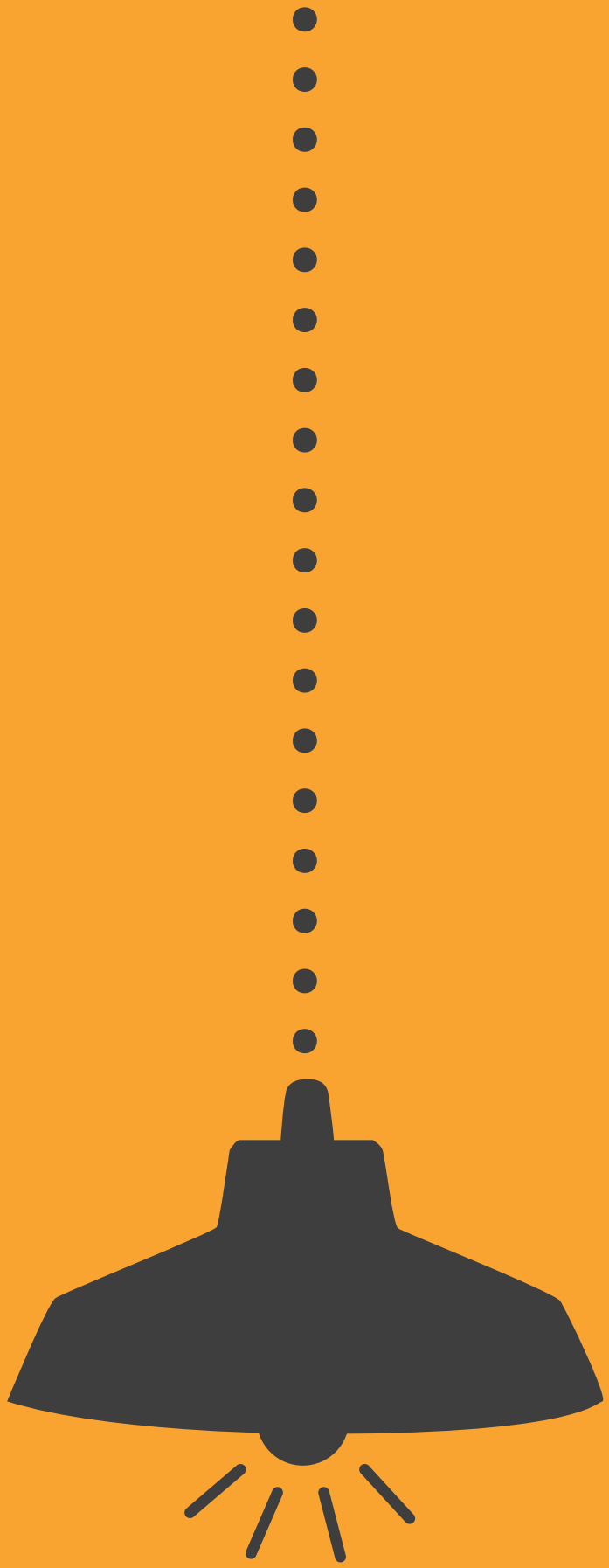
Invest Northern Ireland

Lighting

A Practical Lighting Efficiency Guide for Businesses in Northern Ireland



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Executive Summary

Energy saving is at the forefront of any business in today's economic climate. The goal is to reduce fuel consumption as much as possible without compromising the functionality of your business. Reviewing your lighting system and finding the optimum solution for your business can be a formidable experience when you consider the vast amount of lighting technology available on the market today. This guide serves as a simple tool for providing advice and practical guidance of what you need to consider when reviewing your lighting system.

In the medium to long term the pressures on utility price all appear to be upwards and the only way for most consumers to reduce the impact of increased unit costs, and to reduce their bills, is through energy efficiency improvements. Through the implementation of lighting best practice measures for your business you will be reducing electricity consumption and costs. Electricity today is the most expensive energy utility for an average business so even small improvements in electrical efficiency can represent significant financial savings.

With the right solution very often new lighting technologies and controls can deliver savings of at least 40% on the running costs associated with your current lighting. If you have been provided with a proposal by a lighting supplier always ask for lighting level calculations especially for those areas which require higher levels of lighting. You can use the advice within this guide and supplementary sector guides to obtain guidance on what is suitable for your business.

Invest Northern Ireland (Invest NI) is committed to supporting your business to become more energy efficient through the use of energy efficient technologies and management practices. Invest NI offer free support to eligible companies to help them identify and implement energy saving measures. Please do not hesitate to contact us if we can be of further assistance to support your business on the journey to become more energy efficient.

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1 Introduction to Lighting Efficiency

1.1
Background

Reducing energy use makes perfect business sense; it saves money, enhances corporate reputation and increases profit margins enabling companies to future-proof their business against long-term energy price rises and volatility. However, despite the clear benefits of becoming energy efficient, and the increasing awareness that businesses have of the need to save energy there are still areas with plenty of scope for improvement – lighting has been identified as one of these areas.

Lighting technology itself has evolved rapidly in recent years and there are a wide range of products available on the market today, so much so that for an average business identifying the optimum solution can be a complex and time consuming process. In broad terms an energy effective lighting installation is energy efficient while at the same time delivering the necessary lighting requirements for a particular application. This guide will serve as a tool for Northern Ireland businesses to aid with the identification of the main energy saving opportunities for lighting and to demonstrate how simple actions can save energy and cut costs.

Two sector specific guide supplements accompany this guide;

- Hospitality Sector Supplement
- Industrial Sector Supplement

A glossary of lighting terms has been included within Appendix A.

1.2
Statutory & Regulatory

Design Guides

For designers there are many lighting guides available which cover the varying range of considerations for different sectors. Perhaps the most significant of these are **The Society of Light and Lighting (SLL) Guides** which provide sector specific advice covering all lighting design criteria for particular applications such as offices, educational, industrial, healthcare and retail buildings.

In addition to the above the 2012 SLL Code for Lighting publication provides information on three areas of lighting practice; a summary of the effects of lighting on task performance, behaviour, safety, perception, health, and its financial and environmental costs; a compendium of lighting recommendations (both interior and exterior) relevant to the UK; and detailed descriptions of the calculations required for quantitative lighting design.

Lux levels are a very precise measure of illumination and are used to quantify the minimum recommended amount of illumination for a given application. Below is a preview of some recommended lux levels for various applications, the diversity of environments being a demonstration to how specific these guidelines are.

CIRCULATION AREAS	LUX LEVELS
Entrance Halls, lobbies etc	200
Corridors, Stairs	100
Lifts	100

GENERAL AREAS	LUX LEVELS
Canteens	200
Lounges / Waiting Rooms	200
Cloaks, bathroom & WC	200
Stores	100
Plantrooms / Switchgear	200
Switchboard, Post Room	500

OFFICES	LUX LEVELS
Filing, Copying etc	300
Writing, typing, reading	500
Technical drawing	750
CAD Workstation	500
Conference & Meetings	500
Reception Desk	300

GENERAL AREAS	LUX LEVELS
Entrance Halls, lobbies etc	200
Enquiry Desks	500
Gatehouses	200

COMMERCIAL	LUX LEVELS
Hairdresser	300
Laundry / Dry-cleaning	300
Rooms for physical exercise	300

RETAIL	LUX LEVELS
Sales Area	300
Till Area	500

RESTAURANTS & HOTELS	LUX LEVELS
Reception/cashier desk	300
Kitchen	500
Buffet	300
Conference rooms	500
Corridors	100

DISTRIBUTION & STORAGE	LUX LEVELS
Loading Bay	150
Packing and Dispatch	300
Stores - Occupied	200
Storage Rack Face	200
Gangways - manned	150
Gangways - unmanned	200

INDUSTRIAL	LUX LEVELS
Cutting, Inspection	750
Colour Inspection	1000
Laboratories	500
Assembly;	
Rough (large transformers)	200 - 300
Medium (switchboards)	300 - 500
Fine (telephones, IT)	500 - 750
Precision (circuit boards)	750 - 1000
Welding	300
Painting	750

Control Systems for Lighting
Specific guidance related to control systems for lighting is provided in the **Lighting Control Guide (LIA, 2012)** published by the **Lighting Industry Association (LIA)**. The LIA also provide guidance on the different lamp types available and defining characteristics of each.

This information can be accessed from the LIA website at; **http://www.thelia.org.uk/**

These guidelines are not however mandatory as any lighting system must be designed appropriately for the individual space and is not covered by any regulations other than those stated below.

Building Regulations
For new construction and significant refurbishment projects, your lighting design must comply with the Northern Ireland Building Regulations. **Northern Ireland Building Regulations Part F - Conservation of Fuel and Power (buildings other than dwellings) October 2012.** You can download this document from the Department of Finance and Personnel website, at **http://www.dfpni.gov.uk/tb_f2_online_version-2.pdf**

Guidance on how to comply with the requirements of the Building Regulations for lighting systems in new and existing buildings is given in the Non-Domestic Building Services Compliance Guide (DCLG, 2011) which can be downloaded from; **http://www.planningportal.gov.uk/uploads/br/non-domestic_building_compliance_guide_2010.pdf**

Specific building control requirements will be referred to in this document where applicable.

Health & Safety Executive
HSG 38 Lighting At Work - This guidance explains how lighting contributes to the health and safety of people at work. It deals with assessing and managing the health and safety risks attributable to lighting in the workplace, good practice and the minimum recommended illumination levels that meet health and safety requirements. Although aimed primarily at those who are responsible for health and safety at work, all employees may also find it useful.

You can download a free, web-friendly version of HSG38 (Second edition, published 1997) at **http://www.hse.gov.uk/pubns/priced/hsg38.pdf**

Emergency Lighting
BS 5266-1:2011 Emergency lighting – Part 1: Code of practice for the emergency escape lighting of premises gives recommendations and guidance on the factors that need to be considered in the design of, and the installation and wiring of, electrical emergency escape lighting systems, in order to provide the lighting performance needed for safe movement of people in the event of the supply to normal lighting failing.

Emergency lighting is either termed maintained or non-maintained – maintained means they are integrated emergency light fittings which are maintained and designed to be lit continuously and will continue to work in the event of a power failure and non-maintained refers to separate emergency light fittings (e.g. twin spot floodlights for production areas) which are non-maintained and are designed to turn on in the event of a power failure.

