M5	0,50	0,35	0,40	0,15	15	0,30
M6	0,30	0,35	0,40	0,15	20	0,30

Table 8: Requirements for motorised traffic (M classes), taken from IS EN 13201-2:2015 (Source: CEN 2016, The National Standards Authority of Ireland (NSAI), IS EN 13201-2: 2015 - Road Lighting - Part 2 Performance requirements.)

Type of traffic	Lighting class			
	Normal traffic flow		High traffic flow	
	E3 [A)]	E4 [A)]	E3 [A)]	E4 [A)]
Pedestrian thoroughfare	S2 or P2	S1 or P1	S2 or P2	S1 or P1
Pedestrian only	CE4 or C4	CE3 or C3	CE3 or C3	CE2 or C2
Mixed vehicle and pedestrian with separate footways	CE3 or C3	CE2 or C2	CE2 or C2	CE1 or C1
Mixed vehicle and pedestrian on same surface	CE2 or C2	CE1 or C1	CE1 or C1	CE1 or C1

[A)] Environmental zone, as given in ILP GN01 [N5].

Table 9: C lighting classes based on road surface illuminance, taken from BS 5489-1:2013 (Source: British Standards Institution, 2012, Code of practice for the design of road lighting. Lighting of roads and public amenity areas, BS 5489-1:2013)

3.8.4 Lighting requirements for public car parks

Requirements for the lighting of car parks are set out in BS 5489-1:2013. The requirements are measured in terms of maintained lighting levels and uniformity. In general, public car parks serving towns, cities and villages fall into one of the categories outlined in Table 10.

3.8.5 Recreational areas (walkways), parks and landscapes

The contractor's lighting designer shall advise on all lighting levels required for town parks, landscapes, canal towpaths and walkways (refer to BS 5489-1:2013).

3.8.6 Lighting of steps, stairs, ramps and footbridges

Special care and attention shall be given to the illumination of steps, stairs, ramps and footbridges. Requirements are set out in BS 5489-1:2013 as outlined in Table 11.

3.8.7 Lighting of pedestrian crossings

The provision of lighting at pedestrian crossings shall be considered in conjunction with the guidance contained in the following documents:

- DN-GEO-03084, The Treatment of Transition Zones to Towns and Villages on National Roads.
- DN-LHT-03038, Design of Road Lighting for the National Road network
- Design Manual for Urban Roads and Streets, May 2019 (Version 1.1), Government of Ireland

Type of area and usage	$\bar{E}$ lx	U_o
Light traffic, e.g. parking areas of shops, terraced and apartment houses; cycle parks	5	0.25
Medium traffic, e.g. parking areas of department stores, office buildings, plants, sports and multipurpose building complexes	10	0.25
Heavy traffic, e.g. parking areas of schools, churches, major sports and multipurpose sports and building complexes	20	0.25

Table 10: Maintained lighting levels for outdoor car parks, taken from BS 5489-1:2013 (Source: British Standards Institution, 2012, Code of practice for the design of road lighting. Lighting of roads and public amenity areas, BS 5489-1:2013)

Values in lux

Type	Day		Night	
	$\bar{E}$	E_{min}	$\bar{E}$	E_{min}
Subways				
• open [A)]	—	—	50	25
• enclosed [B)]	350	150	100	50
Footbridges				
• open [A)]	—	—	30	15
• enclosed [B)]	350	150	100	50
Stairways/ramps				
• open [A)]	—	—	30	15
• enclosed [B)]	350	150	100	50

A) "Open" equates to major daylight penetration.
B) For "enclosed" areas emergency lighting might be needed. It is essential that it is installed if the area forms part of an escape route from a shopping centre, car park or transport interchange.

Table 11: Maintained lighting levels for subways, footbridges, stairways and ramps, taken from BS 5489-1:2013 (Source: British Standards Institution, 2012, Code of practice for the design of road lighting. Lighting of roads and public amenity areas, BS 5489-1:2013)

3.9 Economic feasibility analysis

Unlike traditional lamps, the usage of LED lighting will significantly contribute to reducing electricity consumption, environmental impact, and maintenance and operation costs, in addition to its improved distribution of light and better colour characteristics.

Although LED lighting has many strong points from the perspectives of energy savings, maintenance cost savings and eco-friendliness, its price is noticeably higher than traditional lamps. Determining the economic impact of new public lighting can be complex.

Therefore, where the existing luminaire will be replaced with LED luminaire, the steps outlined below should be followed.

3.9.1 Annual energy cost saving

Figure 4 outlines a straightforward calculation with which to determine annual energy cost savings, expressed in kilowatt-hours (kWh), resulting from a lighting retrofit.

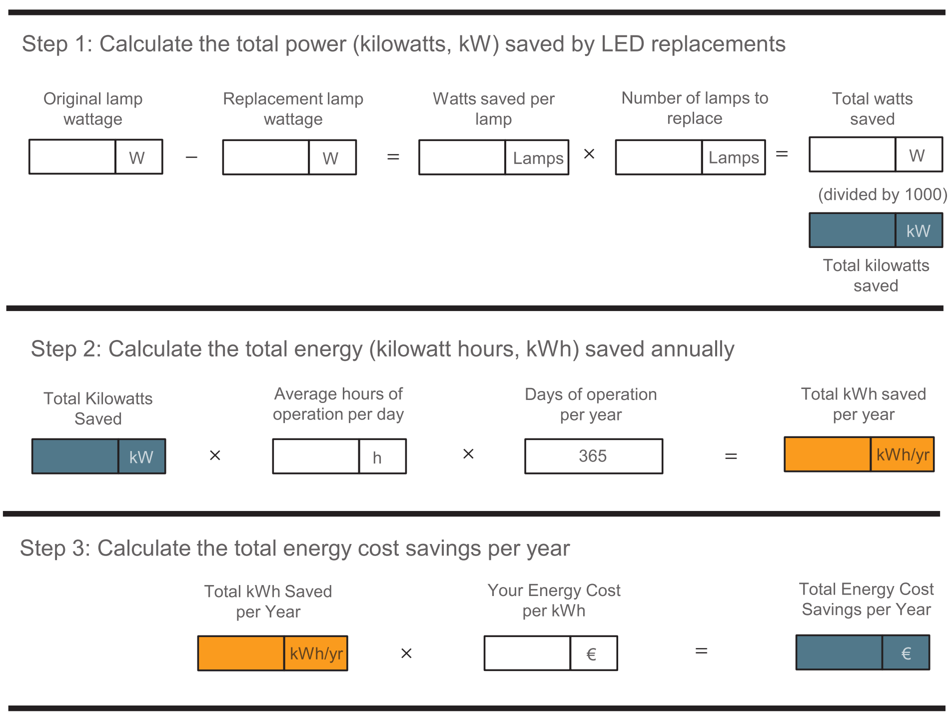
This annual cost savings figure may be compared with the cost of the upgrade to determine simple payback and return on investment. Furthermore, considering life cycle costs such as reduced maintenance requirements and labour cost will improve overall payback.

Default annual burn hours would be 4,150hr dusk to dawn or 2,600hr dusk to midnight unless otherwise advised by the local authority.

The proposed energy-savings (kWh) from constant lighting output (CLO) function (see Section C1.9) and adaptive lighting (see Section C1.7) shall be taken into account for more accurate cost saving calculations in addition to Figure 4.

Wider feasibility checks may be required for lighting retrofit/replacement programmes in order to confirm total energy savings and/or whole-life savings, based on, for example, load profiles, lighting power density indicator ($W/lx/m^2$) and annual energy consumption indicator (Wh/m^2) assessment criteria. Whole life cycle analysis is considered further in Section 3.9.4.

Figure 4: Annual LED retrofit energy cost savings calculation



3.9.2 Existing lighting system

The local authority should assess the current performance and energy consumption of its lighting systems and use this information to develop energy reduction strategies and improve their operation.

A more detailed asset condition inspection and an inventory list are provided in the RMO Public Lighting Asset Management Research Paper.

In order to carry out the asset condition assessment and analysis, the following issues should be examined:

- existing lighting system, including luminaire height and spacing;
- existing luminaire's weight and windage area;
- the age, condition and location of luminaires;
- how lights are currently controlled;
- lamp wattage and ballast type;
- the operational environment of the lighting system;
- moisture or dirt build-up in or around existing lighting fixture;
- structural support systems' condition, including columns, wall brackets, etc.;
- existing electrical circuiting and cabling condition;
- existing public lighting pillars'/mini-pillars' condition;
- the illumination levels of the existing system should be measured and recorded where required in accordance with IS EN 13201-4:2015 and the ILP Technical Report TR28 Measurement of Road Lighting Performance on Site; and
- the measured lighting levels of the existing system should be compared with the requirement of the lighting class.

Once an existing lighting system's condition has been documented, it is possible to analyse:

- LED retrofit investment cost (design, material, installation, commissioning);
- LED retrofit energy savings;
- whole-life cost-benefit analysis;
- existing lighting system total energy cost;
- existing lighting system maintenance cost;
- payback period of LED replacement; and
- environmental impact.

3.9.3 Annual carbon emissions reduction

Figure 5 illustrates the calculation for tonnes of annual carbon savings resulting from an upgrade of one lamp or system type throughout a project.

The CO2 conversion factor will be aligned with Sustainable Energy Authority of Ireland (SEAI) figures.

Figure 5: Annual LED retrofit CO2 emission saving calculation

Calculate the total CO_2 emission reduction per year by LED replacements

Total kWh saved per Year

[ ] kWh/yr

X

CO_2 emission factor

[ ] kg CO_2 /kWh

=

Total annual CO_2 emission reduction

[ ] kg

÷ 1000

Total annual CO_2 emission reduction

[ ] Tonnes

3.9.4 Life cycle analysis

The designer should perform a life cycle cost analysis before embarking on the project.

This attempts to capture all parameters such as capital, operational, and maintenance costs, as well as the expected lifetime of luminaires with the aim of providing the most cost-effective installation during the usage time to compare different alternative solutions. Refer to Figure 6 for whole life cycle analysis.

Capital/investment costs include:

- number of retrofit luminaires;
- material and labour costs per luminaire;
- price per luminaire (including light source, control device, driver, etc.);
- number of new poles, brackets and foundations;
- material and labour costs per pole, bracket and foundation;
- price per pole, bracket and foundation;
- electrical works on the existing network:
  - – number of fuse boxes, cabling installation;
  - – material and labour costs per fuse box, cabling installation; and
  - – price per fuse box, cabling.
- excavation, ducting, electrical works, wiring installation, etc.

Operational costs/savings includes:

- utility cost; and
- effect per luminaire, including operating savings and system effects:
  - – energy savings from LED retrofit (wattage reduction savings);
  - – energy savings by dimming control; and
  - – energy savings by CMS.

Maintenance costs/savings includes:

- labour savings from long-life lighting products;
- vehicles and equipment to travel to the luminaire;
- replacement interval light sources and electrical ballast;
- material savings from long-life lighting products:
  - – electrical ballast cost savings for conventional systems; and
  - – labour cost savings for electrical ballast replacement.
- luminaire inspection and cleaning savings.

3.9.5 Payback period

A simple method of determining investment return is to calculate the payback period, as follows:
Payback period = (cost of project) / (annual savings)
Annual savings are a combination of the operational cost savings and the maintenance cost savings of the new lighting system.

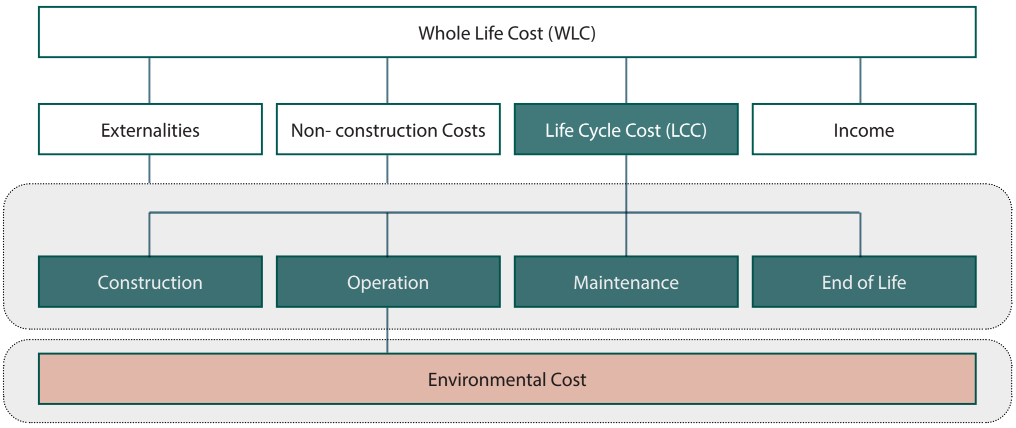


Figure 6: Whole life cycle analysis (Source: BS ISO 15686-5: 2017, Buildings and constructed assets — Service life planning — Part 5: Life-cycle costing)

3.10 Energy efficiency

The lighting design needs to ensure that the right light is in the right place at the right time, and the lighting designer should ensure that the proposed design has considered energy efficiency as part of the design solution. The calculation of energy performance indicators will assist the designer in the selection of the preferred technical solution, particularly when considering options for the lighting.

IS EN 13201-5:2015: Road lighting. Energy performance indicators shall be followed, and the calculations shall be clearly documented in both the Lighting Design File and the handover into maintenance documentation.

The IS EN 13201-5 energy performance metrics are calculated based on the power density indicator (PDI) and the annual energy consumption indicator (AECI).

3.11 Lighting system component approval

The contractor shall ensure that the proposed lighting system components are selected from high-quality grade materials and meet the local authority's specification. The proposed lighting systems components shall be approved by local authority before incorporating them into the design, including:

- luminaire specifications, including manufacturer and model;
- lighting column, foundation detail;
- lighting bracket type;
- lighting control system (photocell, CMS, etc.);
- cable network (cabling type, supply type, earthing arrangement, etc.);
- feeder pillar;
- ducting and chamber;
- overvoltage and circuit protection;
- cut-out (fuse); and
- lighting design software intended to be used.

3.12 Lighting design review

On receipt of approval for the lighting system component and acceptance of appropriate lighting classification for the project areas, the contractor's lighting designer shall carry out the lighting design in accordance with the local authority's design requirements and all relevant standards as part of the LED retrofit project.

It shall be the designer's responsibility to ensure that design calculations and luminaire performance are checked, that pole locations are confirmed, and that the lighting scheme is acceptable and compliant with all the requirements of the local authority and relevant Irish and EU requirements.

On completion of a detailed public lighting design using Lighting Reality or equivalent software, the design should be submitted to the local authority for approval in line with the protocol agreed prior to commencement of construction on site, including:

- project and safety risk assessment;
- environmental assessment, where applicable;
- photometric lighting design calculation showing Emin and Eav, uniformity (Uo), lux contours and luminance (cd/m^2);
- lighting class selection;
- maintenance factor selection;
- luminaire details including lumen output, wattage, correlated colour temperature and colour rendering index;
- The absolute photometric data indicating the optic setting and proposed driver current of the proposed luminaire must be provided in electronic format (.ies/.cib/.ldt/.eul or equivalent);
- Annual energy consumption indicator and Power density indicator calculation;
- full electrical design and power calculation (voltage drop, short circuit, cable carrying capacities, etc.);
- ESB Networks' section pillar locations;
- lighting layouts, including proposed columns', brackets' and lanterns' locations and tilt angles;
- standard construction detail drawings;
- ducting, chamber requirement;
- earthing arrangements;
- details of proposed columns and brackets;
- public lighting section pillar locations;
- prepare supporting schematic drawings including circuits schematics, together with a comprehensive legend and installation notes;
- any non-compliance issues to IS EN 13201-2: 2015 and BS 5489-1:2013.

3.13 Acceptance of design

The designer shall submit the lighting design report, drawings, and calculations along with any other relevant information for acceptance by the local authority before any associated works commence on site. The local authority is the final decision-maker on all designs including the lantern selection.

Additional information may be required by the local authority and shall be provided when requested. The local authority will consider the design and either accept or seek amendments until such time as it is satisfied with the design.

3.14 Commissioning, testing and certification

Prior to accepting any newly commissioned lighting installation, the installation shall be checked by the local authority or its appointed representative. Any remedial work or improvements required to comply with the approved design shall be carried out as identified.

Any work required to be tested by the contractor in the presence of the designer must have been pre-tested and proved satisfactory before test witnessing by the designer and/or the local authority is requested.

At the completion of the physical works, the lighting designer shall check and then certify that:

- the project has met all the requirements of the project brief, the standards and specifications;
- the lighting columns are vertical, and luminaires have been installed and operate correctly and are at the correct mounting height and at the correct tilt;
- all the documentation (safety file, warranties, equipment details, as-built records, test record sheets) that has been completed is correct and has been uploaded to the local authority's public lighting database system.

3.15 Asset register update

On completion of lighting installation works, the asset database system should be updated in line with the installation, so as to ensure proper management and maintenance of the asset.

All inventory changes must be recorded as equipment details change at a connection point, and any changes must be updated to the Unmetered Registrar (UMR) and MapRoad Public Lighting (MPL) database.

Once updated with the UMR and MPL, the up to the date GMPRN shall be uploaded to PL asset management database.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Section 4

Design watch points

4 Design watch points

4.1 Context

Design watch points are items to be aware of during the design process. These are based on best practice but should not be taken as an exhaustive list of items to be considered.

4.2 Light on buildings

Wall-mounted light installations are most commonly used for laneways or narrow streets where poles cannot be installed. This is usually a result of the absence of adequate footpaths for safe pole installation, or the location of major in-ground services that prevent installation of poles and footings, or a strategy to reduce clutter of pole elements in the public area.

The application of wall-mounted luminaires could be also considered due to the urban design impact, including heritage considerations. In such cases, the permission of the building owner and that of ESB Networks is required before lights can be attached to buildings.

Where existing wall-mounted lighting units are replaced with new LED wall-mounted units, the following items should be also considered:

- The contractor should be responsible for obtaining the necessary consent/permissions with the building owner(s) prior to commencement of any installation works. For instance, public lights, cable, cable cover, conduit, interface unit or isolation boxes can be fixed to buildings.
- A consent/permission form should be signed by the consenting owner to ensure continuity in the event of future transfer of ownership of the property.
- The nature and stability of the building; more than two fixing points should be provided, especially for buildings with timber frame, lime or soft brick construction. The wall bracket and complementary anchor bolt suitability shall be determined in accordance with the new LED lantern weight, wind load and building material.
- Interface units or isolation boxes should be fitted to the wall to provide the supply connection and power isolation to each new wall-mounted luminaire and thus enable safe circuit disconnection.
- The contractor shall take special care to avoid damage to buildings when fixing, wall brackets, luminaries and cables, but should damage occur then this shall be made good as approved and accepted by local authority and building owner.

4.3 Daytime appearance

The daytime appearance of fittings, fuse boxes and cables is an important consideration for the lights on the building. Therefore, the designer should consider the visual appearance of lighting systems during the design stage.

4.4 Glare control

LED light sources may provide very high luminance levels which may cause glare. Therefore, during the design, the following should be done in order to reduce disability glare:

- consider an appropriate disability glare classification;
- avoid excess illumination; and
- consider anti-glare shields supplied by the manufacturer to control any unwanted spill lighting.

Luminous intensity glare rating requirements are detailed in *DN-LHT-03038: Design of Road Lighting for the National Road Network* for each type of environmental zone.

4.5 Impact on street trees

Where possible, upgraded lighting designs should use existing serviceable poles, and avoid trimming of tree canopies unless otherwise necessary.
New pole installations and lighting designs shall be coordinated with street tree locations and other streetscape elements in order to avoid conflict.

4.6 Impact on heritage

For projects where the look and ambience of historic lighting is desired, but outdated technology is proving inefficient and/or ineffective, refurbishing existing luminaires with replica lanterns upgraded to the latest technologies should be considered. Alternatively, replacing the internal tray with compatible LED equipment can be considered upon approval of the local authority.

In architectural conservation areas, any public lighting renovation work might require local authority permission if the location and form of street lighting furniture such as street lights, manholes, fuse boxes, lighting brackets, lighting poles, mini-pillars, or metering enclosures may have a potential impact on the character of the area.

4.7 Lamp manufacturer consistency

Lamps/light sources produced by different manufacturers may have a slightly different colour appearance even though they have the same colour temperature marking. In order to ensure colour consistency when retrofitting lighting, lamps with the same colour temperature, and preferably sourced from the same manufacturer, should be used.

4.8 Bat habitat

In line with Bat Conservation Ireland (BCI) guidelines and *ILP Guidance Note 08/18: Bats and artificial lighting in the UK*, the items below should be considered in relation to selection of appropriate luminaire specifications for public lighting retrofit projects:

- All luminaires should lack ultraviolet elements when manufactured.
- LED luminaires should be used where possible, due to their sharp cut-off, lower intensity, good colour rendition and dimming capability.
- A warm white spectrum (ideally <2,700K) should be considered in order to reduce the blue light component.
- Luminaires should feature peak wavelengths higher than 550nm in order to avoid the component of light that is most disturbing to bats.
- Column heights should be carefully considered in order to minimise light spill.
- Only luminaires with an upward light ratio of 0% and with good optical control should be used. See *ILP Guidance Note for the reduction of obtrusive light GN01:2011*.
- Luminaires should always be mounted horizontally, i.e. with no upward tilt.
- The lighting level shall be kept as low as possible while still meeting the minimum required light level required under the health and safety.
- As a last resort, accessories such as baffles, hoods or louvres can be used to reduce light spill and direct it only to where it is needed.

4.9 Residual current device

For lanterns and other luminaires at heights not exceeding 2.80m above ground level, access to the light source shall only be possible after the removal of a barrier or enclosure which requires the use of a key or tool.

These installations shall be protected additionally by means of a residual current device (RCD) with a rated residual operating current not exceeding 30mA.

Where failure of the illumination is likely to cause other danger, e.g. slips, trips or falls, circuits shall be subdivided into several subcircuits, each protected separately by an RCD.

4.10 Electrical vehicle charging points

Electricity charging points for electric vehicles are becoming a feature on some urban streets. Vehicular electricity charging points should be lit to the same lighting class as the adjacent road. For example, electrical charging cables should be adequately illuminated such that their visibility reduces the trip hazard.

4.11 Existing lighting columns assessment

Before installing the new LED luminaires, each lighting column should be subject to both a ground-based visual inspection and, if required, appropriate non-destructive testing in accordance with RMO Asset Condition Survey Specification and *ILP Guidance Note 22/19, Asset-Management Toolkit: Minor Structures* in order to identify any defects (for example, corrosion or cracking to the swage, door cut-out or in the root section) or any impact damage or vandalism. Where defects are identified, the implications of these should be assessed and, where necessary, either remedial works or column replacement carried out.

During the surveys, it is useful to collect other information about the lighting column that may be required for the information of the installing contractor.

For example, the presence, type and diameter of the brackets and luminaire spigot, which will be needed to select the correct diameter side entry or post top luminaire spigot cap.

4.12 Lighting column placement

The lighting column positions should be carefully selected in order to avoid locations where they could be struck by a vehicle. Particularly on residential roads, the lighting columns should, if possible, be situated at the rear of the footway and away from windows and residential properties, so as to minimise light trespass.

The potential risk of secondary injury to other road users from the continued motion of vehicles or from a falling support structure, and therefore the particular design requirement for the post, should be assessed and determined by the designer on a site-specific basis.

If required, passive safe columns along with electrical disconnect systems of an appropriate type shall be used and, as appropriate, in line with the requirements of BS EN 12767: 2007 and *ILP Technical Report TR30: Guidance On The Implementation Of Passively Safe Lighting Columns And Signposts.*

4.13 Privately owned lighting sources

In assessing appropriate levels of illumination, the existing and ambient lighting (e.g. from shops, restaurants, floodlighting schemes, etc.) shall not be considered. Although such lighting adds to the ambience of the area, it should be recognised that the continued operation of ambient or privately owned lighting sources cannot be guaranteed for the life of the scheme.

4.14 Correlated colour temperature

Overall, the selection of the colour temperature is an important aspect of street lighting design, and it depends on the area of application and different preferences. The selection of the light colour temperature requires consideration of the following criteria:

– road types and classification;
– road users;
– pedestrian dominated areas;
– historical buildings;
– facial recognition;
– conservation areas;
– residential areas;
– National Park areas;
– night-time economy;
– crime risk, safety and security; and
– landscape areas such as parks, gardens and rivers.

The following provides the general recommendations with respect to colour temperature selection for public lighting; however, the final decision shall be made by the local authority considering the above-mentioned criteria:

- The CCT for residential estate areas, rural residential settlements and mainly pedestrian areas is recommended to be 3,000K, considering the impact of light on circadian rhythm.
- Where the local authority has a concern over anti-social behaviour in residential estates, the CCT is recommended to be 4,000K.
- A 3,000K CCT is recommended for around historical buildings and old town centres to help enhance the historic character of buildings.
- The CCT for National Park areas and bat conservation areas is recommended to be 2,700K in accordance with *ILP Guidance Note 08/18: Bats and artificial lighting in the UK*. However, it shall be considered on a scheme-by-scheme basis.
- The CCT for other areas is recommended to be 3,000K in accordance with BS 5489-1:2013 unless otherwise stated by local authority.
- Regarding the pedestrian crossings, CCT of LED lanterns shall be distinguishable from the surrounding area, therefore CCT of LED lanterns shall be differentiated on the pedestrian crossings. For example, if the public lighting CCT is 4000K on the road surface, 3000K CCT shall be applied for the lanterns on the pedestrian crossing to create greater contrast or vice versa.

The CCT shall be selected for the national road network as per *DN-LHT-03038 August 2018: Design of Road Lighting for the National Road Network.*

4.15 Remote LED driver programming

Many local authorities require factory pre-set dimming profiles for public lighting lanterns. However, further adjustment of dimming profiles may be required either for further energy savings, or to meet demands from road users and/or residents.

To allow for reprogramming of the LED driver from time to time, LED luminaire drivers should have the ability to be reprogrammed at the column door without the need to directly access the luminaires.

In retrofit projects, extra two core cables should be run from the electronic dimmable driver to the base compartment of the column in order to allow for remote LED driver programming.

Some lantern manufacturers provide a Bluetooth lighting control solution that enables the user to reprogrammed the dimming profile of the LED drivers individually from the ground. It is worth considering the Bluetooth control solution, as it is easy to control the LED lanterns' dimming profile while simply standing by the pole, and without using any extra cabling from the lanterns to the column doors. Following reprogramming, UMR, MPL is to be updated accordingly.

4.16 Lighting column cabling

When a lantern is retrofitted to LED, the cables between the lantern and the fuse box with the column should also be replaced with a new cable. This will ensure that this cable's lifespan is comparable to the lantern's expected lifespan.

4.17 Optional motion sensors

The majority of LED lantern manufacturers provide an autonomous integrated optional passive infrared (PIR) sensor, which reduces light intrusion, light pollution, electrical energy consumption, and carbon emissions, and provides a longer lifetime of LED lights.

In public car park spaces, bat conservation areas and low-density residential areas with little nocturnal activity, lighting levels can be dimmed to a minimum most of the time by using PIR sensors. The level of light can be raised as soon as a pedestrian or a slow vehicle is detected in the area. Each luminaire's level can be configured individually, featuring a minimum and maximum light output with delay period.

A risk assessment should be undertaken prior to making a decision on the final dimming ratio.

4.18 SEAI TRIPLE E Products Register

New LED lighting luminaires shall be a high-efficiency type selected from the SEAI Triple E Products register.

4.19 Closed Circuit Television (CCTV)

Where area suffering from high levels of street robbery, anti-social behaviour or crime and CCTV is being used a by the Gardaí or the local authorities, they should be consulted regarding the lighting requirements.

4.20 LED lighting inrush current

The contractor shall ensure that the number of the fittings on the same lighting circuit is in accordance with the manufacturer's LED driver operating instructions considering the inrush current and the type and size of the protective device.

However, regardless of the lighting manufacturer's guidance, a maximum of nine LED lighting fittings shall be supplied by the same lighting circuit.

4.21 Non-compliant lighting designs and relaxion process

If a lighting design is non-compliant to IS EN 13201-2: 2015 and BS 5489-1:2013 standards, then the lighting design submission shall identify the non-compliance issues and list the best possible solution to deliver a compliant design for acceptance by the local authority.

In some instances, it may not be possible to meet all of the IS EN 13201 lighting class parameters required under the retrofit contracts due to the spacing, configuration and height of lighting units on columns and poles.

Where the contractor is not able to achieve fully lighting design compliance minor relaxations are permitted as subject to acceptance of local authority. for both luminance and illuminance classes as detailed in Table 12 and Table 13.

The lighting designs shall be broken into segments for analysis and the relaxations shall only be used where absolutely necessary, for example, a 100m section of a 2km road. For clarity the relaxations shall only be applied to the minimum number of luminaires and the design shall maximise the number of luminaires which shall meet the lighting standards.

A road safety review and a specific the risk assessment shall be undertaken and submitted to the local authority for the acceptance of relaxation of lighting design.