This is especially important to remember if you are retrofitting an existing lighting system – if your current lighting system has integrated emergency lighting then any replacements will have to provide the same function. Otherwise you may need to provide a separate emergency lighting system to comply with regulations. If your lighting project is going to affect your emergency lighting system we would recommend that you get advice from a specialist to ensure you are in compliance with **regulations.**

End of Life Disposal
Finally, there are disposal regulations to be considered. It is no longer possible to simply dispose of electrical equipment by throwing it into a landfill. Under the **Waste Electrical and Electronic Equipment (WEEE) Regulations**, all lighting equipment, other than filament lamps in domestic premises, is considered to be hazardous waste and has to be disposed of appropriately.

If you are responsible for disposing of WEEE and it contains hazardous substances you must make sure it is treated at an approved treatment facility that is authorised to accept hazardous waste. Find licensed waste sites on the Northern Ireland Environment Agency (NIEA) website.

The **nibusinessinfo** website provides practical advice for Northern Ireland Businesses on a wide range of subjects – one of these is the WEEE Regulations. You can get advice on who is affected by the WEEE Regulations and which types of equipment are covered. It also outlines the key responsibilities for each type of affected business.

https://www.nibusinessinfo.co.uk/content/waste-electrical-and-electronic-equipment-weee

Energy Savings Opportunity Scheme (ESOS)
The ESOS is the UK government's latest attempt to encourage energy efficiency among big organisations. It requires them to assess their energy consumption on a regular basis and consider measures to reduce consumption. It does not actually force companies to act on the proposed measures – that is up to them. Below is a brief synopsis of the scheme – full details can be found on the website: **https://www.gov.uk/government/publications/comply-with-the-energy-savings-opportunity-scheme-esos**

The ESOS Regulations 2014 bring into force Article 8 of the EU Energy Efficiency Directive and mandate that all large businesses in the UK undertake comprehensive assessments of energy use and energy efficiency opportunities at least once every four years.

The deadline for the first compliance period is **5 December 2015**, by which time qualifying businesses will have to achieve compliance with the regulations and notify the Environment Agency.

The criteria for inclusion to ESOS is not entirely straightforward, but essentially it applies to any large undertaking that carries out a trade or a business (typically a Company), and any corporate group where at least one member of the UK group meets the ESOS criteria.

- A large undertaking is one that employs at least 250 people or has an annual turnover in excess of €50 million and a balance sheet in excess of €43 million. Most public sector bodies are excluded, but some, such as many Universities may qualify.

To comply with the regulations, a '**Lead Energy Assessor**' will need to conduct an ESOS Assessment to:

1. Measure your total energy consumption for buildings, industrial processes and transport.
2. Identify areas of significant energy consumption, accounting for at least 90% of your total energy consumption.
3. Identify cost-effective energy efficiency recommendations for areas of significant energy consumption.
4. Report compliance to the Environment Agency.

Organisations may not need to undertake the Assessment if they are fully covered by ISO 50001.

For item 3 it is widely recognised that savings can be achieved through readily available and well-established technologies in areas such as lighting and heating, provided that the technology is properly specified and sized, and that the installer is appropriately skilled.

ESOS offers the following specific advice for lighting: "Install occupancy sensors, install daylight sensors, review and improve the maintenance plan (more regular maintenance), replace inefficient incandescent bulbs with high efficiency LED lighting or energy saving fluorescent lighting (for example, T5 lighting)."

1.3
Importance of Light for your business

Lighting plays an important part in any business and is used with many different purposes in mind - different types of business have different lighting requirements, depending on their property and business activities;

- To ensure relevant tasks can be carried out accurately – different tasks have different visual demands.
- To facilitate that the work being done in an area can be completed safely and in comfort.
- To enhance the aesthetic nature of an area or product in order to create the right atmosphere and generate business.
- To embellish the visual appeal of architecture and/or landscape.
- For security purposes.

Each lighting solution will be specific yet the common aim is to provide a good quality and efficient system. The differences between a good and bad lighting installation are usually obvious. A bad quality lighting system can cause discomfort – you may have to strain your eyes to see, you may be experiencing glare on workstations etc. Good lighting will allow you to see in comfort, complete tasks accurately and has been recognised as a positive tonic for human health.

As a business it is important you know from the outset what it is you are trying to achieve with your lighting system. A focus on the right design aspects will ensure you get the most out of your lighting system.

1.4
Incentives and Barriers

With a continued focus on energy efficiency it is clear most businesses know and understand the reasons for improving lighting systems;

- **Reduce electricity costs –** electricity is usually the most expensive of utilities for businesses in Northern Ireland so any reduction in consumption can equal a significant cost saving.
- **Reduce energy consumption -** reduce your carbon footprint and improve your green credentials.
- **Provide a better working environment -** replacing old inefficient fittings will instantly provide a better light output.
- **Health, Well-being & Productivity -** Existing research documents good evidence of an association between lighting and work performance, facilitated by employee well-being.

Unfortunately the barriers can often far outweigh the incentives and are usually the same for most businesses;

- Financial budgets.
- Restrictions for retrofit/refurbishment projects. (e.g. current fixtures layout, wiring system, etc.)
- Possible disruption to current business operations.
- Lack of knowledge of existing lighting design requirements and technology available, and the awareness of how to start the process.
- Time constraints for someone to take control and organise the project.

One of the objectives of this guide is to educate businesses and provide them with the knowledge and practical advice to overcome the barriers and move forward.

1.5
Commitment to Change

As a business the starting point is to believe and promote that energy management makes good business sense.

Successful energy management cannot happen overnight – it demands long term commitment, planning, implementation and continued effort. This overall focus is fundamental for you to successfully influence others.

Senior management commitment can be the foundation of good energy management as you can demonstrate that energy efficiency is part of your organisation's mission and is as relevant as other management aspects. If a business isn't showing commitment from the top down there is no motivation for a regular worker to save energy. The general consensus would be that savings won't directly affect them, even if the investment would have a highly beneficial impact on the business as a whole.

Starting with senior management set up an energy team – encourage energy champions to volunteer so you have all departments represented. You may be surprised at how many members of your company are 'green'. Develop an energy management policy and strategy setting out your objectives and an action plan. There are many ways to motivate staff and your energy champions can help with this. You may want to provide an incentive scheme – set up a suggestion box and provide monetary/ voucher rewards for the best suggestions. An annual competition could focus on 'the big switch off' – providing a departmental competition to see which department can save the most energy in a week.

There are many guides and tools to aid with energy awareness which can be downloaded free from the Carbon Trust website.
http://www.carbontrust.com/resources/guides/energy-efficiency/employee-awareness-and-office-energy-efficiency

In order for staff to reduce their individual energy consumption in the long-term, energy efficiency awareness and practices must become part of the culture of your business.

Invest NI have recently published a Best Practice Guide to Metering, Monitoring and Targeting which can also be used as a reference tool.
http://secure.investni.com/static/library/invest-ni/documents/best-practice-guide-metering-monitoring-and-targeting.pdf

1.6
Lighting Analysis – Profile of Your Business

See **Appendix B** for step by step instructions on how to create a lighting profile for your business. An example of a lighting schedule with consumption and costs recorded has also been included with all steps referenced.

Calculating the potential savings of a new lighting system is based on first being able to identify your current costs and consumption using:

- The current lighting load. (Watts or kiloWatts)
- The hours of use per annum.
- The unit rate you pay for each kWh of electricity.

This profile can be used to make a business case for any planned upgrade. You carry out the same calculation for the new lighting and compare against the existing as per the following calculations;

Current Lighting Cost £ - **New Lighting Cost £** = **Annual Savings £**

Use this figure to compare against the capital expenditure of the new lighting system to get an expected payback period;

$$\frac{\text{Investment in new lighting £}}{\text{Annual Savings £}} = \text{Payback (yrs)}$$

1.7
Identifying Efficiency Opportunities
The Carbon Trust states;
Lighting uses some 20% of the electricity generated in the UK; and over 75% of lighting installations are thought to be out of date and unable to meet current design standards.

Once you have your schedule of existing lighting types, costs and consumption you are ready to start the process of identifying opportunities for your business. A simple walk round survey to start with will help you identify any immediate savings to be made – very often simple adjustments to current lighting systems can result in energy and cost savings. It is recommended to carry out this check during working hours and also out of hours to get a full picture.

Things to look out for;

- **Awareness –** would strategically-placed posters/ stickers make users aware of the need to switch lighting off?
- **Controls –** how is each area's lighting controlled? Are there opportunities to introduce some level of automatic control?

  (i) **Automatic presence detection control –** a control that will automatically switch off lighting in an area after a predetermined time of no occupancy.

  (ii) **Daylight linking control –** when there is adequate natural daylight in an area this control will regulate the amount of artificial lighting required.

  (iii) **If you have existing sensors are they working correctly?** Check settings and clean sensors in accordance with manufacturer's recommendations.
- **Lamp types –** using the lamp types guide in Section 2 are there opportunities to replace current lamps with low energy alternatives?
- **Light Quality –** Are there areas where the lighting levels are poor and causing discomfort to occupants? Is there sufficient light for tasks to be completed accurately and safely? Check recommended lighting levels for your business using the information contained within this guide – either from Section 1.2 Design Guides or within one of the specific Sector Guides.
- **Maintenance issues –** do any specific types of lamps cause particular problems and have to be replaced more often **than others**? It may be beneficial to focus on replacement types for these. Would lamps benefit from regular cleaning? The reduction in light output due to luminaires and rooms becoming dirty can be very significant.
- **Check if specialist advice would be beneficial –** are there specialist/production areas where not enough information is known about current lighting requirements?

Additionally there are other factors which impact the quality of light in a room besides the lighting system itself;

- Are there roof lights and/or windows in the area which would benefit from cleaning?
- Are blinds installed and are these constantly closed for a reason?
- Is the room painted a dark colour – would this benefit by being changed to a light coloured matt surface which better reflects light?

From your initial walk round you should now have some initial ideas on the way forward. Section 7 of this guide provides specific advice on drawing up an action plan. Before this we will have a more detailed look into the defining characteristics of providing an energy efficient lighting system so you have the knowledge to identify what options are best suited for you.

2 Lighting Characteristics

2.1
Background

There are many design criteria to consider when implementing a new lighting system – whether it be a retrofit, refurbishment or new build project. Each aspect is important in its own right and when combined correctly will maximise the efficiency of the system.

This section should provide an insight into common lighting terminology and offers practical guidance on features you should look for in a new lighting system for your business.

Attached to this guide are two sector specific guidelines which include an outline of what lighting design criteria you should be trying to achieve in typical hospitality and industrial businesses.