For luminance (M Class) lighting classes the designer could have up to two minor non-conformances but only one of these is permitted across the Lav., Uo, and Ul values. The minor non-conformances shall meet the variant values in Table 12.

For illuminance (P Class) lighting classes, the designer is permitted to have one of the following non-conformances for each lighting class as detailed in Table 13.

Note: Variant Uniformity multiplier (>2) shall be applied to Variant Eav lux level not Design Eav lux level for P Class. For an example, taking the P3 Lighting Class Design Eav and Emin values and Uniformity Multiplier of 2, this means that an Eav=12 Lux [6*2] along with an Emin of 1 Lux would be possible in a compliance "relaxed" design. `

The contractor shall ensure that the minimum lux level shall not be less than 1lux anywhere in retrofit project areas taking the dimming and trimming profiles into account.

The contractor shall minimise the number of luminaires in each scheme where relaxations shall apply. They shall maximise full compliance with the deign standards for the scheme.

Table 12 – M Class Relaxation Table.

Class		Lav	Uo	Ul	fT1	Rei
M2	Design	1.50	0.40	0.70	10	0.35
	Variant	1.25	0.35	0.60	15	0.30
M3	Design	1.00	0.40	0.60	15	0.3
	Variant	0.90	0.35	0.50	20	0.3
M4	Design	0.75	0.35	0.60	15	0.3
	Variant	0.65	0.30	0.40	20	0.3
M5	Design	0.50	0.35	0.40	15	0.3
	Variant	0.40	0.30	0.40	20	0.3

Table 13 – P Class Relaxation Table

Class		Eav	Emin	Uniformity Multiplier	Dimming and trimming profiles
P1	Design	15.00	3.00	>1.5	
	Variant	12.5	2.0	>2.0	
P2	Design	10.00	2.00	>1.5	In general Profile U15 to reduce over lighting and light trespass during sleeping hours.
	Variant	8.5	1.5	>2.0	
P3	Design	7.50	1.5	>1.5	No dimming allowed
	Variant	6.0	1.0	>2.0	
P4	Design	5.0	1.0	>1.5	No dimming allowed
	Variant	4.0	1.0	>2.0	

Appendicx A Basic terms and definitions

Appendix A

Basic terms and definitions

Appendix A: Basic terms and definitions

Several elements are common to both the design of a new lighting system and the retrofit of an existing system. The following are elements of lighting design and retrofits that should be considered when designing a new lighting system or replacing an existing lighting system:

Luminance (cd/m²)

Luminance is the measure of light reflected from a surface in a given direction. It indicates the intensity, or brightness, of lighting in that direction and is measured in candelas per square metre. Luminance measurements indicate, for example, how much light is reflected from the paved surface of a road in the direction of a driver.

Illuminance (lux, lm/m²)

Illuminance refers to the amount of light that falls on a surface from a light source. It is measured in lumens per square metre (lm/m²). Typically, the standards provide recommended, maintained illuminance values for specific applications. Illuminance values are also specified as minimum horizontal and vertical values for some applications.

Uniformity

One of the main objectives in street lighting is to provide good street and road surface illumination so that obstacles can be easily identifiable. Thus, it is important to avoid dark areas on a road surface. IS EN 13201-2:2015: Road Lighting Performance Requirement contains recommendations for minimum overall uniformity for illuminance designs, and for both minimum overall uniformity and longitudinal uniformity levels on the road, depending on the road lighting class, for luminance design.

Colour appearance

The colour appearance of a light source is characterised by its colour temperature expressed in Kelvin (K). The CCT of a light source is defined as the temperature at which its colour matches the colour of the radiation emitted by a heated ideal black-body radiator.

CCT is used to describe the colour appearance of a white light source not the colour of illuminated objects. CCT of white light sources ranges from a warmer yellowish white (2,700K), through neutral white (4,000K) to a much cooler blueish white (6,500K).

Figure 7: Correlated colour temperature scale (Source: Wikipedia, Hues of the Planckian locus on a linear scale, https://en.wikipedia.org/wiki/Color_temperature)

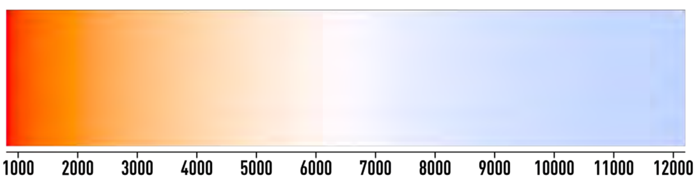
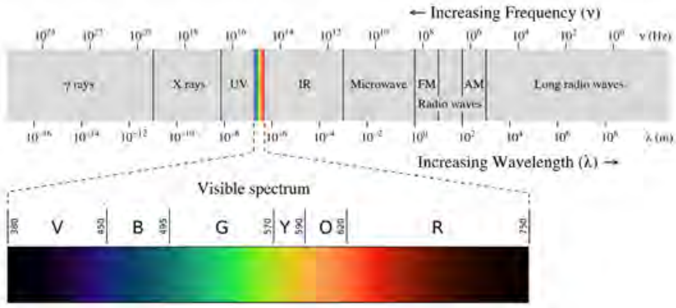


Figure 8: The electromagnetic spectrum (Source: Wikipedia, Electromagnetic spectrum with visible light highlighted, https://en.wikipedia.org/wiki/Electromagnetic_radiation#/media/File:EM_spectrumrevised.png)



When we say light, we mean visible light which is a tiny part of the electromagnetic spectrum with a wavelength between 380 and 760 nanometres.

The different wavelengths in the visible part of the spectrum result in different colour impressions, and the combination of all wavelengths in the visible spectrum results in the white light emitted by the sun or a lamp. The sensitivity of the eye varies significantly with different wavelengths of the same energy content.

Chromaticity diagrams, such as the CIE 1931 (x, y) chromaticity diagram shown in Figure 9, are used to provide a numerical specification for the colour of light. A chromaticity diagram can be used for colour matching.

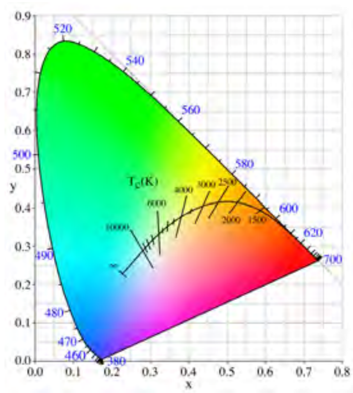
Colour bins or MacAdam ellipses on the chromaticity diagram are used to colour precision of a light source and to specify LED lighting. The small ellipses are five-step MacAdam ellipses on the Figure 10. Lamps with chromaticity coordinates within the same ellipse would appear to be the same, or almost the same, colour. In-real world installation anything better than three-steps is considered imperceptible, with five-steps being 'the norm'. As a rule, colour temperature tolerance shall be within the Five-step MacAdam ellipses for public lighting application.

Correlated colour temperature stability

Colour temperature stability refers to a light source's ability to maintain its colour properties over time

Usually, white light is created by applying a phosphor-based coating to a blue diode, either directly on the diode or on a separate plate over it. The quality of the light is determined both by the specification of the blue LED and by how carefully the phosphor is matched to the selected diode. This coating converts some of the blue light to white light of various colour temperatures. This process is similar for other lamps such as high-pressure discharge lamps. In addition to phosphors degrading within a lamp, ageing of the materials used in its optics and driver performance can cause variation in light colour temperature.

Figure 9: Chromaticity diagram (Source: Wikipedia, https://en.wikipedia.org/wiki/Chromaticity#/media/File:PlanckianLocus.png)



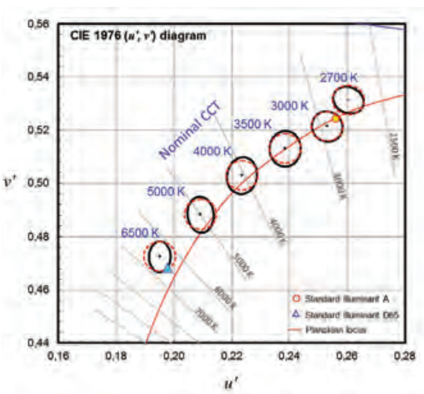


Figure 10: Five Step MacAdam ellipses in IEC 60081 (IEC, 1997) and cirles (radius 0,0055) in the CIE 1976 (u',v') chromaticity diagram, (Source: International Commission on Illumination, CIE TN 001:2014, CIE 2014.)

Colour rendering index (CRI)

Colour rendering index (CRI) defines the ability of a light source to render object colours accurately. It is expressed by the general CRI with values from 0 to 100, where 100 is the best (100 is provided by daylighting).

The appropriate standards and guidance documents advice on colour rendering depends on the task to be lit. Reference to BS 5489-1:2013, higher colour rendering index values should be used where there is a high level of pedestrian activity or where the appearance of an area is important. Under the Ecodesign regulations, LEDs for exterior use should have a CRI of 65 or better.

Light pollution

Light pollution is commonly defined as any adverse effect of artificial light on people, animals and the environment.

For people, the effects range from excessive illumination of the night sky in and around cities to disruptions of the sleep cycle due to badly positioned outdoor lighting in residential areas. On the other hand, animals use natural light sources as a navigational aid and thus may become confused or scared away by artificial illumination.

Light pollution is mainly caused by obtrusive light, sky glow, light trespass or glare emitted by an artificial light source.

However, careful selection and design of street lighting can minimise their effects.

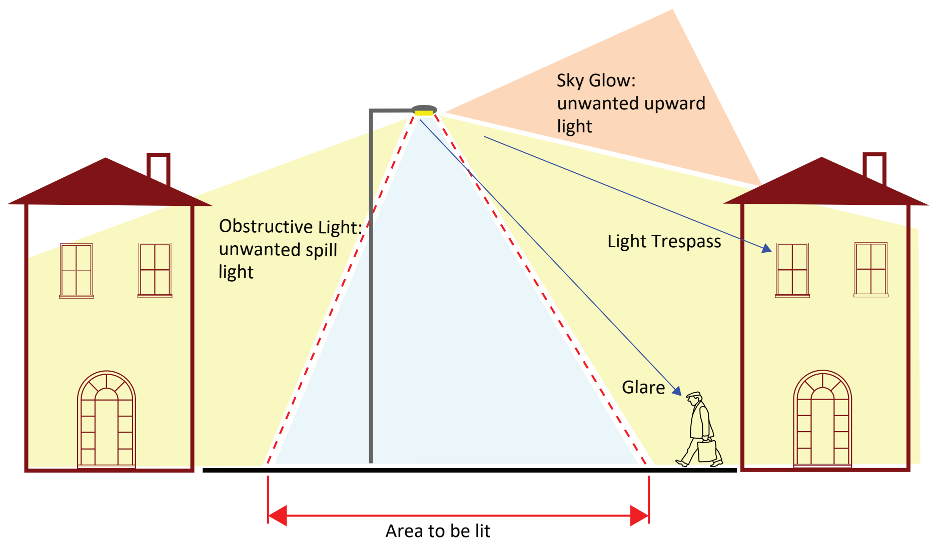
Obtrusive light: is misdirected light or light that falls on surfaces where no lighting is required, such as homes, gardens or other outdoor areas.

Obtrusive light can be avoided by selecting and positioning light fittings to avoid creating unwanted light spill on residential properties.

Directional light sources incorporating LEDs are especially suited for achieving optimised light distribution. The environmental zones and associated maximum allowable obtrusive light levels on properties are set out in Table 14 for exterior lighting installations.

Curfew is the time after which stricter requirements (for the control of obtrusive light) will apply; often, a condition of use of lighting is applied by the local planning authority. If not otherwise stated, 23.00hrs is suggested.

Figure 11: Types of obtrusive light from a typical street lighting luminaire



Further information and guidance can be found in "Guidance Notes for the Reduction of Obtrusive Light GN01:2011" from the ILP.

Upward light (sky glow): This refers to brightening of the night sky over inhabited areas. It can be caused by overdesign, poor luminaire selection and light reflection from the ground. Upward light should be reduced and eliminated where possible to maintain dark skies. Design considerations should include incorporating full cut-off fixtures that only direct light downwards, although careful design is required in order to minimise the amount of light reflected off the ground and into the sky.

Special consideration to be given to dark sky areas.

Glare: Intense and blinding light resulting in reduced visual performance and visibility, often accompanied by discomfort.

Glare triggered by LED road lights can be caused by the following factors:

- the ratio between the illuminance from the glare source at observer's eye and the background luminance;
- the angle between the glare source and the observer's line of sight.

LED light sources can provide very high luminance levels which may cause glare. For this reason, utilising anti-glare shields to help to avoid this luminance is sometimes recommended. Moreover, public lighting systems should be designed in a way that avoids significant difference in luminance levels at the light source and on lit areas.

Further options for reducing lighting pollution include:

Reducing illumination: Illuminance level can be adjusted to appropriate levels for specific times (see Section C1.7 Adaptive lighting of this document) considering safety requirement for road users, such as junctions, conjunction areas, etc.

Changing the spectrum: The sensitivity of animals and birds to different light colours varies from species to species. Warmer light sources should be considered in areas of ecological interest. With LED technology, colour temperature can be varied according to needs. However, quality and safety requirements must still be met.

Table 14: Environmental zones and maximum obtrusive light permitted for exterior lighting installations according to BS EN 12464-2:2014)

Zone	Lighting environment area	Example	Maximum lighting level on properties	
			Pre-curfew (lx)	Post-curfew (lx)
E1	Intrinsically dark	National Parks or protected sites	2	0
E2	Low district brightness	Industrial or residential rural areas	5	1
E3	Medium district brightness	Small town centres or suburban locations	10	2
E4	High district brightness	Town/city centres, high level of night activity	25	5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Blue light hazard

Blue light hazard is defined as the potential for retinal injury due to high-energy short-wavelength light.

Some wavelengths are more effective at causing harm than others, with the peak effect very close to the sensitivity of the short-wavelength cones; in other words, blue light at around 440nm. The 4,000K (neutral white) LEDs used in street lighting generally emit at around 450nm to 460nm. For this reason, there are concerns that the guidelines may be exceeded, especially by lights arising from LED chips in direct view.

Reference to *CIBSE, CRCE-RDD 01-2014: "Human Responses to lighting based on LED lighting solutions "*document, detailed assessments were made for the street lights as part of ocular safety and blue light hazard. The street LED lamps measured were not bright enough to cause retinal damage in normal use at reasonable distances.

However, at a distance of 2 m, reaching the exposure limit values for the Blue Light Hazard would require steady fixation for over 2½ hours, based on conservative calculations.