2.2
Lighting Levels

Lighting levels are stated as **illuminance levels** and are measured in lux. For example a corridor would only require an illuminance level of around 100lux whereas an office is required to have 350-500lux. To give an idea of the spectrum of lighting levels this ranges from moonlight at 0.2lux to bright sunlight at 100,000lux.

Lighting designers use specially designed lighting programmes to calculate the average lux across a working plane when preparing a new lighting design. If you have been provided with a proposal by a lighting supplier always ask for lighting level calculations especially for those areas which require higher levels of lighting. While it is important to get the right illuminance level there is a fine balance to be met as excessive lighting levels will increase both capital and running costs.

If you wish to check your current lighting levels hand held lux meter devices are readily available and easy to use.

The Society of Light and Lighting guidebooks provide comprehensive details on lighting levels for all types of areas, tasks or activities across all industry sectors. The Society is part of the **Chartered Institution of Building Services Engineers (CIBSE**) and the guidebooks can be downloaded by members for free from the CIBSE Knowledge Portal.

Creating a CIBSE account is free and gives you instant access to download pdf versions of documents; **https://ols.cibse.org/membersarea/login/register_visitor.asp**

Once you have registered you can find the full list of Lighting Guides available for download at: **http://www.cibse.org/knowledge/cibse-publications/cibse-lighting-guides**

2.3
Lamp Efficiency

This is termed **lumen efficacy** and is defined as the ratio of light emitted by a light source to the power consumed by the light source, including power consumed by any auxiliary control gear (Lumens provided per Watt consumed). The higher the efficacy value the more efficient the light source uses electricity. **Northern Ireland Building Regulations Part F October 2012** states that "Every fixed building service should be at least as efficient as the minimum acceptable efficiency for that particular type of appliance or fitting given in the Non-Domestic Building Services Compliance Guide". This guide sets the minimum efficacy standards for all fixed building services including lighting systems.

These are stated below;

Recommended minimum lighting efficacy in new and existing buildings;

- All luminaires for office, industrial and storage areas have an average initial efficacy not less than 55 luminaire-lumens[1] per circuit-watt. Office areas are deemed to cover desk based tasks such as classrooms, conference and seminar rooms. In calculating the average luminaire lumens, the circuit-watts for each luminaire may first be multiplied by the appropriate control factor (known as the light output ratio - LOR) which indicates the losses within the luminaire;

Light Output Control	Control Factor
a. The luminaire is in a daylit space and its light output is controlled by photoelectric switching or dimming control, with or without override.	0.9
b. The luminaire is in a space that is likely to be unoccupied for a significant number of operating hours, and where a sensor switches off the lighting in the absence of occupants but switching on is done manually except where this would be unsafe.	0.9
c. Circumstances a. and b. above.	0.85
d. None of the above.	1.0

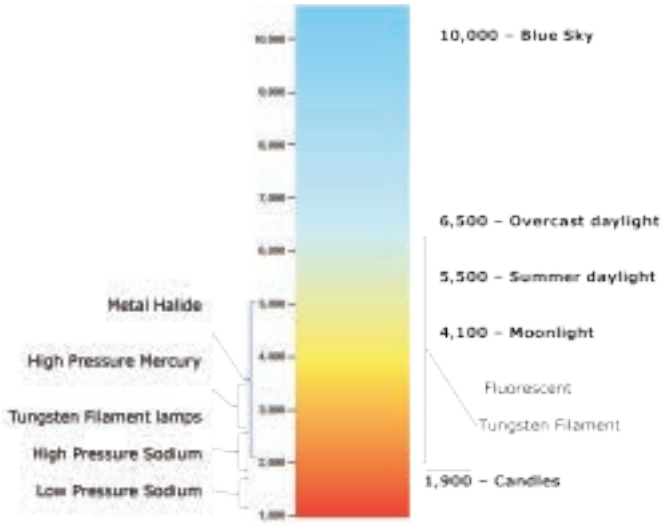
- Luminaires in other areas (or luminaires without photometric data[2]) have an average initial efficacy not less than 55 lamp-lumens[1] per circuit-watt.
- Luminaires for display lighting have an average initial efficacy not less than 22 lamp-lumens per circuit-watt.

[1]What is the difference between luminaire lumens per circuit-watt and lamp lumens per circuit-watt?
Lamp lumens per circuit-watt is the total lamp lumens summed for all luminaires in the relevant areas of the building divided by the total circuit-watts for all the luminaires. Luminaire lumens per circuit-watt is the (lamp lumens x LOR) summed for all luminaires in the relevant areas of the building divided by the total circuit-watts for all the luminaires.

[2]What is photometric data? There are two photometric units that we need to consider here, total luminous flux and luminous intensity. Total luminous flux is the total amount of light emitted from a light source, corrected for the spectral response of the human eye to light. It is measured in lumens. The luminous intensity defines the amount of lumens in a given direction, per solid angle. This is measured in lumens per steradian, or candela. The luminous intensity data presented in photometric files is useful because it allows lighting designers to observe both the total light output and the angular spread of the light output. A photometric data file will also contain the input electrical power that the light source consumes (in Watts).

Links for downloading the Building Regulations Technical Booklet and the Non-Domestic Building Services Compliance Guide have been included in Section 1 of this guide.

2.4
Colour Quality
The colour appearance of a lamp refers to the apparent colour (chromaticity) of the light emitted. It is quantified by its correlated colour temperature (CCT) and it is measured on the Kelvin scale as the figure above right illustrates;



The colour appearance of artificial light can also be categorised as below;

Colour appearance	Correlated colour temperature
Warm	Below 3300 K
Intermediate	3300 to 5300 K
Cool	Above 5300 K

When you consider environments such as restaurants and pubs, the ambience they are trying to achieve dictates that they use lighting which appears warm and which will usually falls below the 3300k range. In contrast, a medical examination room would require a much a higher colour temperature to provide a cooler and more crisp appearance.

Very often in lighting installations expired lamps will have been replaced with the same type of lamp but not necessarily with the same colour temperature of lamp – this is especially common with fluorescent lamps where the colour range varies widely. Colour temperature for individual lamps can usually be found on the lamp itself and should be easily identifiable when it comes to purchasing replacements. Differences in colour temperatures between lamps in one luminaire and even in one room can take away from the aesthetics and quality of the lighting system.

Colour rendering
Colour rendering is the ability of a light source to reveal the colours of an object. It is measured by the colour rendering index (Ra). (The higher the number the better, up to a maximum of 100).

Some special tasks which require colour matching have high demands in accurate colour rendering and will require special attention when it comes to designing a new lighting system. For normal production, offices, etc however, the colour rendering group will usually be 1A - 2, which is easily achieved with normal fluorescent lamps.

Colour rendering group	RA	Typical Application
1A	90 - 100	accurate colour matching is needed e.g. colour print inspection
1B	80 - 90	accurate colour judgement and good colour rendering appearance required
2	60 - 80	moderate colour rendering is required
3	40 - 60	accurate colour rendering is of little importance
4	20 - 40	accurate colour rendering is of no importance and colour distortion is acceptable

The reason for lamps with a poor colour rendering such as high and low pressure sodium being used at all is their high efficacy. They output more light per Watts of electrical power than lamps that provide a good colour rendering.

2.5
Maintenance Factor
During the life of a lighting installation, the light available for the task progressively decreases due to accumulation of dirt on surfaces and the aging of equipment. The rate of reduction is influenced by the equipment choice and the environmental and operating conditions. In lighting scheme design, it is necessary to take account of this fall using a maintenance factor and plan suitable maintenance schedules to limit the decay. Consequently when designing a lighting installation it is common to design for a maintained lighting value, that is the lighting level achieved when the luminaires, lamps and reflective surfaces are at their oldest or dirtiest.

The maintenance factor (*MF*) is a multiple of four factors:

MF = LLMF x LSF x LMF x RSMF

Where:
LMF is *the amount of light lost due to the luminaire through aging and dirt deposition on the luminaire*

LLMF is in *the amount of light lost due to a reduction lamp flux as the lamp ages*

LSF is *the amount of light lost due to failed lamps which are not immediately replaced*

RSMF is *the amount of light lost due to reduced reflection from surfaces within the installation*

Data for these factors should be available from manufacturers. However it is important to note that this data will assume the unit is operating within normal conditions as specified by the manufacturer. Many lighting design software packages allow the maintenance schedule to be defined and use this to calculate an installation maintenance factor.

The SLL Code for Lighting Handbook 2012 states;
The designer shall:

- state the MF and list all assumptions made in the derivation of the value,
- specify lighting equipment suitable for the application environment and prepare a comprehensive maintenance schedule to include frequency of lamp replacement, luminaire, room and glazing cleaning intervals and cleaning method.

Further guidance on calculating and using maintenance factors may be found in publications CIE 97-2006 - Maintenance of Indoor Electric Lighting Systems and CIE 154:2003 - The Maintenance of Outdoor Lighting Systems.

A high maintenance factor together with an effective maintenance programme promotes energy efficiency, good design of lighting schemes and limits the installed lighting power requirements.

2.6
Rated Life
The Average Rated Life of any lamp is defined by how long it takes for a percentage of the lamps in a test batch to fail. For instance, if 100,000 lamps were tested and after 1,000 hours, 70,000 (70%) of the bulbs had expired, this product would have an average rated life of 1,000 hours at L70. There will of course have been many failures during the initial 1,000 hours and likewise there would have been a number of lamps lasting well in excess of 1,000 hours.

The two important factors when understanding the life expectancy of your chosen lamp are the hours and the L rating stated. Examples below:

- 2,000 hours at L50 indicates that 50% of light bulbs had failed at 2,000 hours.
- 5,000 hours at L70 indicates that 70% of light bulbs had failed at 5,000 hours.
- 12,000 hours at L80 indicates that 80% of light bulbs had failed at 12,000 hours.
- 20,000 hours at L95 indicates that 95% of light bulbs had failed at 20,000 hours.

It is an extremely simple but very important factor in understanding the expected life of any light bulb purchased.