LED street lights could, in theory, be fitted close to a window, balcony, ledge, or simply close to the ground instead of at a normal height. This should be avoided, or appropriate assessments should be carried out considering but not limited to following risk factors:

- the amount of blue light contained with the total spectrum of the light source:
- the amount of light that can be coupled in to the eye to expose the retina, determined by the radiance of the light source; and
- the duration of exposure and cumulative duration of repeated exposures.

Figure 12: Example of before and after public lighting upgrade scheme in Co. Offaly

Appendix B How the eye works

Appendix B

How the eye works

Appendix B: How the eye works

The eye-brain system allows us to see and interpret our surroundings. Light enters the eye through the iris, a variable-sized opening, which controls the brightness of the image to avoid over- or underexposure. A lens then focuses an inverted image onto the retina, the image sensors at the back of the eye.

There are two types of photoreceptor cells: rods and cones. Each covers a different range of brightness. The rods provide low-brightness night vision without colour; they are sensitive to movement and are incredibly sensitive to light. The cones provide day vision, which become active in brighter light and can detect colour.

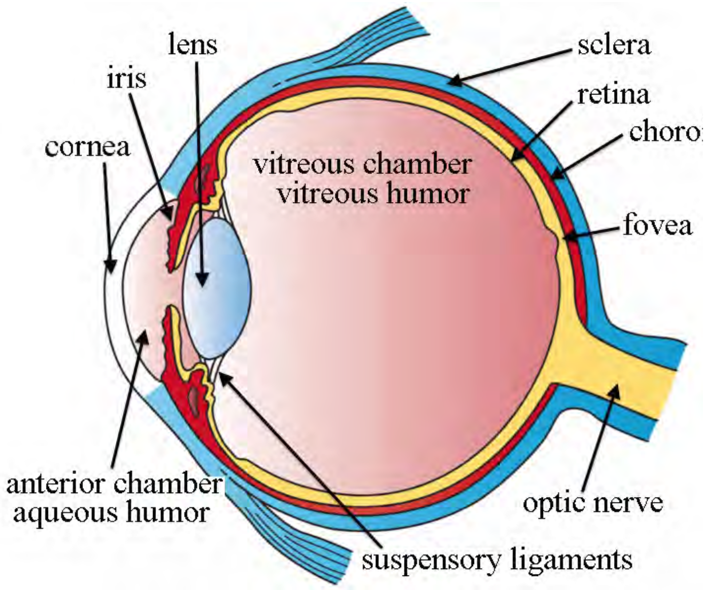


Figure 13: Human eye components (Source: Wikipedia, https://upload.wikimedia.org/wikipedia/commons/d/d0/Three_Main_Layers_of_the_Eye.png)

Photopic, mesopic, scotopic – concepts

How the human eye perceives the light source is critical. This perception is dependent on surrounding visual conditions. There are three general types of visual conditions: scotopic, photopic and mesopic.

Scotopic vision: Visual function under very low light levels. The rod cells of the human eye are activated under scotopic conditions. It is generally associated with adaptation to light levels below 0.034cd/m^2.

Photopic vision: Vision mediated essentially or exclusively by the cones. It is generally associated with adaptation to high light levels, i.e. a luminance of at least 3.4cd/m^2.

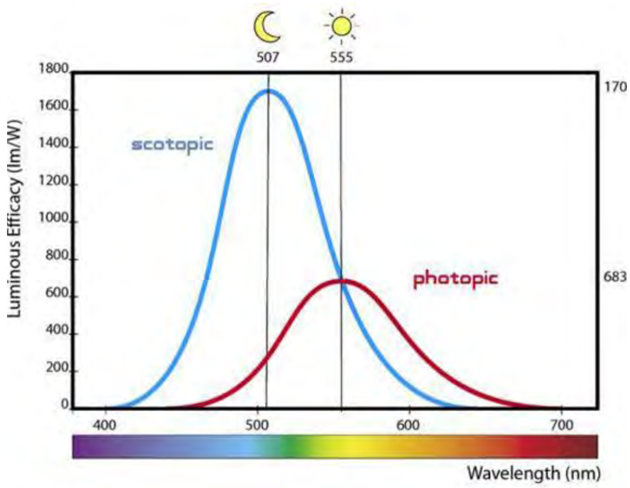


Figure 14: Scotopic and photopic human vision response

Mesopic (night-time) vision: Vision with fully adapted eyes at intermediate light levels, between photopic and scotopic conditions, or about 3.4–0.034cd/m².

Artificial public lighting creates lighting scenarios which lie between the realms of the photopic and scotopic areas, known as mesopic vision. During this state, both photopic and scotopic vision are required in order for the person to be able to see.

All light sources have a scotopic/photopic (S/P) ratio. Lighting with a higher S/P ratio permits better visual performance under mesopic conditions. For further guidance on S/P ratio and visual tasks associated with lighting pedestrian associated roads refer to ILP PLG03:2012.

Generally, the whiter the light source, the higher the S/P ratio. The reduction in minimum and maintained lighting levels is greater when using lamps with a higher S/P ratio. Table 15 gives S/P ratios for three typical cases, which is sourced from BS5489-1:2013. A more complete table giving S/P ratios for different lamps can be found in ILP PLG03:2012, or the manufacturer can be consulted.

As Table 15 shows, the level of illumination required on subsidiary roads and paths may be reduced by as much as 30% if the light source has a colour rendering index (Ra) of 60 or higher.

Consequently, LED light sources with high S/P ratios at lower wattages (or dimmed) provide the same perceived light level similar to high wattage, low S/P ratio sources.

However, colour appearance/colour temperature must also be considered, as many people do not like a 'cold' appearance.

Table 15: Variation of maintained lighting level with S/P ratio of light, sourced from BS 5489-1:2013 (Source: British Standards Institution, 2012, Code of practice for the design of road lighting. Lighting of roads and public amenity areas, BS 5489-1:2013)

Values in lux

Lighting class	Benchmark (e.g. R_a < 60 or when S/P ratio of light source is not known or specified)		S/P ratio = 1.2 and $R_a \geq 60$ (e.g. some types of warm white lamp such as metal halide)		S/P ratio = 2 and $R_a \geq 60$ (e.g. some types of cool white compact fluorescent or LED)	
	$\bar{E}$	E_{min}	$\bar{E}$	E_{min}	$\bar{E}$	E_{min}
P1 or S1	15.0	3.0	13.4	2.7	12.3	2.5
P2 or S2	10.0	2.0	8.6	1.7	7.7	1.5
P3 or S3	7.5	1.5	6.3	1.3	5.5	1.1
P4 or S4	5.0	1.0	4.0	0.8	3.4	0.7
P5 or S5	3.0	0.6	2.2	0.4	1.8	0.4
P6 or S6	2.0	0.4	1.4	0.4	1.1	0.4

Appendicx C Overview of specification and requirements

Appendix C

Overview of specification and requirements

Appendix C: Overview of specification and requirements

This section contains the basic information relevant for understanding the procurement criteria, together with the important quality and efficiency aspects for public lighting and IS EN 13201 standards for road lighting all parts and BS 5489-1:2013 standard.

The section should be read in conjunction with the LED Procurement Criteria template provided in appendix D.

C1.1 Luminaire and LED module Lifetime

To quantify the lifetime of LED lighting sources, the IEC 62722-2-1:2014 standard defines two characteristics: Lx and By.

L value (Lx): Lx defines the remaining luminous flux as a percentage of the original value and is used in combination with a defined operation time.

B value (By): By defines the percentage of LED modules that fail to achieve the specified Lx.

For example, L90/B20 at 100,000 hours means that after 100,000 operating hours of operation, 20% of the LEDs will have equal to or less than 90% of the original luminous flux.

The designer should obtain all relevant data from the manufacturer in order to select a luminaire fit for the intended installation. In general, LEDs have a lifetime of 100,000 hours or above, although the actual lifetime of a luminaire may depend on several factors, such as the luminaire physical condition, lifetime of the luminaire driver, environmental conditions, overvoltage protection, and quality of workmanship for luminaire installation and maintenance.

C1.2 Physical performance characteristics

C1.2.1 Thermal management

Total failure and the degradation of the luminous flux of a luminaire further depend on its electrical and thermal operating data, ambient temperature and other parameters. The performance of LED lighting systems depends on the effectiveness of thermal management.

A lighting system should be provided with specification data that clearly defines its performance at given thermal ranges and ambient temperature.

Table 16: IP rating according to BS EN 62622

IP code	First digit (protected against)	Second digit (protected against)
0	No special protection	No special protection
1	Solid object greater than 50mm	Dripping water
2	Solid object greater than 12mm	Vertical dripping water, when the item is tilted at an angle of 15°
3	Solid object greater than 2.5mm	Vertical dripping water, when the item is tilted at an angle of 60°
4	Solid object greater than 1mm	Splash-proof in all directions
5	Dust protected	Water jets (6.5mm nozzle) in all directions
6	Dust tight	Power water jets (12.5mm nozzle) from all directions
7		Temporary immersion in water up to 1m deep
8		Continuous immersion in water deeper than 1m

C1.2.2 Physical protection

The resistance of luminaires against intrusion from foreign materials is defined as ingress protection (IP) according to BS EN 60529:1992+A2:2013. The first digit represents the resistance against solid matter; the second digit represents its resistance against liquids (see Table 16).

For public luminaires, the higher the IP rating of the luminaire, the better protected the enclosure from foreign material. Therefore, minimum IP66 luminaires should be used so as to ensure sufficient resistance to external environmental influences.

The resistance of luminaires to mechanical impacts is indicated by an IK rating in accordance with BS EN 62622:2002, Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code).

For public lighting luminaires, the higher the IK rating, the greater the resistance to mechanical impacts (see Table 17). Therefore, a minimum rating of IK07 should be used to ensure sufficient resistance to strong winds, hail, loose tree branches, vandalism, etc.

Table 17: IK rating

IK code	Equivalent impact
00	No test
01	Drop of 200g object from 7.5cm height
02	Drop of 200g object from 10cm height
03	Drop of 200g object from 17.5cm height
04	Drop of 200g object from 25cm height
05	Drop of 200g object from 35cm height
06	Drop of 500g object from 20cm height
07	Drop of 500g object from 40cm height
08	Drop of 1,700g object from 29.5cm height
09	Drop of 5,000g object from 20cm height
10	Drop of 5,000g object from 40cm height

C1.3 System performance

As illustrated in Tables 1 and 2 in Section 2.1, LED lighting luminaires have very high efficacy (lm/W) compared with conventional lighting technologies.

The total efficiency of LED lighting systems not only depends on the LED luminaire efficacy, but also on the light control system and the overall light¬ing system design. For this reason, it is important to distinguish efficacy at the LED lighting luminaire level and at the total system level. In order to assess the energy efficiency at road system level, IS EN 13201-5:2015 - Road Lighting, Energy performance indicator describes the two energy performance metrics:

- Power density indicator (PDI), measured in W/lx/m², which is the value of the system power divided by the product of the surface area to be lit and the calculated maintained average illumination on this area.
- Annual energy consumption indicator (AECI), measured in Wh/m², which is the total electrical energy consumed by a lighting installation day and night throughout a year in proportion to the total area to be illuminated by the lighting installation.

The AECI allows a comparison to be made of different setups and technologies for the same street lighting project, as different locations will have a different geometry and environmental conditions. PDI values can only be used to compare different setups for the same installation.

These indicators should be used to compare the energy performance of different road lighting solutions and technologies for the same road lighting project.

C1.4 Electrical characteristics

C1.4.1 Overvoltage protection in the LED driver

In contrast with conventional lighting sources, LEDs are only designed for low operating voltages and they are therefore more sensitive to overvoltage. The same applies for related LED drivers. Practical experience has shown that LED lights do not survive real overvoltages that occur without protection. Efficient protection of LED lighting systems is therefore essential.

Manufacturers of LED lighting systems frequently design LED drivers for overvoltage of between 2kV and 4kV. However, this protection level may be insufficient for street lighting systems. The lighting system designer should specify the minimum surge protection level for LED drivers, considering the installation environment.

C1.4.2 Power factor

Power factor describes how efficiently an LED driver uses electricity. It is calculated by dividing the power being used by the driver (wattage) by the product of the input voltage multiplied by the current going in (volts × amps).

The range for power factor is a decimal between 0 and 1. The closer to 1 the power factor is, the more efficient the driver is. A good power factor is 0.9 or above.

LED drivers should be specified with the desired power factor correction figure at full loads and for dimmed situations.

C1.5 Photometry

Photometric data describe directional performance of a reflector or lens from the tested lamp/luminaire combination. Conventional lighting technologies have photometric data that are generally simpler than LED lamps because the physics of LEDs allows a significantly greater number of variables to be changed, thus making them more customisable to a greater range of applications. Photometric data are essential for good design so that the lighting product is matched to requirements, as well as to calculate and provide the PDI value.

C1.6 Trimming

Trimming is the process of shortening the lighting period of a lamp. Modern lights achieve full light output quickly compared with older technologies which took a longer period to reach full output.

Traditionally, the public lighting on/off switch has been controlled by 70/35 photocells set to 70 lux (switch on) and 35 lux (switch off), as SON and SOX lamps take about 15 minutes to warm up to full light output.

As LED lamps reach full output capacity almost instantly, this warm-up period is not required to reach the required lumen output; therefore, 35/18 or 20/20 lux photocells are being used with LED luminaires. Refer to Figutre 15 for 35/18 lux trimming profile.

C1.7 Adaptive lighting

Adaptive lighting is the ability to change the lighting levels based upon the area being lit. Adaptive lighting is a name for a group of controls that allows light output to be modified during the night and includes part-night lighting, standalone dimming (single-step, multilevel static dimming), and dynamic dimming. A central management system (CMS) is generally needed for dynamic dimming.

C1.7.1 Dimming

Dimming is the process of reducing the current and consequently the lighting intensity during periods where there is little vehicle or pedestrian movement. Besides the obvious benefits of reduced energy consumption, dimming controls allow greater flexibility to prevent over lighting during certain periods of the night.

There are several different control systems available for dimming controls. These controls can operate independently based on one-step static dimming, multilevel static dimming or a dynamic dimming system (linked to a CMS that permits remote control by operators).

C1.7.2 Single-step static dimming

Factory-set drivers are available from several manufacturers, and these can be pre-set to dim several times and commonly by one step down.