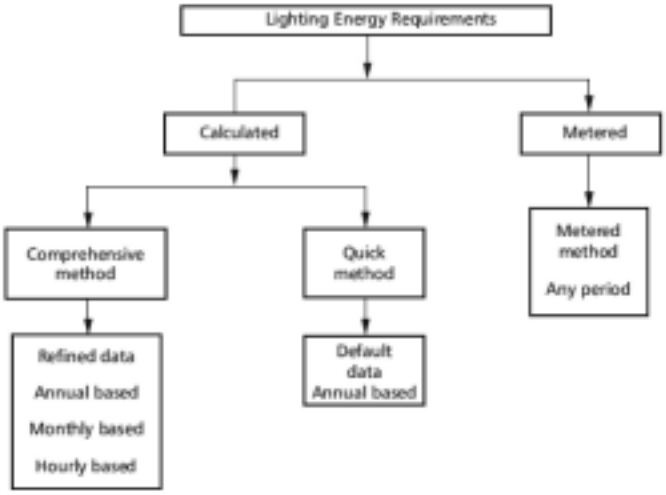
Another important aspect to take into consideration is that all light bulb ratings are carried out under perfect laboratory conditions. There are numerous other factors that will determine the life of any light bulb. Electrical surges, extreme cold, vibration and extreme heat are just a few examples of instances where the life time of the product will be affected. Any number of factors could determine the performance and ultimately the life of a light bulb.

2.7
Lighting Energy Numeric Indicator (LENI)
With the increased awareness of lighting efficiency it has become apparent that all aspects of a lighting system should be taken into consideration when it comes to assessing the efficiency of a system.

A procedure for the estimation of the energy requirements of a lighting installation is given in BS EN 15193 (BSI, 2007a). It is called LENI (the Lighting Energy Numeric Indicator) and it measures the efficiency of the whole lighting installation, not just the components.

Providing energy efficient lighting is of extreme importance and using a metric like LENI, which expresses the energy used by lighting in terms of kilowatt hours per year, is the best way to characterise the energy performance of a lighting system.

The diagram below is an extract from the BS guidance which schematically illustrates how the LENI process works.



1. The most accurate measure for lighting is by **direct metering** of the energy used as this is the most positive feedback process on the effectiveness of lighting management and controls.
2. Alternatively, there are two options for the **estimation** of lighting energy requirements in buildings.

   (i) A **quick annual energy estimation** (where simple annual default values are given) for use in the Energy performance certificate of the building.

   (ii) A more **accurate comprehensive method** (where all the dependency factors are known, including occupancy and the availability of daylight) used for estimating energy over different periods (monthly or annually) and for use in combination with energy needed for heating and cooling the building.

3 Lighting Systems

3.1
Background

The most successful of energy saving lighting projects is about reducing your energy consumption and running costs without compromising the quality of light. Compromising on quality should not be an option when it comes to considering energy efficiency measures – therefore any proposed lighting system must take into consideration the occupant and task requirements for that area. If done correctly, lighting can play a central role in saving energy, resources and costs. Very often new lighting technologies and controls can deliver savings of at least 40%.

A complete lighting system is made up of three elements:

- the lamp (or light bulb).
- the luminaire (the fitting that includes the lamp).
- the controls (either manual or automatic).

This section looks at each of these components that make up a lighting system.

3.2
Lamp Types

Lamps can be classified into five main categories;

1. *Incandescent Lamps* – standard filament and tungsten halogen type bulbs.

2. *Discharge Lamps* – light sources that generate light by sending an electrical discharge through ionised gas.
   - Metal Halide lamps.
   - High pressure mercury lamps.
   - High pressure sodium.
   - Low pressure sodium.

3. *Fluorescent Lamps* – (also gas discharge lamps). By far the most common form of discharge lighting, fluorescent lamps are supplied in tubular or compact forms. The warm up to full brightness is quick; usually less than one minute. Fluorescent lighting is also the most easily controlled of discharge lighting. They can be switched on and off quite readily, and with the right control gear they can be successfully dimmed.
   - Compact Fluorescent lamps.
   - Tubular Fluorescent lamps – the most common type of discharge lighting;
     - o T12 – 38mm diameter - filled with argon gas.
     - o T8 – 25mm diameter – uses argon and krypton and is more efficient than T12.
     - o T5 – 15mm diameter – operates from high frequency control gear and is the most efficient of the tubular types.

4. *Induction Lamps* – In contrast with all other electrical lamps that use electrical connections through the lamp envelope to transfer power to the lamp, in electrodeless lamps the power needed to generate light is transferred from the outside of the lamp envelope by means of (electro)magnetic fields.

5. *Light emitting diodes* – LEDs, the latest rapidly developing technology. These are electronic components that produce light by conversion of electrical energy directly to light by the movement of electrons within the material of the diode. LEDs are explored in greater detail later in the Guide.

To benefit from maximum energy savings, it's very important to choose the right lamp. Each type of lamp gives light of a different colour appearance, brightness and warmth. Lamps also have different characteristics such as efficiency and lifecycle (hours).

Below is a table identifying the most common sources of light and the defining characteristics of each light source;

TYPE	CHARACTERISTICS	Luminous Efficacy (lm/W)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Incandescent / Filament 	• Poor efficacy • Very short lamp life • Excellent colour rendering • Low capital cost • No requirement for control gear • Currently being phased out	10 - 18	2,600	100	1,000
Tungsten Halogen 	• Addition of halogen gas to standard filament increases efficacy • Still less efficient than discharge lamps • Low voltage versions require transformer	5 - 27	2,700 – 3,200	100	2,000 – 16,000
Metal Halide 	• Very good efficacy • Good Colour rendering • Long lamp life • Unless modern hot re-strike control gear is used the re-strike time can take up to 10mins	75 - 140	3,000 – 5,600	65 - 95	8,000 – 20,000
High Pressure Mercury 	• Cheaper than sodium lamps • Long lamp life • Not very efficient • Average colour rendering • Electronic control gear required • Long startup and re-strike time	35 - 60	3,400 – 4,000	35 - 60	9,000 – 24,000
High Pressure Sodium 	• Good efficacy rates • Long lamp life • Moderate – good colour rendering available • Long startup and re-strike time	50 - 130	2,000 – 2,500	25 - 80	8,000 – 30,000
Low Pressure Sodium 	• Highest efficacy ratings • Long lamp life • Very poor colour rendering • Usually found in street lighting • Long startup and re-strike time	100 - 200	1,800	N/A	6,000 – 16,000

TYPE	CHARACTERISTICS	Luminous Efficacy (lm/W)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Compact Fluorescent 	• Long lamp life • Good efficacy ratings • Good energy savings when replacing incandescent lamps • Very good colour rendering • Light output can diminish over time • Electronic control gear required	50 - 85	2,700 – 6,500	80 - 90	8,000 – 20,000
Tubular Fluorescent 	• Long lamp life • Good efficacy ratings • Very good colour rendering • Electronic control gear required	60 - 105	2,700 – 6,500	80 - 95	12,000– 60,000
Induction 	• Virtually maintenance free • Very long lamp life • High capital cost • Specialist lamp so not as readily available	62 - 70	2,700 – 4,000	85	10,000– 60,000
Light Emitting Diodes (LED) 	• Very long lamp life • Low maintenance • Low energy consumption • High efficiency level • Small dimensions available • Provides instant light • Wide operating temperature range • Rapidly developing technology • Not as suitable for areas where high lighting levels are required • High capital cost	50 - 120	3,000 – 8,000	70 - 90	50,000

3.3
Luminaires

So far the focus has been on identification and characteristic of the different lamp types. A luminaire is the name given to the complete light fitting which houses the lamp and is comprised of the following mechanisms;

- *Housing* – the shell of the luminaire.
- *Control Gear* – the electrical components which transform the 230V mains electric supply into one which the lamp is compatible with. For conventional lighting (e.g. ballast, starter) and high frequency lighting (e.g. dimming, daylight linking control).
- *Lamp holder* - the device for securing a lamp to its support; specifically, a socket or holder fitted with electric terminals.
- *Lamp* – the device which gives light.
- *Attachments* - Light fixtures may also have other features, such as reflectors for directing the light, diffuser for spreading out or scattering light in an even manner, to give soft light, or an outer casing for protection. Depending on the type of environment you have you may need to choose light fittings in accordance with the IP (Ingress Protection), IK (Impact Resistance) and/or ATEX (Hazardous Area) scales. In these instances you should seek specialist advice to ensure you are getting the most suitable solution for your environment.

The type of luminaire which you pick for a specific area will depend on many factors – if this is a retrofit or refurbishment project you may have to design to the current ceiling type – i.e. a modular suspended ceiling grid will lend itself to recessed luminaires while a plasterboard ceiling will require surface or suspended mounted luminaires.

There exists a wide-ranging choice of luminaires which can be sub-divided into various categories, each of which has specific applications. These are summarised below;

Suspended luminaires

Downlights

Pendant luminaries

Spotlights/Tracklights

Architectural / Decorative luminaires

Uplights

Recessed-luminaires

Surface-mounted luminaires

Trunking lighting systems

Free- standing luminaires

Images supplied by Thorn Lighting, Zumtobel Group

3.4
Interior Lighting

The objective is to provide lighting for interior spaces which has been designed to meet the lighting requirements of a particular task or space in the most energy efficient manner. It is important not to compromise the quality of a lighting installation simply to reduce energy consumption; take into consideration all factors – lighting levels (illuminance), lamp type, lamp efficacy, colour appearance and colour temperature. Finding the correct balance of both aspects will provide your business with optimum savings.

Interior lighting covers many different applications and uses – choosing the right lighting layout for your work area may be dictated by factors such as ceiling types, cable routes etc. but below are the various options generally used;

- General lighting systems – a lighting system designed usually as a ceiling mounted arrangement which is functional and effective.
- Local lighting systems for general ambience plus task lighting – in this case a smaller ceiling arrangement may provide a background/ambience lighting with localised lighting in areas where tasks are performed.
- Localised lighting systems – only localised luminaires are used to provide the necessary lighting levels. These will be required at task areas and in general areas to provide the correct lighting levels.
- Display lighting – lighting which is installed purely to promote or highlight a product or space. This will usually be supplementary to the normal lighting system. To comply with building regulations it is recommended that display lighting should be controlled on dedicated circuits that can be switched off at times when not required.

3.4.1
Interior Lighting – Typical Applications

Type of Lamp	Typical Applications
Incandescent	• Usually found in domestic applications. (EU Phase-out regulations effectively ban the manufacture, importation or sale of incandescent light bulbs.)
Tungsten Halogen	• Impact display lighting for retail. • Reception area – ambient light levels. • Bars/Restaurants – requiring ambient lighting. • Decorative lighting in meeting / function rooms.
Metal Halide	• Impact display lighting for retail. • Illuminate upwards as well as downwards with wall mounted direct/indirect luminaires in staircases/ atria. • Suitable for industrial applications of mounting above 3.5m - low and high bay applications. Most suitable in areas of infrequent switching and where dimming and presence controls are not required. • Warehouses general lighting.
High Pressure Mercury	• Industrial applications where good colour rendering is not important e.g. Warehouses.
High Pressure Sodium	• Industrial applications where good colour rendering is not important e.g. Warehouses.
Low Pressure Sodium	• Usually only found in outdoor lighting.

Type of Lamp	Typical Applications
Compact Fluorescent	• Desk lamp for task lighting. • Illuminate upwards as well as downwards with wall mounted direct/indirect luminaires in staircases/ atria. • Reception areas for impact effect. • General lighting for circulation areas. • General lighting for small stores. • Industrial lighting – both low bay and high bay applications.
Tubular Fluorescent	• General and wall washing lighting for retail. • General lighting for office type areas – recessed, surface and suspended luminaires. • General lighting for circulation areas. • General lighting for Kitchens, Plantrooms, Stores. • Industrial lighting – both low bay and high bay applications. • Warehouses general lighting.
Induction	• Industrial lighting – both low bay and high bay applications. • Decorative lighting for showrooms, retail, exhibition areas, atriums.
Light Emitting Diodes	• Suitable for all types of applications across a variety of sectors – explored further in the next section of this guide.

3.5 External Lighting

The overall principle for external lighting is just the same in that maximising the efficiency of your exterior lighting system will reduce energy consumption and save on electricity costs.

The main applications for exterior lighting are:

- Car parks
- Security
- Architectural
- Amenity
- Sports
- Street lighting

As with interior lighting it is important to establish from the outset what you are trying to achieve – the different applications will require different design considerations. For the average business in Northern Ireland the external lighting installations are primarily for car parks and security and to a lesser extent some architectural lighting. When you know what your lighting is supposed to be doing you can identify the most suitable type of luminaire.

External lighting usually comes in the following forms;

Floodlights – these can be ground, wall or column mounted

Lanterns – usually column mounted

Bollards – usually for amenity lighting

Bulkheads – generally for wall mounted perimeter lighting

Recessed Architectural – generally for ground mounted decorative lighting

Images supplied by Thorn Lighting, Zumtobel Group

Next you need to establish what your requirements for operating hours are and identify relevant controls to regulate hours of use. It is important to make sure that your external lighting is only provided when necessary. Ensure you know your insurance requirements for external lighting and/or any lighting requirements for CCTV systems you have monitoring your building.

The following controls are applicable for exterior lighting systems;

- Photoelectric – sensor which controls lighting from dusk till dawn.
- Motion Sensor – sensor which brings lights on when someone approaches the building.
- Time Control – a timeclock which regulates the hours of use – this can be used in conjunction with a photoelectric sensor or a motion sensor where lighting is not required all night.

If you are choosing a lighting system for a carpark or larger external areas it will be necessary to consult with a lighting designer or supplier and ensure your design is achieving the correct lighting levels. This will also be necessary to identify a suitable column height for any flood lighting or lanterns. At this stage you will also need to consider any light pollution implications which can be known as 'sky glow' and 'light spill'. It is necessary to minimise all types of light pollution which is where careful design of your lighting system comes into play. This is apparent by the identification of light as a potential statutory nuisance in the Clean Neighbourhoods and Environment Act (Northern Ireland) 2011. You can download the full document at **http://www.legislation.gov.uk/nia/2011/23/contents**

As with interior lighting LED luminaires are fast emerging as the preferred technology for exterior applications. It is perhaps still most suitable for architectural applications but the development of the technology has seen the emergence of LED type bollards, floodlights and lanterns in recent times.

3.5.1
Exterior Lighting – Typical Applications

Type of Lamp	Typical Applications
Metal Halide	• General area floodlighting. • Sports and recreational floodlighting. • Floodlighting for architectural features. • Post top lighting for general amenity lighting. • External wall mounted perimeter lighting.
High Pressure Mercury	• Floodlighting for architectural features.
High Pressure Sodium	• General area floodlighting. • Sports and recreational floodlighting. • Floodlighting for architectural features.
Low Pressure Sodium	• Street lighting.
Compact Fluorescent	• Bollard lighting for walkways. • External wall mounted perimeter lighting. • Post top lighting for general amenity lighting.
Tubular Fluorescent	• Usually only found in outdoor lighting.
Induction	• General area floodlighting.
Light Emitting Diodes	• Suitable for all types of applications across a variety of sectors – explored further in the next section of this guide.

3.6
Lighting Controls

Energy savings can be made by harvesting daylight, responding to occupancy patterns, using motion sensors and most of all by making full use of controls.

In its simplest form lighting controls can be;

- Manual
- Automatic
- Combination of both

Factors influencing which type of controls are suitable for your business will include the amount of natural daylight available (windows and rooflights), and patterns of occupancy for different areas – are some areas more transient than others? In the end, a well-designed lighting control system will achieve energy savings while maintaining lighting quality and without compromising user comfort or safety.

Manual – Manual wall switches are the most common form of lighting control – to be used effectively they need to be easily accessible, well organised and labelled clearly so the user knows exactly what they are controlling. For example in larger open plan offices a switchbank with a number of switches can be used to control different rows of lights. There may be times of the day when perimeter lighting is not required due to sufficient natural daylight and these rows can be switched off. This is made easier if the user can readily see which switches are for perimeter rows. One of the main flaws with manual switching is the reliance on the user to ensure all lighting is switched off when leaving an area. Additionally, supplementary switching for security or cleaning purposes can provide an alternative level of background lighting when full illuminance levels are not required.

Automatic – The most cost effective measure is to use lighting only when it is needed and the following technologies provide this level of control;

- **Time Control –** This will set the times for the lighting to operate. The biggest disadvantage is that the occupancy patterns need to be the same or the settings would have to be constantly changed or easily overridden. If you have a central building management system (BMS) lighting can be designed to schedule controls from here. (This type of control is usually best suited to external lighting applications).
- **Presence Detection –** Control is regulated by monitoring the occupancy of a room. This type of control can be used for most types of rooms and is frequently found in transient and less frequented areas such as WC's, corridors, stores etc. For some applications, e.g. hotel corridors which would usually benefit from automatic controls, the short delay between the person entering the space and lights coming on may not be acceptable. In this case it is possible to have a low level of lighting on at all times and have full lighting come on when the space is in use. After the corridor has been empty for a predetermined time the sensor will dim the lighting to 10% output and remain at this setting until the occupancy sensor is activated again and the lights will raise to 100% output. Also known as Auto-On-Off.
- **Absence Detection –** As before control is regulated by monitoring of occupancy in a room, however in this instance the lighting is manually switched on. Also known as Manual-On Auto-Off.
- **Photoelectric control (also known as daylight harvesting) –** To employ this type of control your lamp types may have to be dimmable. The setting on the sensor takes into account the amount of natural daylight coming into the space and will either regulate (through dimming) the amount of artificial lighting required to provide a pre-determined lighting level or switch the lighting in response to the amount of natural daylight available. Research has demonstrated that daylight has great physiological and psychological benefits for occupants. Successfully managing the balance of natural daylight and artificial light is key but by having them work together they can be used efficiently.

Combination - In general, to maximise energy savings, a control system should be configured to be turned on by manual control and to be turned off automatically. In such situations the lights may be switched on or off by users and even dimmed up and down, but when there is no one in the room, the lights are switched off automatically and when there is enough daylight available, the lights are automatically dimmed to compensate for the daylight available.

Perhaps one of the most well-known lighting control standards is the Digital Addressable Lighting Interface (DALI) standard. This was originally introduced as a way of switching and dimming fluorescent tubes and halogen lamps but has been continuously extended and updated over the years. The protocol now includes LED lighting technologies as well as the ability to control relays and interface with touch, light or occupancy sensors. DALI is a data protocol and transport mechanism that was jointly developed and specified by several manufacturers of lighting equipment. The common platform of DALI enables equipment from different manufacturers to be connected together. DALI has an international standard IEC 62386 which is a technical standard for network-based systems that control lighting in building automation. The latest version was released in November 2014 which saw a complete overhaul of the standard to make it relevant for modern technology.

You can find more details on DALI on their website; **http://www.dali-ag.org/**

The obvious benefit from implementing automatic controls is the cost savings – if you are successfully reducing the electricity consumption then you are reducing your running costs. Depending on the current lamp types in your business you may be able to retrofit lighting controls with some simple alterations to the existing wiring system.

3.7
Costs

It is important to consider both the capital and operational costs of a lighting system to ensure an overall economic picture when assessing the full life cycle of a lighting installation.

- **Capital cost** should include the costs of buying the required equipment; lamps, luminaires, control systems, plus the cost of installing the equipment.
- **Operating costs** will depend on the number of hours of use and the price of electricity for your business. (If you have automatic controls don't forget to factor them in here).
- **Maintenance costs** will vary for different systems – e.g. replacement lamp cost, will cleaning be required regularly, are luminaires mounted at high level so replacing lamps is more labour intensive.
- Finally, there are **disposal costs** to be considered. It is no longer possible to simply dispose of electrical equipment by throwing it into a landfill. Under the Waste Electrical and Electronic Equipment (WEEE) Regulations, all lighting equipment, other than filament lamps and that in domestic premises, is considered to be hazardous waste and has to be disposed of appropriately.

A common error when it comes to assessing the economic viability of a new lighting system is looking at the capital costs only. In fact cheaper alternatives are very often chosen just to keep total expenses within financial limits. This can create a false economy - you may have a cheap lighting system but unless you calculate the electricity to be consumed and the expected maintenance costs over the life of a system, you are not getting the full picture and in the long run this may not be the most economical solution for your business.

Investment in a well-designed lighting installation usually repays itself not just in higher return-of-investment but will take into account wider benefits such as improvements in comfort and the environment and a lower total cost of ownership during its lifetime.

4 LED Lighting

4.1
Background

The current evolution of LED lighting has driven the most significant transformation of the lighting industry in recent times. As LED materials technology have grown more advanced, light output has risen, while maintaining efficiency and reliability at acceptable levels. LEDs have many advantages over other light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching.

While we cannot ignore the advancements in lighting made with the introduction of T5 fluorescent tubes, electronic ballasts and Compact Fluorescents, LED technology is widely acknowledged as having the potential to deliver much greater energy and life cycle cost savings. Even these more modern fluorescent based installations are seen as somewhat outmoded and some form of LED replacement is now readily available.

This section will guide you on the characteristics you should be assessing when ascertaining if an LED solution is suitable for your business.