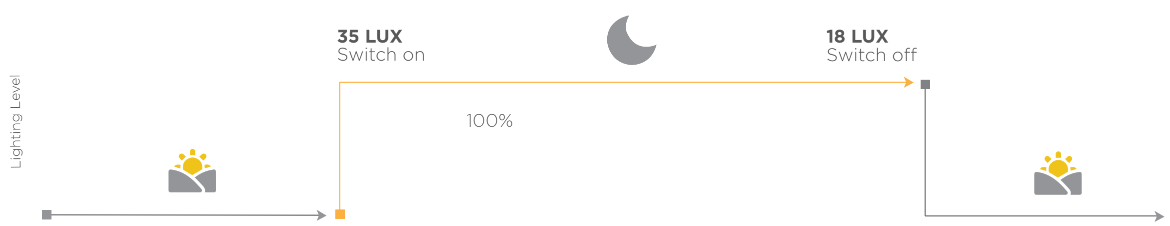
Unless a minimum lighting class is being adopted, as a minimum, a pre-set dimming regime should be applied with at least one step down in lighting class that is applied during the period of darkness.
The commonly used unmetered dimming profiles that have been agreed with ESB Networks are illustrated in Figure 16.

The four initial burn profiles identified in sections C1.6 and C1.7 had been acknowledged as those that would be most prevalent across all local authorities. Notwithstanding this acknowledgement, it was recognised that some local authorities will seek to introduce an extended period of dimming that could commence earlier in the evening and extend later in the morning (See Figure 17).

C1.7.3 Multilevel static dimming

Multilevel static diming indicates that more than one level of dimming is used each night. Once the regime is factory set, the dimming level/times may not be able to be changed on site. The common multi-level dimming profiles are shown in Figure 18.

Figure 15: Trimming only (LED) (Source: Sustainable Energy Authority of Ireland, public lighting burn profiles)



Programmable drivers are also available, and these are generally pre-set in the factory with a range of dimming levels and periods of operation; however, these can be reprogrammed later on site by an operator. Rather than operators working at height, reprogramming the driver is possible by installing a communications lead from the luminaire housing down to the base of the lighting column, or by using Bluetooth. Programming is generally carried out using a laptop, tablet or software provided by the manufacturer.

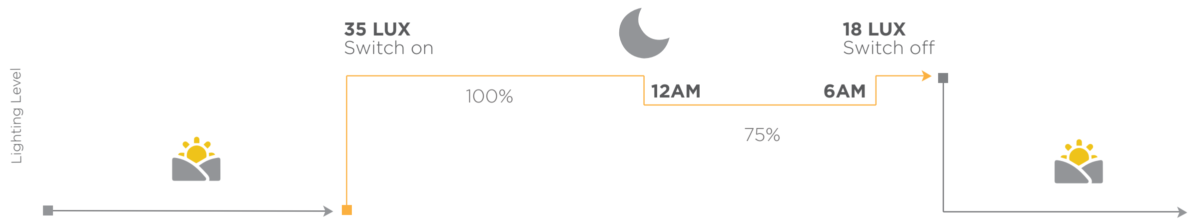
C1.7.4 How were these percentage reductions derived?

The percentage reduction will vary between lighting classes and will also depend on whether the dimming profile accommodates a reduction in lighting class by either one or two steps.

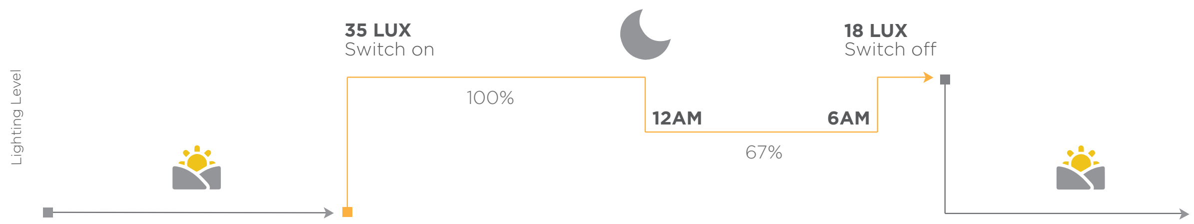
An assessment was made across the range of lighting classes based on both one and two steps down in lighting class and is depicted in Figure 19.

Figure 16: One-step dimming, standard period, profiles U14, U15 and U16 (Source: Sustainable Energy Authority of Ireland, public lighting burn profiles

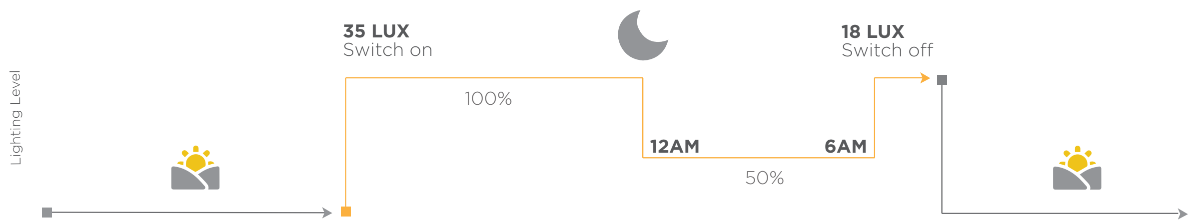
Profile U14



Profile U15



Profile U16



The 75% and 67% dimming profiles are most prevalent when reducing the lighting levels by one class, and 50% was the most prevalent lighting class reduction where lighting levels are reduced by two lighting classes. A one-class reduction for dimming is expected to be the one most commonly applied, given that the implementation of dimming is still in its infancy and local authorities may be reluctant to apply a greater variation in dimming levels.

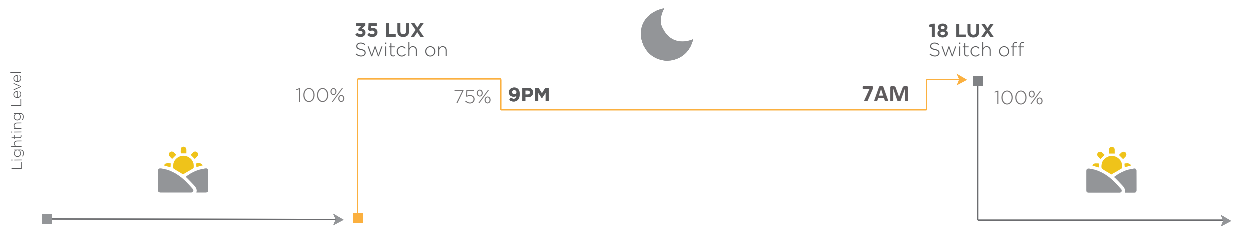
C1.7.5 Dynamic dimming system

Dynamic control differs from static control in its ability to vary lighting levels either by remote operation, daylight sensors, movement sensors or automatically based on real-time traffic flow. This type of control can be facilitated by the application of CMSs, which can also be used to provide remote monitoring including fault reporting without having to undertake night patrol.

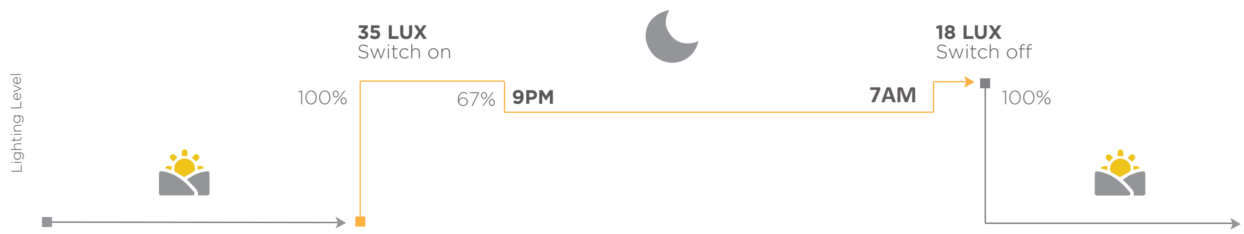
Figure 17: One-step dimming, extended period, profiles U17, U18 and U19 (Source: Sustainable Energy Authority of Ireland, public lighting burn profiles

Profile U17

1st Step Dimming - Extended Period



Profile U18



Profile U19

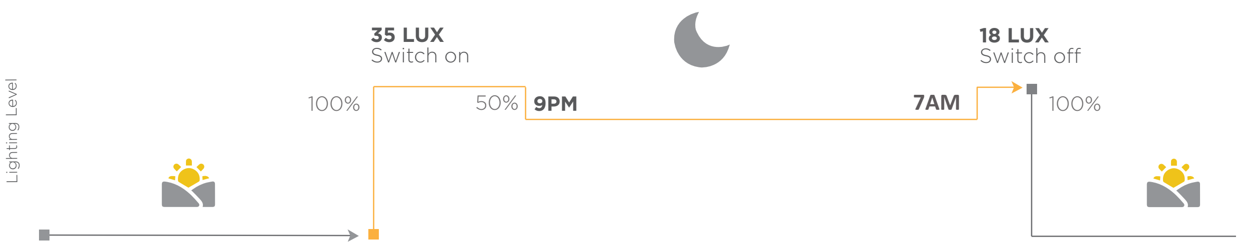
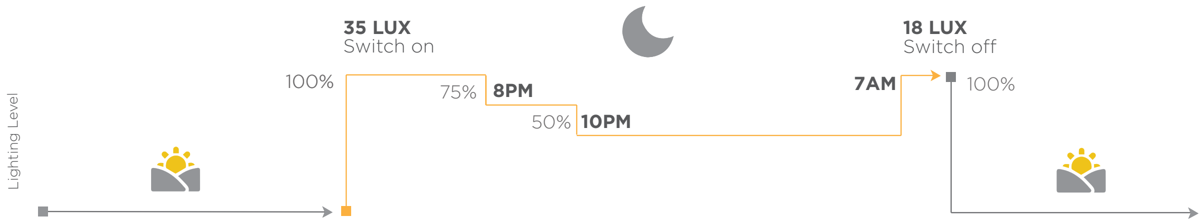


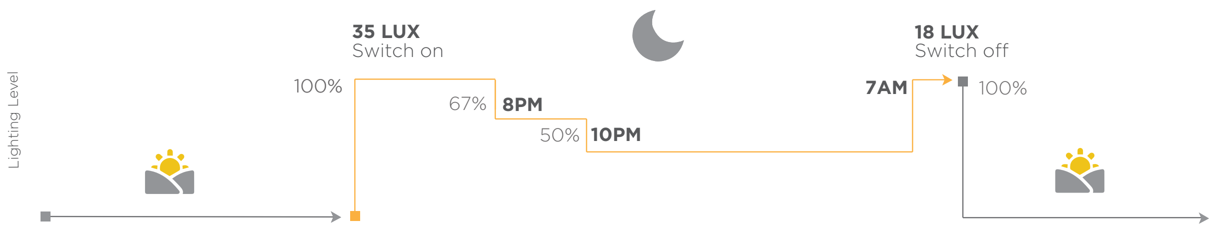
Figure 18: Multilevel dimming, profiles U20, U21, U22, and U23 (Source: Sustainable Energy Authority of Ireland, public lighting burn profiles

Profile U20

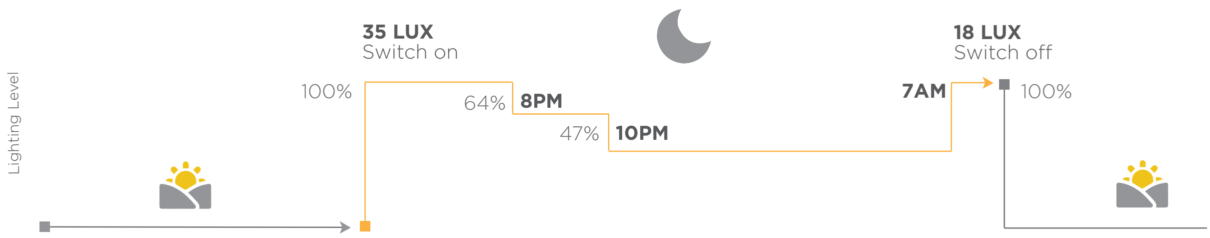
Multi Step (2-steps) Dimming



Profile U21



Profile U22



Profile U23

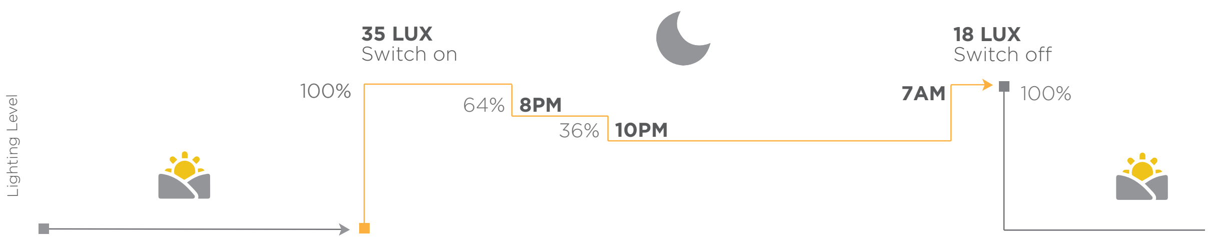


Figure 19: Lighting class reductions (ME, M, S and P classes are detailed in ME, M, S and P classes are detailed in PD CEN/TR 13201-1:2014 and BS EN 13201-2:2015) (Source: Sustainable Energy Authority of Ireland, public lighting burn profiles)

A One Lighting Class Reduction

From	To	Output	Profile
ME1	ME2	75%	U14/U17
ME2	ME3	67%	U15/U18
ME3	ME4	75%	U14/U17
ME4	ME5	67%	U15/U18
ME5	ME6	60%	U15/U18

S/P = 1.2			
From	To	Output	Profile
P1	P2	64%	U15/U18
P2	P3	73%	U14/U17
P3	P4	63%	U15/U18
P4	P5	55%	U15/U18
P5	P6	64%	U15/U18

RA< 60			
From	To	Output	Profile
S1	S2	67%	U15/U18
S2	S3	75%	U14/U17
S3	S4	67%	U15/U18
S4	S5	60%	U15/U18
S5	S6	67%	U15/U18

S/P = 2			
From	To	Output	Profile
P1	P2	63%	U15/U18
P2	P3	71%	U14/U17
P3	P4	62%	U15/U18
P4	P5	53%	U15/U18
P5	P6	61%	U15/U18

A Two Lighting Class Reduction

From	To	Output	Profile
ME1	ME3	50%	U16/U19
ME2	ME4	50%	U16/U19
ME3	ME5	50%	U16/U19
ME4	ME6	40%	U16/U19

S/P = 1.2			
From	To	Output	Profile
P1	P3	47%	U16/U19
P2	P4	47%	U16/U19
P3	P5	35%	U16/U19
P4	P6	35%	U16/U19

RA< 60			
From	To	Output	Profile
S1	S3	50%	U16/U19
S2	S4	50%	U16/U19
S3	S5	40%	U16/U19
S4	S6	40%	U16/U19

S/P = 2			
From	To	Output	Profile
P1	P3	45%	U16/U19
P2	P4	44%	U16/U19
P3	P5	33%	U16/U19
P4	P6	32%	U16/U19

A Three Lighting Class Reduction

From	To	Output	Profile
ME1	ME2	75%	U20
ME1	ME2	67%	U21
ME1	ME2	64%	U22

S/P = 1.2			
From	To	Output	Profile
P1	P2	64%	U22
P2	P3	73%	U20
P3	P4	63%	U23
P4	P5	55%	U23

RA< 60			
From	To	Output	Profile
S1	S3	67%	U21
S2	S4	75%	U20
S3	S5	67%	U21
S4	S6	60%	U22

S/P = 2			
From	To	Output	Profile
P1	P3	63%	U22
P2	P4	71%	U20
P3	P5	62%	U23

C1.8 Central management system

A CMS is the next step in remote dynamic street lighting control, allowing a local authority to choose exactly when to switch each individual street light on or off and/or by how much to reduce the lamp's power. Dimming controls and two-way communication linked to other sensors at the individual luminaire level could play a vital role in intelligent lighting systems. CMSs can be enabled using wireless/ General Packet Radio Services (GPRS) or using wired systems (typically power line communications). Some of the advantages of a CMS include:

- demand response control for future electrical utility load levelling;
- easily adjustable light dimming profiles either by remote operation or automatically based on real-time traffic flows;
- interoperable with motion sensors to create well-lit areas of light;
- remote data assessment via Internet connections, including maintenance tracking and data storage;
- ability to identify individual light unit failures; and
- increase in light units' lifetime.

All new luminaires should have the functionality to be fully compatible with a CMS. Refer to Appendix F for a diagrammatic description of a road lighting CMS.

C1.9 Constant light output

The constant light output (CLO) functionality compensates for light loss over time, ensuring that LEDs will always deliver the necessary light level. A driver can be programmed to start at a dimmed level for a new luminaire and gradually increase power over the lifespan of the light source in order to maintain a constant light output, saving energy and extending the lifetime of the system.

The advantage of CLO is that the installation does not need to be over-installed to compensate for future light depreciation of the diodes. Using CLO, it is possible to get the correct light output from the luminaire for the duration of its service life. CLO also decreases the installation's environmental impact. See Figure 20 and Figure 21 for maintained illuminance lifecycle and energy consumption for LED lanterns with CLO option.

C1.10 Correlated colour temperature

Light sources often emit a large range of different wavelengths while usually being perceived as having a single colour. This apparent colour is referred to as the 'colour temperature' of the light source.

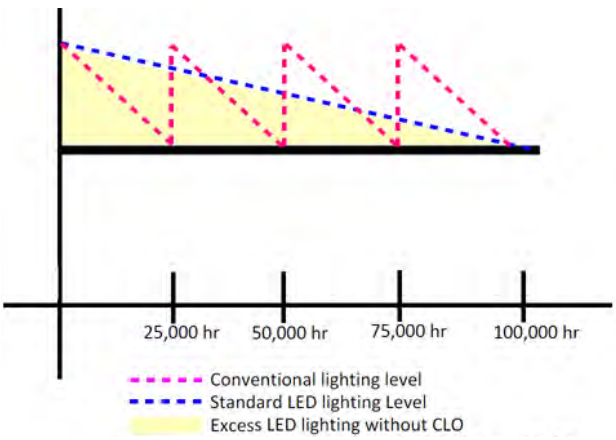


Figure 20: LED lighting-maintained illuminance lifecycle with CLO

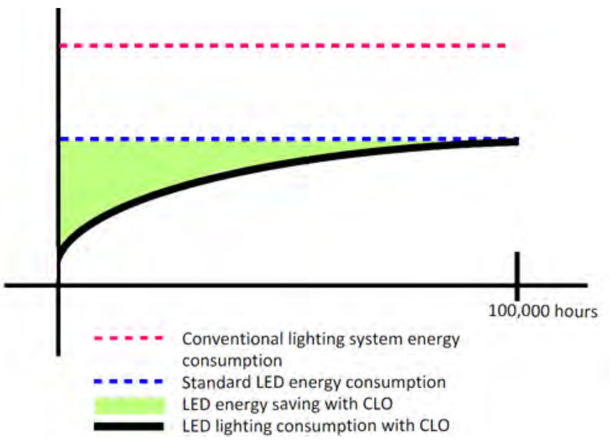


Figure 21: LED lighting energy consumption with CLO

The light colour used for street lighting typically varies between yellowish, neutral and bluish white corresponding to colour temperatures between 2,500 and 5,000 Kelvin (K). Correlated colour temperature of lighting sources are usually categorized into one of three groups (warm, intermediate or cool colour appearance) as shown in Table 18.

Luminaire efficacy varies with the colour temperature of the light source, and LED luminaires with higher colour temperatures provide comparably higher efficacy.

White light supports the perception of the human eye more effectively than yellowish light, and therefore appears brighter. Due to this, white light (e.g. 4,000K) may typically be preferred for com¬plex road situations with different types of road users involved (e.g. cars, cyclists, pedestrians).

Using a white light source allows a reduction of the required lighting level in the selected lighting class, as explained in Appendix B.

The correlated colour temperature (CCT) to be used on the national road network shall be a warm (3,300K) or intermediate colour temperature. The intermediate CCT shall be restricted to a maximum of 4,000K in accordance with DN-LHT-03038 (August 2018) – Design of Road Lighting for the National Road Network.

Colour temperature	Colour appearance
Less than 3,300K	Warm (yellowish) white
3,300K–5,000K	Neutral/intermediate white
More than 5,000K	Cool (bluish) white

Table 18: Light source colour appearance groups

Refer to the section 3.8, regarding the recommended colour temperatures for residential roads, national park areas, city centres and main roads.

C1.11 Mark of conformity

Any product placed in Ireland must comply with all relevant EU directives and shall appear on the SEAI's Triple E Products Register.

All equipment shall bear the CE marking and shall include Declaration of Performance, where required. CE Marking must be awarded by an EU based certifying body only.

The area of products certification will be changed post-Brexit. At the end of the transitional period of the withdrawal of the UK from the European Union, UK Notified Bodies will lose their status as EU Notified Bodies and will no longer have any formal legal status in the EU. Certificates of conformity from UK Notified Bodies will no longer be valid for the purposes of affixing 'CE' marking.

It should be the requirement of the Contractor that any all products when procured, particularly those proposed for certification from a UK based certifying body, will still be supplied with CE certification from an EU-27 notified body regardless of the outcomes of Brexit.

Appendicx D Luminaire selection criteria

Appendix D

Luminaire selection criteria

Appendix D: Luminaire selection criteria

Luminaire selection criteria	Recommendation
Luminaire energy efficacy	Luminaire minimum energy efficacy figure for different colour temperatures in accordance with reputable manufacturer products. Colour temperature: Recommended efficiency ≥4,000K: ≥130lm/W 2,700K–3,300K: ≥110lm/W Due to the rapid technological developments in luminaire efficacy of LED-based lighting, recommended figures above shall be reviewed and updated every year.
Power factor	≥0.9 for full loads and dimmed situations
Lighting control feature	• All luminaires should be capable of communicating with a CMS via wireless or power line technologies. • All luminaires will be individually switched via a 7 pin NEMA socket, with all communication and power connections made at the time of assembly by the manufacturer. • Options for lighting control features should be assessed for every project, and requirements should be specified.
Energy consumption metering	A luminaire built-in energy measuring (per lighting point) option should be considered as part of the CMS.
Colour temperature	• 4,000K CCT is recommended to obtain a better Ra and higher efficacy from public lighting applications, such as complex road situations with different types of road users involved (e.g. cars, cyclists, pedestrians). • In contrast, lower, warmer colour temperatures 3,000K may be preferred for domestic areas. • However, the desirable colour temperature should be specified according to road type, area, building types, and habitat.
Colour rendering	• In areas with high night-time pedestrian use, light sources with ≥60Ra should be used. • Desired colour-rendering level to be specified according to road type.
Colour consistency	Colour temperature tolerances beyond a 5-step Macadam ellipse are not acceptable.

Luminaire selection criteria	Recommendation
Glare protection	• For disability glare, it is recommended to use products with a glare class of a minimum G4 or higher for rural areas, G3 or higher for suburban areas, and G1 or higher for residential roads. • For discomfort glare, it is recommended to use products with a glare class of D5 or higher for local roads and residential areas and pedestrian streets.
Ingress protection (IP) rating	Minimum IP66
Impact protection (IK) rating	Minimum IK07
Mark of conformity for all components	• The luminaires shall bear the CE marking, awarded by an EU based certifying body. • The luminaires shall be a high-efficiency type selected from the SEAI Triple E Products register. • The luminaires shall be tested and approved by an independent 3rd Party ENEC (European Norms Electrical Certification) national Certification Body
Luminaire and LED module lifetime	System lifetime L90B10 for 100,000 hours
Light distribution and reflector	• Luminaires contain optical elements like reflectors, refractors and lenses which create the desired light distribution and ensure glare control and limitation of light pollution.
Luminaire S/P ratio	• Minimum 1.2 for 2,700-3,000K • Minimum 1.5 for 4,000K
Driver efficiency	Minimum operating efficiency should be 90%.
CLO	The drivers shall be of the Constant Light Output type (CLO). The CLO value shall be 90% of the initial lumen output
CMS	The driver shall be DALI registered and capable of communication and interaction with a CMS communication module should it be required in the future.
Dimming	• The driver should be enabled for dimming and communication via the DALI protocol if required by the local authority. • Luminaire dimming regime shall be decided by the local authority. • It is recommended in areas where there is high crime risk that the lighting levels are not reduced at any time of the night.
Photocell	A 35 lux on/18 lux off or a 20 lux on/20 lux off dusk-to-dawn photocell should be specified for the trimming process. Lanterns in the vicinity of pedestrian crossings will be 70/35lux On/Off.
Surge protection	Lanterns in the vicinity of pedestrian crossings will be 70/35lux On/Off.
Warranty	The warranty and/or service agreement should cover a minimum of 10 years, including the LED luminaire and all components, such as driver, LED module, etc.

Appendix E

Standards & Best practice documents

Appendix E: Standards & Best practice documents

The latest edition of the relevant standards, best practice documents, and local, regional and national regulations should be met to provide high-quality LED public lighting system design and installation. These include, but are not restricted to, those outlined in this appendix.

E1.1 IS EN 13201 and BS 5489-1

The lighting designer shall determine the appropriate lighting performance parameters in accordance with IS EN 13201 standards and BS 5489-1:2013 standard, which cover the following topics:

PD CEN/TR 13201-1:2014 – Road lighting. Guidelines on selection of lighting classes

IS EN 13201-2:2015 – Road lighting. Performance requirements

IS EN 13201-3:2015 – Road lighting. Calculation of performance

IS EN 13201-4:2015 – Road lighting. Methods of measuring lighting performance

IS EN 13201-5:2015 – Road lighting. Energy performance indicators

BS 5489-1: 2013 – Code of practice for the design of road lighting. Part 1: Lighting of roads and public amenity areas

E1.2 Institution of Lighting Professionals guidance notes

The lighting designer should be familiar with the following Institution of Lighting Professionals (ILP) guidance documents to get the most benefit from advanced LED lighting technologies while minimising negative impacts:

- Guidance Notes for the Reduction of Obtrusive Light GN01:2011
- GP03: Code Of Practice For Electrical Safety In Highway Electrical Operations
- GP09: Lighting the Environment Lighting the Environment (1995) (joint ILP/CIBSE publication)
- GP10: Safety During the Installation and Removal of Lighting Columns and Similar Street Furniture in Proximity to High Voltage Overhead Lines
- PLG01: Central Management Systems
- PLG02: The Application of Conflict Areas on the Highway
- PLG04: Guidance on Undertaking Environmental Lighting Impact Assessments
- PLG07: High Masts for Lighting and CCTV
- PLG08: Guidance on the Application of Adaptive Lighting within the Public Realm
- ILP Guidance Note 3/16: Measurement of the photometric performance of LED lighting
- ILP Guidance Note 5/17: Using LEDs
- TR12: Lighting of Pedestrian Crossings
- GN22: Asset-Management Toolkit: Minor Structures (ATOMS)
- TR23: Lighting of Cycle Tracks
- TR28: Measurement of Road Lighting Performance on Site
- TR29: White Light
- Lighting against crime: A guide for crime reduction professionals.

E1.3 Transport Infrastructure Ireland standards

- DN-LHT-03038 – Design of Road Lighting for the National Road Network
- AM-LHT-06058 – Standardised Public Lighting Inventory Template User Manual
- CC-SPW-01300 – Specification for Road Works Series 1300 - Road Lighting Columns and CCTV Masts.
- CC-SPW-01400 - Specification for Road Works Series 1400 – Electrical Work for Road Lighting and Traffic Signs

E1.4 ESB Networks standards

- National Code of Practice for Customer Interface, 4th Edition (2008)
- ESB Housing Schemes Electrical Services Standards Guidebook
- ESB Networks Code of Practice for Avoiding Danger from Overhead Electricity Lines
- ESB Requirements for Work on Public Lighting on ESB's Networks.

E1.5 Other documentation

Individual local authority lighting specifications/standards/planning policies include, but are not limited to:

- ET 101:2008: National Rules for Electrical Installations
- EN 50110-1:2013: Operation of electrical installations -- Part 1: General requirements
- BS EN 60529: 1992+A2:2013: Degrees of protection provided by enclosures (IP Code)
- BS EN 60598-2-3:2003+A1:2011– Luminaires - Particular requirements - Luminaires for road and street lighting
- IEC 62722-2-1:2014: Luminaire performance - Part 2-1: Particular requirements for LED luminaires
- Irish Standard I.S. 10101: 2020 - National Rules for Electrical Installations, Edition 5.0
- ET 211 – Code of Practice for Public Lighting Installations in Residential Areas (published by ETCI)
- BS EN ISO 1461: Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
- BS EN 40-1:1992 – Lighting columns. Definitions and terms
- IS EN 40-2:2004 – Lighting columns. General requirements and dimensions
- IS EN 40-3-2:2013 – Lighting columns. Design and verification. Verification by testing
- IS EN 40-5:2002 – Lighting columns. Requirements for steel lighting columns
- CIE 115:2010: Lighting of Roads for Motor and Pedestrian Traffic
- PD CEN/TS 17165:2018 – Light and lighting. Lighting system design process.

E1.6 Case studies

- Case studies on mass LED retrofit schemes completed in other countries.
- Case studies of pilot schemes completed by Irish local authorities.