4.2
Applications

LED-based products are being developed to replace light sources in virtually all lighting applications – both indoors and out. The latest technology development in LEDs permits them to be used in a diverse range of applications across all sectors from commercial to home use with applications including general, accent and task lighting.

- **Street and Outdoor Lighting -** LEDs are an ideal solution for street lighting due to their long life, directional light, uniform brightness and illumination.


- **Architectural Lighting -** LEDs are fast becoming the light source of choice when it comes to eco-friendly buildings and structures. LEDs are long lasting, provide directional light and come in an endless array of colours.


- **Down Lights -** The potential for energy savings with LED lighting compared to traditional and standard down lighting is significant. Different effects can be created for different applications – from a relaxing spa to a welcoming lobby.


- **Offices - Glare-free LED light sources meet the required standards and can adapt to daylight or detect the presence of individuals if required. Light colour provides a pleasant working atmosphere and has been known to increase motivation. LEDs good colour reproduction, high energy efficiency and a long service life – reducing maintenance costs.**


Images supplied by Thorn Lighting, Zumtobel Group

- **Entertainment –** LEDs provide stable colour temperatures, high luminance and outstanding luminous efficacy which are essential for applications in AV/cinema, studio, stage and theatrical installations.
- **Retail Display and Accent Lighting -** LEDs enhance the aesthetic beauty of the product display and are the perfect solution for retail lighting due to their long life, directional light, uniform brightness and illumination. Retail was one of the first sectors to dabble in LED lighting – replacing typical energy intensive halogen spotlights with LED replacements resulted in big energy savings. Many big companies implemented LED lighting throughout their stores e.g. Sainsbury's. Small and medium sized retailers are being urged to make the switch to LED lighting, in a campaign by the British Retail Consortium, with backing from the Lighting Industry Association. They state that while major retailers understand the message very well they are concerned that the smaller independent sector is missing out on huge energy savings.
- **Horticultural Lighting -** Durable and long lasting LEDs are the green alternative to standard horticultural lighting.
- **Portable Lighting/Lamps -** Lasting longer than their incandescent equivalents, energy efficient LEDs provide attractive lumen packages while maximising the beam distance and peak beam intensity.
- **Aviation Lighting –** Airbus and Boeing use LEDs in some of their aircraft and LEDs are also being used in airport and heliport lighting.
- **Medical Lighting –** LED provides a suitable light source for surgical and examination lighting etc. which need good colour rendering, maximum luminance and as little infrared radiation as possible.

4.3
LED Lighting Components

LEDs require a constant power source to provide the correct DC Voltage and current from the mains supply. An LED lamp is therefore comprised of;

- **LED module -** This is the LED together with mechanical and optical components making a replaceable item for use in a luminaire.
- **Driver –** LED drivers are typically 85% efficient which means LED efficacy must be reduced by 15% to compensate for this loss.
- **Heat sink –** Very important aspect of LED lighting design. The key factor is the temperature at the LED junction which is affected by the drive current, the heat sink design and the ambient temperature which dictates the rate of heat dissipation. In general, the higher the drive current, the greater the heat generated at the LED die. This must be removed to maintain the expected light output, life and colour. White LEDs in a well-designed luminaire with adequate heat sinking can produce 10 to 15% less light than indicated by the manufacturer's typical luminous flux. The reduction in light output for products with poor thermal design can be significantly higher.
- **Optical components -** To modify the distribution of light.
- **Protective casing**.

4.4
LED Characteristics

Efficiency: LEDs emit more lumens per watt than traditional incandescent light bulbs. The efficiency of LED lighting fixtures is not affected by shape and size, unlike fluorescent light bulbs or tubes. Luminous efficiency is covered by EU standard 244, which defines the equivalent incandescent lamp power for an LED lamp. Typically, the equivalent incandescent lamp's power rating will be 3.5 to 5 times the LED lamp rating, so today's best LED lamps offer energy savings of up to 80% compared with incandescent lamps.

Life Expectancy: A standard 40-watt incandescent bulb has an expected lifespan of 1,000 hours, whereas an LED can continue to operate with reduced efficiency for more than 50,000 hours, 50 times longer than the incandescent bulb. The light output from an LED will slowly decline over time but unlike its counterparts it will continue to operate even after the light output has decreased to very low levels. The LED itself, therefore, has a long life expectancy and is unlikely to completely fail but the life and reliability of other essential components, such as the driver and control electronics, have to be factored in when considering luminaire life and reliability.

Useful Life: The operating time in hours at which the LED light output has declined to a level deemed to no longer meet the needs of the application. For general lighting, research has shown that the majority of occupants in a space accept light level reductions of up to 30%, particularly if the reduction is gradual. Therefore, a level of 70% of initial light level could be considered an appropriate threshold to represent useful life. In this case the useful life, designated the L70 life, would be the average number of hours that the LED will operate before depreciating to 70% of initial lumens. Leading LED manufacturers have started publishing using L70, L80 or L90 performance.

Colour Temperature: LEDs can emit light of an intended colour without using any colour filters as required by traditional lighting methods. This is more efficient and can lower initial costs. LEDs with the highest efficacy and lowest cost tend to have a high colour temperature, often above 5,000K, producing a "cold" bluish light which will not suit applications where a warm feel to the space is important. However, warm white LEDs (2,500K to 3,500K) are also now available.

Colour Rendering: LED colour rendering is improving with leading warm white LEDs now readily available with colour rendering index of 80, equivalent to CFLs with many LED products having a CRI>80.

On/Off time: LEDs light up very quickly.

Cycling: LEDs are ideal for uses subject to frequent on-off cycling, unlike incandescent and fluorescent lamps that fail faster when cycled often, or even high-intensity discharge lamps (HID lamps) that require a long time before restarting. This also makes them suitable for occupancy type controls.

Dimming: LEDs can easily be dimmed - often improving efficiency as the unit is running cooler.

Operating in low ambient temperatures: LEDs are impervious to temperature meaning their efficiency does not drop when operating in lower temperatures. Traditionally, fluorescent lights have been used in refrigeration/freezer display units in the retail market. However, fluorescent light output dims by around 75% at -20°C so you need nearly four times as much energy to match the light output required. Using LED technology offers immediate energy and cost savings over the fluorescent counterparts. Furthermore, the technology even lends itself for use in large back of store cold rooms and freezer rooms, and can be teamed with occupancy sensors to gain even more savings.

Shock resistance: LEDs, being solid-state components, are difficult to damage with external shock, unlike fluorescent and incandescent bulbs, which are fragile.

Focus: The solid package of the LED can be designed to focus its light. Incandescent and fluorescent sources often require an external reflector to collect light and direct it in a usable manner.

Life Cycle Costs: For good quality LED products reduced maintenance costs from extended lifetime, coupled with lower running costs provide life cycle cost savings. Not all LED characteristics are favourable - as with most lighting products there are areas for caution.

High initial price: LEDs are currently more expensive, price per lumen, on an initial capital cost basis, than most conventional lighting technologies. The additional expense partially stems from the relatively low lumen output and the drive circuitry and power supplies needed. Costs are continuously becoming more competitive.

Temperature dependence: LED performance largely depends on the ambient temperature of the operating environment or "thermal management" properties. Over-driving an LED in high ambient temperatures may result in overheating the LED package, eventually leading to device failure. An adequate heat sink is needed to maintain long life. This is especially important where devices must operate over a wide range of temperatures, which require low failure rates.

Area light source: Single LEDs do not approximate a point source of light giving a spherical light distribution. Therefore LEDs are difficult for applications requiring a spherical light field. However, different fields of light can be manipulated by the application of different optics or "lenses".

Electrical polarity: Unlike incandescent light bulbs, which illuminate regardless of the electrical polarity, LEDs will only operate with correct electrical polarity. To automatically match source polarity to LED devices, rectifiers can be used.

Efficiency droop: The luminous efficacy of LEDs decreases as the electrical current increases. Heating also increases with higher currents which compromise the lifetime of the LED. These effects put practical limits on the current through an LED in high power applications.

4.5
LED Quality Characteristics

We have all heard the claims made by manufacturers of LED products on lamp life, lumen output etc, however it is important if investing into LED technology you are choosing the right type of lighting for your business and not just jumping on the LED bandwagon or installing a 'quick fix'. The LED characteristics listed previously are all important to bear in mind. However, as a user and consumer you need information which is quantifiable in order to carry out a proper assessment.

Assessing the quality of an LED light should be done on a whole luminaire basis rather than assessing the lamp itself which is usually the data that is more readily available. As a first step we would recommend referencing the eligibility criteria for LED luminaires listed on the Energy Technology List of the Government's Enhanced Capital Allowance Scheme.

The criteria document for 'White Light Emitting Diode Lighting Units' states that products must have the following performance criteria:

- Have a luminaire efficacy (i.e. lighting efficiency) that is greater than, or equal to, the thresholds set out in the table below, after 100 hours of continuous operation.

Category	Minimum luminaire efficacy (in luminaire lumens per circuit watt)	
	With dimmer and photocell control	Without dimmer and photocell control
Amenity, accent and display lighting units	>=60	>=60
General interior lighting units using downlighting (DLO/TLO>0.9)	>=60	>=65
General interior lighting units using uplighting (DLO/TLO>0.1)	>=75	>=80
General interior lighting units using combined up and down lighting (DLO/TLO>0.1 and <0.9)	>=75 - (15xDLO/TLO)	>=75 - (15xDLO/TLO)
Exterior area lighting units	>=65	>=65
Exterior floodlighting units	>=65	>=65

- Be able to provide a light output (in lumens) after 6,000 hours of continuous operation that is not less than 90% of their initial light output (in lumens).
- Have a colour rendering index that meets the requirements of Section 2.2 of Commission Regulation (EU) no 1194/2012 (implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment).
- Have a power factor that is greater than, or equal to, 0.7 at all levels of product light output.

Further details on this scheme and eligibility can be found later in this guide.

CE Mark

The CE mark shows that a product conforms to the required European directives for placing on the European market. It helps customs and market inspectors in facilitating the free trade and movement of product within Europe. Displaying the CE mark signifies compliance to four main European directives.

4.6

Comparing LED products

'A Guide to the Specification of LED Lighting Products 2012' is a technical document providing guidance to consumers on how to assess and compare LED lighting. This is the fourth edition of the guidance notes produced under the umbrella of the Lighting Liaison Group, which is an informal body representing the major lighting organisations in the UK who have endorsed and added their names to this Guidelines document. The document can be downloaded from; **http://www.npl.co.uk/upload/pdf/led-lighting-spec-2012.pdf**

To summarise;
The International Electrotechnical Commission (IEC) published two Public Available Specification (PAS) performance requirement documents dealing with LED products.

- IEC/PAS 62717 Performance requirements – LED modules for general lighting.
- IEC/PAS 62722 Performance requirements – LED luminaires for general lighting.

These were developed together to provide:

- the definition of a set of quality criteria related to the initial specifications of a product;
- a standardised description on how to measure these quality criteria.

There are two methods for comparing LEDs;

1. For comparison of **initial performance** of different LED luminaires:

As a user of LED luminaires it is important to apply the same set of standardised quality criteria when evaluating manufacturer's claims. Users of LED luminaires should ask for LED luminaire specifications measured in compliance with the new IEC/PAS documents. This will allow you to judge comparison claims on an equal, like-for-like basis.

2. When considering **performance over time** of a LED luminaire:

Look for luminaire life based on 'lumen maintenance' and 'abrupt failures' of the complete LED luminaire or system.

4.7
Choosing a Supplier
LED suppliers are in abundance today, the market is getting more and more competitive and consumers should be able to shop around for the right product at the right price. We recommend always getting at least three quotes to ensure competitiveness.

The Carbon Trust have a document titled 'CTL164 How to implement LED lighting'. They provide some questions to ask when choosing an LED supplier;

1. Are the LEDs fully CE marked and is there a genuine Certificate of Conformity available?

2. How long has the supplier been in business? How many LED installations have they done?

3. What lighting qualifications or experience has the supplier got? Can the supplier provide references, and / or previous case studies?

4. When are LEDs not appropriate? Can we change one or two lamps before changing them all?

Assessing both the supplier and the product should ensure you get the best deal for your company.

4.8
LED Development
From the beginning of the LED revolution there have been many examples of poor quality, where a well-meaning business person has decided to save money on energy and replace existing lighting with an LED type, only to be left with a poorly lit space. These bad experiences coupled with uncertainty and mistrust over exaggerated claims by manufacturers have put some businesses off investing in this technology. In the early days of LEDs colour rendering was very much a trade off with luminous efficacy, as a result many companies still believe that going LED means compromising on colour quality. However, if you can avoid the cheap low quality products this is not the case as many LEDs are now outperforming their traditional counterparts and have proved their worth.

Overall, LED technology today has been significantly tested and developed, suppliers are much more transparent with their information and consumers have an awareness on what they should be looking for. There is always a certain risk when you invest in a new technology but with improved quality, warranties, funding opportunities and/or tax breaks (See Section on Implementation & Finance) there is a good level of trust today in this technology.

5 Lighting Applications

5.1
Background
The installation of a new lighting system will usually occur in one of three scenarios;

1. New Build

2. Refurbishment

3. Retrofit

The objective will always be the same - delivering an energy effective lighting installation necessary for a particular application;

- Ensuring that the combination of lamp type, control gear and luminaire is the most efficient to meet the practical requirements.
- Using modern luminaire technology to provide required illuminance levels usually with fewer lamps or luminaires as any existing system.

The key for any designer is to identify the most practicable measures to achieve the savings and provide a solid financial case for same.

The standard design criteria still applies in all of these situations, however there may be specific restrictions to consider for each application.

This section identifies what the different terms above mean within the construction industry and any specific advice for each application type.

5.2
New Build Design
Perhaps the easiest of these scenarios is the new build project – starting from scratch with a clean slate. With this blank canvas there are usually no site restrictions to consider – i.e. a new wiring and distribution system will be provided so the designer is free to propose the most efficient layout and controls available. You also have the opportunity to design with furniture and layouts in mind – providing the right amount of light in the right place. From the beginning there should be a focus on the long term cost implications of the lighting system e.g. operational costs and maintenance costs. The obvious constraint placed on the project will be the capital expenditure limit but if you remember to factor in the life cycle costs of the system it should be easy for you to identify the best solution.

5.3
Refurbishment
Refurbishment schemes can take many forms and may be undertaken for a variety of very different reasons. The works may include a large part of the overall building services or it may just be focused on the lighting system. In any instance if done correctly it can be used to reduce energy consumption and provide better lighting than prior to the refurbishment.

Before beginning any refurbishment works it will be necessary to plan a strategy i.e. exactly what is the goal to be achieved. Typical refurbishment strategies for a lighting scheme are to:

1. Approach it as a complete redesign with new luminaires, controls and new layout, taking into account any wiring alterations that may be required to facilitate same.

2. Replace the luminaires but retain the existing layout, controls and wiring.

Your strategy must take into account whether the current system meets the needs of the space users. Whilst simple modifications can deliver energy savings, if the existing lighting system hasn't been sufficiently reviewed then any issues or problems will remain.

The refurbishment strategy should take into account the following design considerations;

- Are the current lighting levels adequate for the tasks being performed? You may wish to have these checked with a light meter.
- What is the age of the existing lighting system and what are the current maintenance requirements?
- Are the controls for your lighting system sufficient?
- Would your business benefit from a new lighting layout? Many businesses move into existing buildings and may have not have made any changes to the lighting scheme – redesigning a layout to suit your plan would be beneficial.
- What level of building work will be required to facilitate the works? Take into consideration the type of ceiling you have i.e. a new lighting layout for plasterboard ceiling will require cutouts, covering up existing holes and repainting.
- Are alterations to the wiring system feasible? Are there existing busbars/distribution systems which can be easily modified?
- Identify your current emergency lighting system and what the refurbishment implications will be for same.

Today, even lighting systems that are only 5 to 10 years old could benefit from some form of refurbishment as the installation of modern technology can often result in significant energy savings.

Below is a table identifying typical lamp replacement options for each common type of lighting identified in Section 3.

Type of Lamp	Typical Replacement Options	Benefits
Incandescent / Filament 	– CFL – LED	– 75% energy saving with CFL – up to 90% energy saving with LED – longer lamp life with each
Tungsten Halogen 	– CFL – LED	– 80% energy saving with CFL – up to 90% energy saving with LED – longer lamp life with each
Metal Halide 	– LED	– up to 5 times the lamp life – up to 50% energy savings – new luminaire required
High Pressure Mercury 	– Metal Halide – High Pressure Sodium – Induction – LED	– plug-in lamps can be retrofitted with equal-wattage lamps to mercury control gear. – increased light output 45 – 65% – higher colour rendering with metal halide – 12-15% energy savings with high pressure sodium – lower wattage to achieve the same light – longer lamp life – lower wattage to achieve the same light – much longer lamp life – up to 5 times the lamp life – up to 50% energy savings – new luminaire required
High Pressure Sodium 	– Metal Halide – LED	– plug-in lamps can be retrofitted with equal-wattage lamps – good colour rendering with metal halide – up to 5 times the lamp life – up to 50% energy savings – new luminaire required
Low Pressure Sodium 	– LED	– up to 5 times the lamp life – up to 50% energy savings – new luminaire required

Note: Where LED will be the replacement lighting system and where illumination level is a key requirement, it is very important to ensure that the illumination level with LED is the same or better compared with the illumination level of the old system.

Type of Lamp	Typical Replacement Options	Benefits
Compact Fluorescent 	– LED	– longer lamp life – up to 30% energy savings – lamp for lamp replacements can be done in some luminaires
Tubular Fluorescent 	– Fluorescent (Replace T12 and T8 with T5) – LED	– up to 10% saving with T8 – up to 50% saving with T5 – longer lamp life – better light output Retrofit adaptors should be considered when upgrading lamps to T5 as they eliminate the need to replace the ballast and luminaire. Retrofit adaptors should only be used to convert lamps utilising switch start control gear. T12 to T8 versions are available, however replacing the luminaire may be a more suitable option – up to 70 % energy savings when compared to a T8 fluorescent tube – lifespan up to 5 times longer than conventional fluorescent tubes – higher efficiency of up to 105 lumens per watt
Induction 	– LED	– up to 5 times the lamp life – up to 50% energy savings – new luminaire required
Light Emitting Diodes (LED) 		In most applications LED lighting is becoming the most efficient solution and the most economical long term replacement solution for other types of lighting

5.4
Retrofit

Retrofitting is the process of changing something after it has been manufactured – in the case of a lighting system this could involve the introduction of more modern technology onto the existing systems;

- **Relamping –** Replacing old fluorescent tubes with new types usually provides an opportunity to reduce wattage output.
- **Remove lamps from multi-lamp luminaires -** This may be possible where lighting levels are considerably higher than the requirement. For example in a corridor you may have a number of downlights with 2x26W lamps – removing one of the lamps from a number of these fittings may still provide sufficient lighting levels. With this type of modification it is easy to play around and find the optimum solution.
- **Replacing ballasts –** Ballasts provide the controlled current for fluorescent lamps. Older type magnetic ballasts can deteriorate greatly over time leading to excessive flickering and increased start up times.
- **Installing controls –** This can be a highly effective retrofit measure.
- **Replace diffusers/reflectors –** Your current lighting may have old diffusers which could have discoloured over time. Replacing these with more appropriate covers / reflectors can significantly boost output.

Again, if done correctly, a retrofit can improve the efficiency of the system. Given the age of much lighting systems stock in Northern Ireland and with advances in lighting technology, retrofits can usually achieve significant reductions in energy usage while also improving light quality.

Typical common retrofit schemes for businesses in Northern Ireland include:

- Replacement of tungsten filament lamps with fluorescent or LED lamps; a 20W LED or a 26W compact fluorescent lamp gives a light output equal to that of an older type 100W filament lamp, provided the illumination level of the 20W LED is the same as that of the 100W filament lamp, and more often than not can easily be retrofitted into the same fitting. Typical LED lamp specifications will include power rating, the equivalent incandescent lamp rating, the operating voltage and frequency, the light colour emitted, its colour rendering index (CRI), luminous flux, operating lifetime, fitting type and whether the lamp is dimmable.
- Replacement of older T12 fluorescent tubes with T8 energy saving tubes.
- Replacement of T12 and T8 switchstart fluorescent luminaires with new high frequency T5 fluorescent luminaires.
- Introduction of high-frequency control gear for switchstart fluorescent lighting - typically using 10% less electricity than the mains frequency equivalent. Retrofit kits can be utilised to convert the existing fluorescent luminaire in order to install T5 fluorescent or LED lamps.
- Plug in Ballasts: These can be fitted directly onto the ends of standard T5 tubes and will provide the appropriate ballast and increased tube length to enable operation with existing fittings. This solution avoids any inconvenience and disruption caused by installing new luminaries and the use of these products can offer energy savings of between 25 and 56%.
- LEDs can easily replace most display and directional lighting. However, some consideration needs to be given to the existing luminaire. If the installed lamp operates at 12V DC (Low Voltage) it will be supplied by a transformer. Some LED replacements claim compatibility with existing control gear but a trial should always be carried out especially when considering a larger scale project.