Appendicx F Road lighting central management system

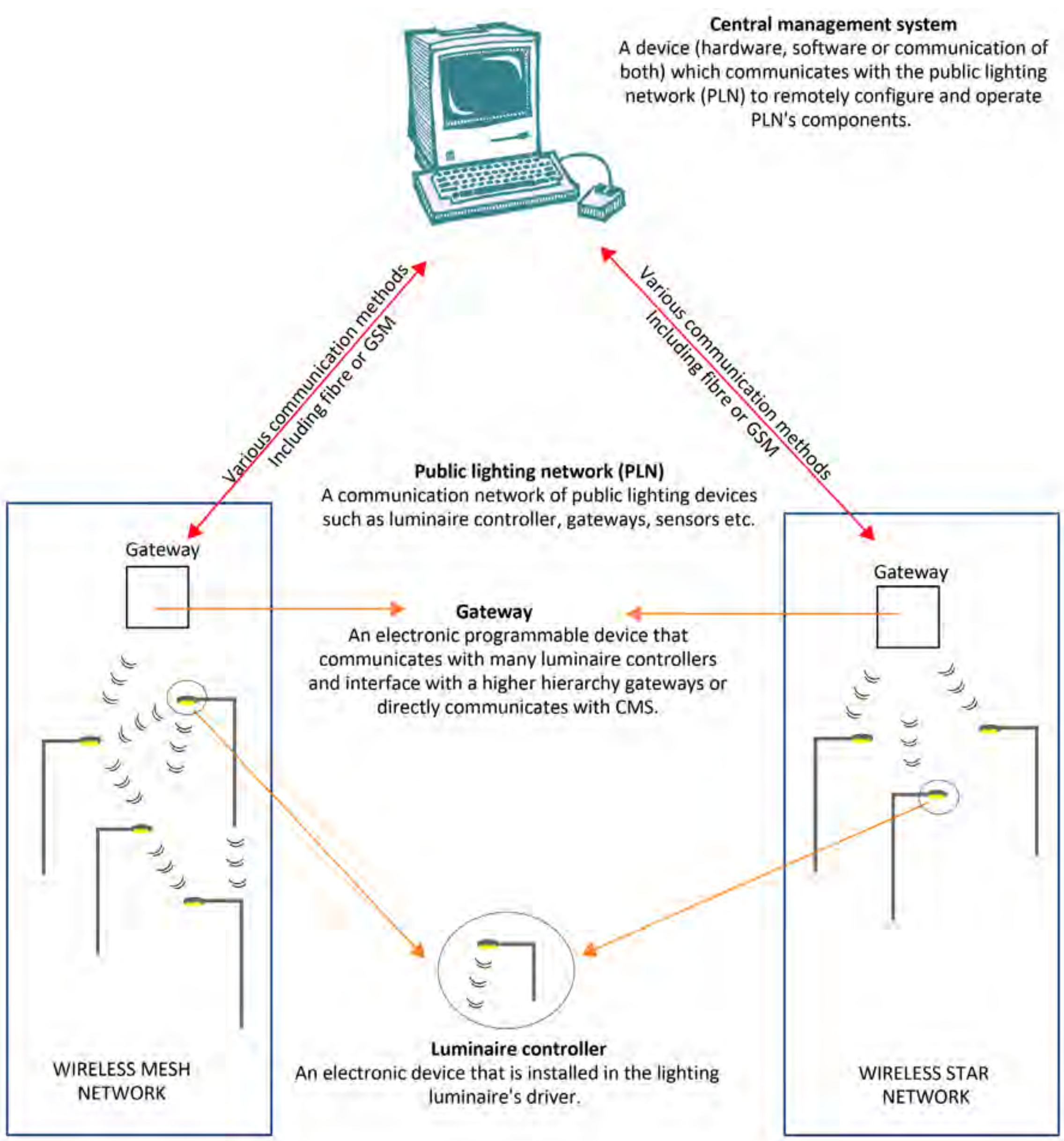
Appendix F

Road lighting central management system

Appendix F: Road lighting central management system

This appendix provides a diagrammatic description of a road lighting central management system (CMS).

Use of a CMS should be considered where there is electricity metering, or the system includes energy metering, as the energy usage can easily be confirmed.



Appendicx G How is a road lighting classification selected?

Appendix G

How is a road lighting classification selected?

Appendix G: How is a road lighting classification selected?

This appendix is a guide for determining typical road lighting classifications.

The lighting designer shall determine the appropriate lighting performance parameters in accordance with PD CEN/TR 13201-1:2014 and BS 5489-1:2013. Guidance on the selection of lighting classes is given in Annex A of BS 5489-1:2013 to provide an initial determination of the lighting class.

PD CEN/TR 13201-1:2014 standard gives further guidance for the selection of the appropriate lighting classes (M, C or P) considering the different parameters relevant for the given visual tasks.

A point-based system is used for the selection of road lighting classes in accordance with PD CEN/TR 13201-1:2014, including city centre, urban and rural environment case studies, using the steps outlined in Figure 22.

Figure 22: The steps of lighting class selection

Step 1	Examine the relevant area and collect the relevant data in order to determine the lighting classification. Relevant data include speed limit, traffic volume, traffic composition, seperation of carriageway, parked vehicles, ambient luminance, and traffic control.	Step 1
Step 2	• Define the traffic category (M, C or P) of the relevant area using BS 5489-1:2013. • M: Motorised vehicles on traffic routes (moderate or fast). • C: Conflict areas such as junctions, roundabouts, interchanges, pedestrian crossings, etc. • P: Mostly pedestrian areas with low-speed traffic.	Step 2
Step 3	• Assign the appropriate weighting values to each parameter, using: • Table 17: Parameters for the selection of lighting class M • Table 18: Parameters for the selection of lighting class C • Table 19: Parameters for the selection of lighting class P	Step 3
Step 4	• Calculate the sum of the weighted values (Vws). This is done by adding up all the selected weighting values. • Calculate the final lighting classification by applying the following formula: Number of lighting class = 6 – Vws	Step 4

Table 19: Parameters for the selection of lighting class M

Parameter	Options	Weighting value (Vw)
Speed limit	Very high (v ≥100km/h)	2
	High (70 < v <100km /h)	1
	Moderate (40 < v ≤70km/h)	–1
	Low (v ≤40km/h)	–2
Traffic volume	Very high to high (AADT >40,000)	1
	Low to moderate (AADT between 7,000 and 40,000)	0
	Very low (AADT <7000)	–1
Traffic composition	Mixed with high percentage of non-motorised	2
	Mixed	1
	Motorised only	0
Separation of carriageway	No	1
	Yes	0
Junction spacing	High (junction centres spaced <3km apart)	1
	Moderate (junction centres spaced >3km apart)	0
Parked vehicles	Present	1
	Not present	0
Ambient luminosity	High	1
	Moderate	0
	Low	–1
Visual guidance/traffic control	Poor	1
	Moderate or good	0

AADT: Annual average daily traffic (total number of vehicles in traffic per day)

Table 20: Parameters for selection of lighting class C

Parameter	Options	Weighting value (Vw)
Speed limit	Very high (v ≥100km/h)	3
	High (70 < v <100km /h)	2
	Moderate (40 < v ≤70km/h)	0
	Low (v ≤40km/h)	–1
Traffic volume	Very high to high (AADT >40,000)	1
	Low to moderate (AADT between 7,000 and 40,000)	0
	Very low (AADT <7000)	–1
Traffic composition	Mixed with high percentage of non-motorised	2
	Mixed	1
	Motorised only	0
Separation of carriageway	No	1
	Yes	0
Parked vehicles	Present	1
	Not present	0
Ambient luminosity	High	1
	Moderate	0
	Low	–1
Visual guidance/traffic control	Poor	1
	Moderate or good	0

AADT: Annual average daily traffic (total number of vehicles in traffic per day)

Notes:

1. The conflict area should, as a minimum, have a lighting level no lower than that of the highest lighting class used for the connecting road or roads. However, it is recommended that the lighting class used for the conflict area should normally be one step higher than the highest lighting class used for the road or roads leading to the conflict area (e.g. M2 instead of M3).

Table 21: Parameters for selection of lighting class P

Parameter	Options	Weighting value (Vw)
Speed limit	Low (v ≤40km/h)	1
	Very low (walking speed)	0
Use intensity	Busy	1
	Normal	0
	Quiet	–1
Traffic composition	Pedestrians, cyclists and motorised traffic	2
	Pedestrians and motorised traffic	1
	Pedestrians and cyclists only	1
	Pedestrians only	0
	Cyclists only	0
Parked vehicles	Present	1
	Not present	0
Ambient luminosity	High	1
	Moderate	0
	Low	–1
Facial recognition	Necessary	Additional requirements
	Not necessary	No additional requirements

AADT: Annual average daily traffic (total number of vehicles in traffic per day)

Notes:
1. If facial recognition is necessary, an additional minimum vertical illuminance and a minimum semi-cylindrical illuminance is necessary to achieve this, as detailed in IS EN 13201-2:2015, Table 3: P lighting class.
2. A high colour rendering contributes to better facial recognition.

Case study 1: Limerick City

In this case study, Limerick City was used for the selection of the lighting class for roads in an urban area.

It is a high-district-brightness lighting environment, as the area is a city centre with a high level of night activity.

The area studied is in environmental zone E4 (refer to ILP Guidance Notes for the Reduction of Obtrusive Light GN01:2011)

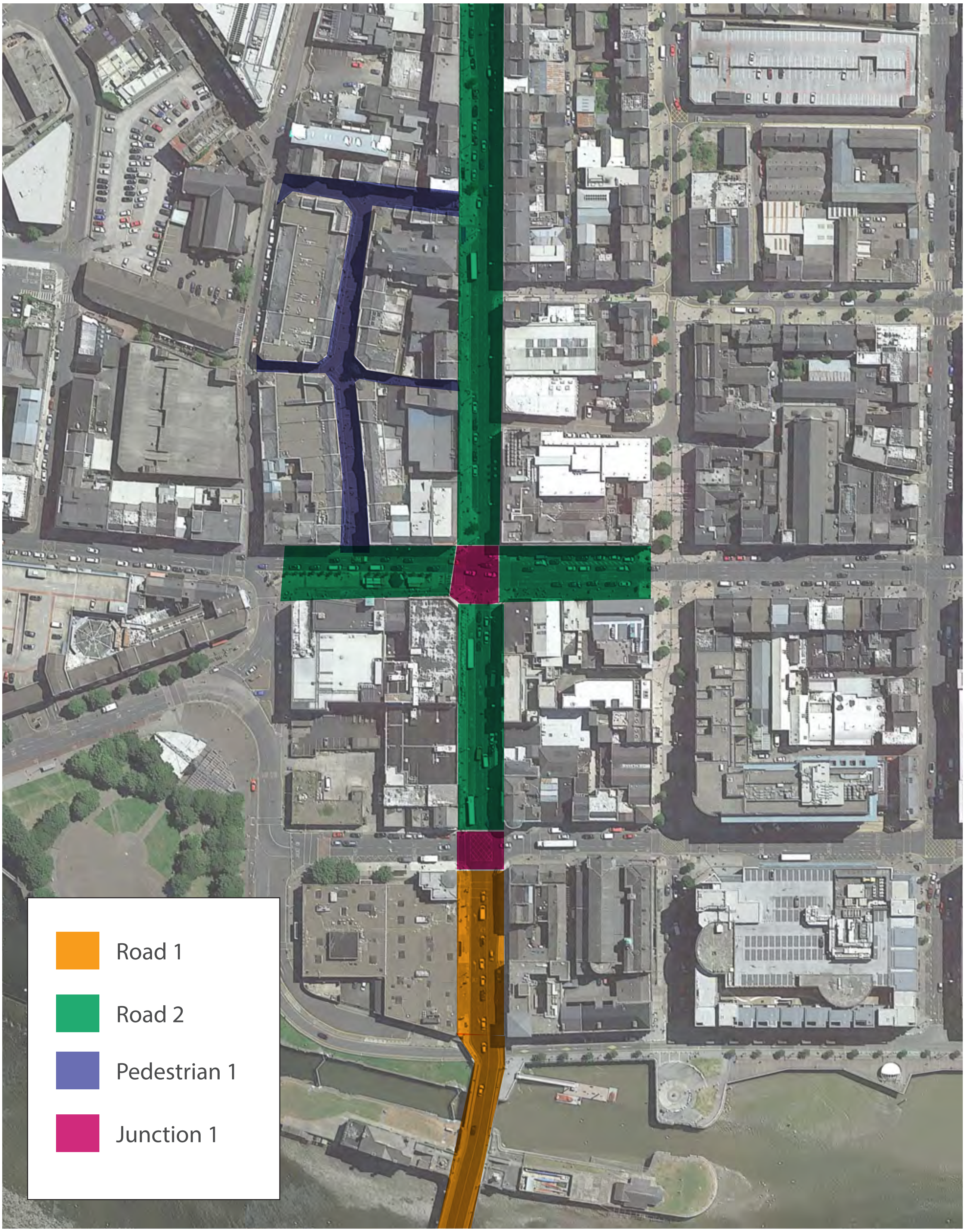
There is no separation of carriageway available for the roads examined.

The legal road speed limit is 50km/h for vehicles on Road 1, Road 2 and Junction.

The lighting classes will be examined for the following highlighted areas in Figure 23 using the steps outlined at the start of Appendix G:

- motorised traffic areas: Road 1;
- pedestrianised areas with low-speed traffic: Pedestrian 1; and
- conflict areas: Road 2, Junction 1.

Figure 23: Case study 1: Limerick City



Road 1

Step 1
Traffic composition is mixed, as the road carries motorised vehicles and cyclists. There are separate footpaths for pedestrians and ambient luminosity is high. The speed limit is 50km/h. The annual average daily traffic (AADT) is between 8,000 and 11,000. There are no parked vehicles, and separation of the carriageway is not present.

Step 2
Since it is an approach road to the city centre with a moderate speed limit, this road belongs to lighting class M.

Step 3
The weighting factors for each parameter are identified in Table 22.

Step 4
The sum of weighting values (Vws) is calculated as 3.

To calculate the number of the lighting class, apply the formula: **M = 6 – Vws**

The number of the lighting class is calculated using the formula: **M = 6 – 3 = 3**

As a result, Road 1's lighting class is calculated as **M3.**

Table 22: Weighting Factors for Case Study 1, Road 1

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	–1
Traffic volume	Low to moderate (AADT between 7,000 and 40,000)	0
Traffic composition	Mixed	1
Separation of carriageway	No	1
Junction spacing	High (junction centres spaced <3km apart)	1
Parked vehicles	Not present	0
Ambient luminosity	High	1
Visual guidance/traffic control	Moderate or good	0
Sum of weighting values (Vws)		**3**

Road 2

Step 1
This road is situated in the city centre. The speed limit is low (30km/h). There is mixed vehicular and cyclist traffic on the road. Pedestrian light-controlled crossing is provided along this road. In general, parked vehicles are present. For security and visual guidance purposes, the full street width will be illuminated from building facade to building facade.

Step 2
The traffic category of the relevant area is classified as a conflict area (C), since this road is in the city centre with a combination of pedestrians, cyclists and motorised traffic.

Step 3
The weighting factors for each parameter are identified in Table 23.

Step 4
The sum of weighting values (Vws) is 4.

To calculate the number of the lighting class, apply the formula: **C = 6 – Vws**

The number of the lighting class is calculated using the formula: **C = 6 – 4 = 2**

As a result, Road 2's lighting class is **C2.**

Table 23: Weighting Factors for Case Study 1, Road 2

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	0
Traffic volume	Low to moderate (AADT between 7,000 and 40,000)	0
Traffic composition	Mixed	1
Separation of carriageway	No	1
Parked vehicles	Present	1
Ambient luminosity	High	1
Visual guidance/traffic control	Moderate or good	0
Sum of weighting values (Vws)		**4**

Pedestrian Area 1

Step 1
The traffic on this shopping street is mainly pedestrians and cyclists in the city centre. No parked cars are present, and the area has a high ambient luminance. For security and for visual guidance purposes the full street width will be illuminated from building facade to building facade. Motorised traffic is allowed only from 6am to 11am.

Step 2
The lighting class is to be designed for a conflict area (C), since this road is in the city centre with a combination of mainly pedestrians and cyclists.

Step 3
The weighting factors for each parameter are identified in Table 24.

Step 4
The sum of weighting values (Vws) is **3**.

To calculate the number of the lighting class, apply the formula: **C = 6 – Vws**

The number of the lighting class is calculated using the formula: **C = 6 – 3 = 3**

As a result, Pedestrian 1's lighting class is **C3**.

Table 24: Weighting Factors for Case Study 1, Pedestrian Area 1

Parameter	Options	Weighting value (Vw)
Speed limit	Low (v ≤40km/h)	–1
Traffic volume	Very low (AADT <7,000)	–1
Traffic composition	Mixed with high percentage of non-motorised	2
Separation of carriageway	No	1
Parked vehicles	Not present	0
Ambient luminosity	High	1
Visual guidance/traffic control	Poor	1
Sum of weighting values (Vws)		**3**

Junction 1

Step 1
The relevant area highlighted is a junction located in the city centre. There are traffic lights in place for pedestrian crossing and motorised vehicle traffic control. No parked cars are present. The area has a high ambient luminance.

Step 2
As the area highlighted is a junction, its lighting class is C (conflict area).

Step 3
The weighting factors for each parameter are identified in Table 25.

Step 4
The sum of weighting values (Vws) is **4.**

To calculate the number of the lighting class, apply the formula: **C = 6 – Vws**

The number of the lighting class is calculated using the formula: **C = 6 – 4 = 2**

However, the junction area should require a lighting class one step higher than the highest lighting class used for the connecting road or roads (e.g. C1 instead of C2).

As a result, since the highest lighting class of either of the connecting roads is C2, Junction 1's lighting class is defined as C1.

Table 25: Weighting Factors for Case Study 1, Junction 1

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	0
Traffic volume	Low to moderate (AADT between 7,000 and 40,000)	0
Traffic composition	Mixed with high percentage of non-motorised	2
Separation of carriageway	No	1
Parked vehicles	Not present	0
Ambient luminosity	High	1
Visual guidance/traffic control	Moderate or good	0
Sum of weighting values (Vws)		**4**

Case study 2: Tramore, Co. Waterford

This case study analyses an urban area in Tramore.

The area studied is in environmental zone E3 (refer to ILP Guidance Notes for the Reduction of Obtrusive Light GN01:2011).

There is no separation of carriageway available for the roads examined.

Using the steps outlined at the start of Appendix G, the following highlighted areas in Figure 24 are to be examined:

- regional road: Road 1;
- residential road: Road 2; and
- a roundabout.

Figure 24: Case study 2: Tramore, Co. Waterford

Road 1

Step 1
The road highlighted is a regional road. The speed limit on the road is 50km/h with a low traffic volume. Both cyclists and motorists use this road. There are no vehicles parked on the road. Walkways are present for pedestrians and they are separated from the road by green areas. Junction intensity is high and there is no traffic control present.

Step 2
Since it is an approach road to the city centre with a moderate speed limit, this road belongs to lighting class M.

Step 3
The weighting factors for each parameter are highlighted in Table 26.

Step 4
The sum of weighting values (Vws) is calculated as **2.**

To calculate the number of the lighting class, apply the formula: **M = 6 – Vws**

The number of the lighting class is calculated using the formula: **M = 6 – 2 = 4**

As the result, Road 1's lighting class is **M4.**

Table 26: Weighting Factors for Case Study 2, Road 1

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	–1
Traffic volume	Low to moderate (AADT between 7,000 and 40,000)	0
Traffic composition	Mixed	1
Separation of carriageway	No	1
Junction spacing	Moderate (junction centres spaced >3km apart)	0
Parked vehicles	Not present	0
Ambient luminosity	Moderate	0
Visual guidance/traffic control	Poor	1
Sum of weighting values (Vws)		**2**

Road 2

Step 1
Road 2 is a residential road in a housing estate. The flow is low speed. There are parked vehicles present on the road. Separate footpaths are available for pedestrians. Ambient luminosity is low.

Step 2
The traffic category of the area highlighted is P (drivers of motorised vehicles at low speed on residential roads).

Step 3
The weighting factors for each parameter are highlighted in Table 27.

Step 4
The sum of weighting values (Vws) is calculated as **2.**

To calculate the number of the lighting class, apply the formula: **P = 6 – Vws**

The number of the lighting class is calculated using the formula: **P = 6 – 2 = 4**

As a result, Road 2's lighting class is **P4.**

Table 27: Weighting Factors for Case Study 2, Road 2

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	–1
Traffic volume	Low to moderate (AADT between 7,000 and 40,000)	0
Traffic composition	Mixed	1
Separation of carriageway	No	1
Junction spacing	Moderate (junction centres spaced >3km apart)	0
Parked vehicles	Not present	0
Ambient luminosity	Moderate	0
Visual guidance/traffic control	Poor	1
Sum of weighting values (Vws)		**2**

Roundabout

Step 1
The area highlighted is a roundabout. No parked cars are present. There is a moderate speed limit of 50km/h with no traffic lights. There is no traffic control at the roundabout.

Step 2
The traffic category of the highlighted area is conflict area (C), since the motorised traffic intersects with itself and with cyclists.

Step 3
The weighting factors for each parameter are highlighted in Table 28.

Step 4
The sum of weighting values (Vws) is calculated as **3.**

To calculate the number of the lighting class, apply the formula: **C = 6 – Vws**

The number of the lighting class is calculated using the formula: **C = 6 – 3 = 3**

As a result, the roundabout's lighting class is **C3.**

Table 28: Weighting Factors for Case Study 2, Roundabout

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	0
Traffic volume	Low to moderate (AADT between 7,000 and 40,000)	0
Traffic composition	Mixed	1
Separation of carriageway	No	1
Parked vehicles	Not present	0
Ambient luminosity	Moderate	0
Visual guidance/traffic control	Poor	1
Sum of weighting values (Vws)		**3**

Case study 3: Riverstick, Co. Cork

This case study analyses a rural village in County Cork.

It is a low-district-brightness lighting environment, as the area is a residential rural area. Therefore, the environmental zone is identified as E3 (refer to ILP Guidance Notes for the Reduction of Obtrusive Light GN01:2011).

Using the steps outlined at the start of Appendix G, the highlighted areas in Figure 25 for Road 1, Road 2 and Road 3 are to be examined.

Figure 25: Case study 3: Riverstick, Co. Cork

Road 1

Step 1
The highlighted road is used by cyclists and motorised vehicles in the village area. There is a low traffic volume in this rural area, and the speed limit is 50km/h. The road has intermediate areas with roadway lighting and the density of junctions is high on this road.

Step 2
The traffic category of the highlighted area is M (motorised vehicles on traffic routes).

Step 3
The weighting factors for each parameter are highlighted in Table 29.

Step 4
The sum of weighting values (Vws) is calculated as **3**.

To calculate the number of the lighting class, apply the formula: **M = 6 – Vws**

The number of the lighting class is calculated using the formula: **M = 6 – 3 = 3**

As a result, subtotal Road 1's lighting class is calculated as **M3.**

Table 29: Weighting Factors for Case Study 3, Road 1

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	–1
Traffic volume	Low to moderate (AADT between 7,000 and 40,000)	0
Traffic composition	Mixed	1
Separation of carriageway	No	1
Junction spacing	High (junction centres spaced <3km apart)	1
Parked vehicles	Not present	0
Ambient luminosity	Moderate	0
Visual guidance/traffic control	Poor	1
Sum of weighting values (Vws)		**3**

Road 2

Step 1
The highlighted area is a residential road in a housing estate. The speed limit is 20km/h. There are parked vehicles present on the road. Both motorised vehicles and cyclists use the road. Many roads intersect in the highlighted area.

Step 2
The traffic category of the area highlighted is P (drivers of motorised vehicles at low speed on residential roads).

Step 3
The weighting factors for each parameter are highlighted in Table 30.

Step 4
The sum of weighting values (Vws) is calculated as **2.**

To calculate the number of the lighting class, apply the formula: **P = 6 – Vws**

The number of the lighting class is calculated using the formula: **P = 6 – 2 = 4**

Road 2's lighting class is calculated as **P4.**

Table 30: Weighting Factors for Case Study 3, Road 2

Parameter	Options	Weighting value (Vw)
Speed limit	Low (v ≤40km/h)	1
Traffic volume	Quiet	-1
Traffic composition	Pedestrians, cyclists and motorised traffic	2
Parked vehicles	Present	1
Ambient luminosity	Low	-1
Facial recognition	Not necessary	No additional requirements
Sum of weighting values (Vws)		**2**

Road 3

Step 1
The highlighted area is a rural road with a high density of junctions. The speed limit is 50km/h with a low traffic volume. The ambient luminance in the area is low due to the rural location. There are no parked vehicles or traffic controls present.

Step 2
The traffic category of this road is identified as M (motorised vehicles on traffic routes), since the average speed of this road is moderate.

Step 3
The weighting factors for each parameter are highlighted in Table 31.

Step 4
The sum of weighting values (Vws) is calculated as **1**.

To calculate the number of the lighting class, apply the formula: **M = 6 – Vws**

The number of the lighting class is calculated using the formula: **M = 6 – 1 = 5**

As a result, subtotal Road 1's lighting class is calculated as **M5.**

Table 31: Weighting Factors for Case Study 3, Road 3

Parameter	Options	Weighting value (Vw)
Speed limit	Moderate (40< v ≤70km/h)	–1
Traffic volume	Very low (AADT <7,000)	–1
Traffic composition	Mixed	1
Separation of carriageway	No	1
Junction spacing	High (junction centres spaced <3km apart)	1
Parked vehicles	Not present	0
Ambient luminosity	Low	–1
Visual guidance/traffic control	Poor	1
Sum of weighting values (Vws)		**1**

Appendicx H **Glossary**

Appendix H

Glossary

Appendix H: Glossary

Ambient luminosity: assessed luminance levels of the surroundings.

Black-body radiator: a perfect light absorber that absorbs all the electromagnetic radiation (light) that strikes it and does not reflect any. To stay in equilibrium, it must emit radiation at the same rate as it absorbs it.

Blue light: light of wavelengths between 400nm and 500nm in the visible light spectrum which can cause retinal damage due to high-intensity exposure.

Circuit-wattage: the power consumed in lighting circuits by lamps and, where applicable, their associated control gear (including transformers and drivers) and power factor correction equipment.

Conflict area: junctions, interchanges, roundabouts and pedestrian crossings where streams of motorised traffic intersect with each other or with other road users such as pedestrians and cyclists from different approaches. The extent of a conflict area will be determined on a project-specific basis.

Dali: Digital Addressable Lighting Interface (DALI) is a trademark for network-based systems. The digital nature of DALI allows two-way communication between devices, so that a device can report a failure, or answer a query about its status or other information.

Disability Glare: is caused by the scattering of light in the eye which reduces contrast sensitivity.

Discomfort Glare: is an immediate occurrence and arises from light sources or luminaires whose luminance is greater than the eye can adapt to.

Efficacy (lm/watt): a measure of the efficiency of the light in terms of output per unit of energy consumption.

Facial recognition: visual task of pedestrians consisting of the recognition of a face at certain distances that allows authorities to take evasive or defensive action if thought necessary.

Fixation: the maintaining of the visual gaze on a single location.

Illuminance (lux, (lx): The amount of light failing on a surface of unit area. The unit of illuminance is the lux equal to one lumen per square metre.

Institution of Lighting Professionals (ILP): the UK and Ireland's professional lighting association, dedicated solely to excellence in lighting.

Junction: location where a number of traffic routes meet, join, or cross each other, and a location where traffic can change between different routes.

LED: light-emitting diode.

Light source: any device serving as a source of illumination.

Lumen: a unit of measurement that expresses the total quantity of light given off by a source, regardless of direction.

Luminaire: a complete lighting fixture consisting of one or more lamps or light sources, along with the socket connections and other parts that hold the lamps in place and protect them, the wiring that connects the light source to a power source, and a reflector/lens or other optical system that helps direct and distribute the light.

Maintenance Factor: The maintenance factor is a number (positive and less than 1) used in calculations to account for the depreciation in light output over time.

National road: a public road or a proposed public road which is classified or is intended to be classified as a national road under Section 10 of the Roads Act, 1993.

Professional Lighting Guide (PLG): guidance notes developed by the ILP in relation to lighting best practice.

Photocell: A daylight activated switching device for controlling the switching on and off of a single luminaire, a lighting circuit or a number of lighting circuits.

Retrofit: replacing the entire old luminaire with a new energy-efficient LED luminaire on the existing column(s) or bracket(s). Semi-cylindrical illuminance (at a point): total luminous flux falling on the curved surface of a very small semi-cylinder divided by the curved surface area of the semi-cylinder.

S/P Ratio: This is obtained from the type of light source proposed and is used to convert traditional lumens into the actual lumens perceived by the eye to give a more accurate representation of light levels required.

Traffic composition: distribution of vehicle types in the traffic stream, directional distribution of traffic, lane use distribution of traffic, and type of driver population on a given facility.

Traffic volume: the number of vehicles passing a given point in a stated period of time in both directions.

Vertical illuminance (at a point): illuminance at a point on a vertical plane.

Visual guidance/traffic control: means of ensuring that motorists are given adequate information about the course of the road.

Visual task: the term given to an activity requiring visual perception and located in a certain place (driving, walking, cycling, etc.). The activity involved can change during the course of the day or from day to day. For that reason, a variety of visual tasks should be considered when planning a lighting system.