Some of the more common problems that come from replacement projects are;

The new lamps are flickering - *Check the control gear is compatible*.

The new lighting is not bright enough - *The supplier's claims for equivalence are wrong or the change in luminaire type has changed the appearance*.

The lighting control system no longer dims smoothly, or at all - *The replacements are not compatible with the existing controls*.

Refer to the previous table for examples of retrofit lamp options. Attached to this Guide are sector specific guidelines which identify replacement options for typical lighting types found in the hospitality and industry sectors.

When implementing a retrofit project you may wish to consider doing one test area initially. This should allow you to establish if the lighting levels and quality of light is sufficient or if a larger refurbishment project would be warranted. Very often you will find that replacing tungsten filament lamps with LEDs or CFLs will provide a different light output and distribution which may/may not be acceptable.

In both instances of refurbishment and retrofit it may also be practical to consider some sort of upgrade to internal finishes i.e. cleaning surfaces – including any glazing and rooflights or painting walls and ceiling with a bright colour. Any of these improvements alone can significantly boost light reflectance and generally improve visual conditions.

5.5
Legislation
For lighting systems the main legislative requirements for energy efficiency are the current Building Regulations – **Northern Ireland Part F Technical Booklet - Conservation of Fuel and Power for buildings other than dwellings**.

All other publications provide guidelines for designers including those from **The Society of Light and Lighting and the Lighting Industry Association**.

The Construction (Design and Management) Regulations 2007 also known as **CDM Regulations** or **CDM 2007**, define legal duties for the safe operation of UK construction sites. The regulations place specific duties on clients, designers and contractors to plan their approach to health and safety. The regulations apply throughout the life of a construction project, from its inception to its subsequent final demolition and removal. Within the Designers Guidelines it specifically states under Section 2.6 Hazard elimination and risk reduction - What should be considered?

"*Clearly there will be some variation with the project type and consequently other issues may also be important, for example avoiding lacerations through the careful specification of sheet metal components in fit-out projects; or avoiding poor location of lighting units, from a maintenance perspective, in hazardous environments, for example close to works with open tanks.*"

New Construction (Design and Management) Regulations 2015 (CDM 2015) came into force in GB on 6 April 2015. It is envisaged that the new Regulations will come into force in Northern Ireland mid to late 2015.

5.6
Maintenance
When it comes to a new lighting system, maintenance is not just something to be considered further down the line - there are important maintenance factors to consider when designing a new system;

- Luminaire position – as highlighted in the CDM Regulations consideration should be given to mounting positions where maintenance of luminaires is difficult, for example in a stairwell. In this instance wall mounted luminaires rather than ceiling mounted could easily be used to provide the required illuminance levels.
- Lamp life – with today's technology there are many low energy lamps with long lamp life expectancy which are suitable for all types of mounting heights and applications. Where possible preference should be given to these types when designing.
- Specify any suitable attachments e.g. reflector, diffuser which may help to reflect light effectively.
- Where possible choose luminaires that provide easy access to the lamp and are easy to clean.

Implementing a good quality lighting system is just the beginning of the journey – to keep your system operating as efficiently as possible for many years to come it is vital to have a clear maintenance regime in place. Regular maintenance is essential to ensure that your business retains the desired quantity and quality of light which can yield a range of benefits including a brighter and more attractive workplace, increased comfort levels, and even enhanced productivity.

Lack of knowledge about a lighting system can cause problems when it comes to maintenance - simple things like replacing expired lamps with inappropriate types can greatly affect the light output and quality of a system. In fact, very often we find lighting systems are neglected. With no set maintenance programme in place any improvements or good design qualities will have been lost over time.

If you are retrofitting or refurbishing an existing system write down your current maintenance requirements and identify if there are any specific areas which require improvement.

The main points to consider when drawing up your maintenance plan are;

- Cleaning luminaire parts – this includes any exposed lamps, covers, reflectors, diffusers. How often you should undertake this depends on the type of business and ease of access? It should usually range between 6 – 24 months. One option for maintenance staff to clean luminaires is to wipe surfaces when changing lamps.
- Consider how often you will replace lamps – for large businesses which may have high mounted fittings it may not be feasible to replace every lamp as it expires but rather wait until there are a certain number of lamps which need replacing. Labour costs will be more economical - factor in any mobile platforms you may require for this work. Ease of access and the type of business you have will determine this.

- When you are buying replacement lamps, consider bulk buying so you have at least 10% for each lamp type in stock. Very often bulk buying is more economical anyway.
- Consider the average lamp life of your system – some lamps deteriorate significantly over time and although they are still providing light, the actual output may have reduced somewhat enough to warrant replacement. Replacing all the lamps in a lighting system at the same time can sometimes save labour costs while maintaining your desired illumination levels will also avoid stressing ballasts with failing lamps.
- Identify what disposal costs are associated with your system. Under the Waste Electrical and Electronic Equipment (WEEE) Regulations, all lighting equipment, other than filament lamps and that in domestic premises, is considered to be hazardous waste and has to be disposed of appropriately. As an equipment user it is important to dispose of expired lamps properly as many fluorescents and other electric discharge lamps contain mercury. Establish what would be the best disposal solution for your company – either taking them to approved recycling centres or arranging for pickup from a specialist company.
- Assess each area for decoration and light reflectance opportunities. How often would each area benefit from a new paint job? We would suggest roughly every 2-3 years. Alternatively, can the surfaces (walls, ceiling and glazing) be cleaned down? Try and avoid dark colours especially where you are trying to provide higher illuminance levels.

Remember – your emergency lighting system requires a separate maintenance regime depending on the type of system you have. Check with your electrician on the requirements for your business. Or if you have operations and maintenance (O&M) manuals* available for your building you should find details of the maintenance regime for your system here.

When it comes to new build projects we would expect a full O&M manual to be provided on building handover. This should include details of your lighting system as follows;

- Schedule of luminaires with associated floor plans as installed drawings.
- Schedule of lighting controls with associated floor plans as installed drawings.
- Schedules for cleaning luminaires.
- Schedule for replacing lamps and ballasts.
- Sources and contact details for replacements.
- Lighting (design and installed) illuminance levels for each area.
- Lighting control and wiring diagrams.
- Procedures for the adjustment of controls and occupancy sensors.
- An overview of correct disposal procedures for lamps and ballasts.

Ideally, even if you are undertaking a retrofit or refurbishment project you should ask your installer to provide the information as listed above. Having this level of detail available makes it easier to troubleshoot any issues that come up in the future and can be used as an aid to prepare for any proposed upgrades and as a tool to implement an effective maintenance regime.

* Operation and maintenance manuals contain the information required for the operation, maintenance, decommissioning and demolition of a building. They exist for a reason and they should be adhered to. Contractors have a specific duty in the CDM Regulations to pass the Health and Safety File to the Principal Contractor, who in turn has to pass it to the CDM Co-ordinator. This information could include 'as built' and 'as installed' drawings as well as operation and maintenance manuals.

5.7
Lighting for your future

Developments in technology are happening at an incredibly fast pace as demonstrated by the development of LED technology. Wasted energy is now a focus and is regarded as a design imperfection and something which can be designed to a minimum. Being aware of carbon emissions associated with lighting is also increasingly important as environmental pressures grow. Consumers are now selecting products which take into account the overall lifecycle of the product and not just that which offers a 'quick fix'.

6 Lighting Efficiency Action Plan

6.1
Background
Lighting technology is an exciting and rapidly changing area that is improving every day. With a clear action plan in place, there is enormous potential for energy savings and environmental benefits through embracing energy efficient technologies. Developing an action plan for your business will realise economic and environmental benefits through;

- a reduction in lighting energy consumption.
- a reduction in the use of inefficient lighting.
- long-term behavioural changes of employees towards the adoption of efficient lighting practices.
- recognition of benefits though increased knowledge of new efficient lighting technologies.
- maintained or improved quality of lighting for your business.

After you carry out your survey and identify opportunities for your business you can set out some initial goals – some examples are;

1. Eliminate inefficient incandescent (GLS) lighting

2. Eliminate inefficient halogen lighting

3. Eliminate inefficient fluorescent lighting

4. Eliminate inefficient mercury vapour lighting

5. Increase the use of appropriate controls and efficient lighting design

6. Eliminate inefficient street lighting installations

You can prioritise these goals to suit your business.

This section provides some specific advice for domestic and non-domestic situations on energy saving lighting technologies and practices available. This should guide you with preparation of your own action plan.

6.2
Lighting Efficiency Opportunities – Domestic
Instilling an energy awareness ethos does not just relate to work situations. Being aware of energy saving opportunities at both home and work will enable you save money on not only business energy charges but also your household bills which have been subject to the same energy price increases over the last few years.

Every individual has different preferences of what type of lighting they prefer and often when building a new home the lighting is designed as a major feature. Some people prefer pockets of local light for a homely feel and others a bright and airy feel.

The problem with the latter can lead to lighting being overdesigned and in such cases finding the right balance between aesthetics and functionality can be difficult.

Household lighting generally falls under the following headings;

- **General light -** typically described as ambient lighting and usually in the form of a single central light. A general light is the light that you switch on to give you enough light to see when you are in the room.
- **Mood lighting -** this may be table lamps, wall lights or picture lights that give added interest and highlight interesting objects or features within the room. This type of lighting allows you to add personality and character to a room.
- **Task lighting -** this is brighter light focused where you need it and when you need it. The most common use of task lighting is as a reading light, or in the kitchen this could be under-cupboard lighting to give lots of light on the worktops.

This section identifies some simple lighting efficiency measures you can implement in your home.

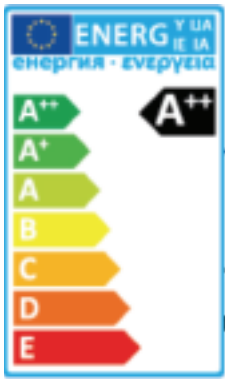
If you are designing lighting for a new home or as part of a major refurbishment the following design criteria are worth considering for a low energy lighting system:

- Consider the amount of light you need for the size of the room – factor in the ceiling height.
- How much fixed lighting do you need? Could you supplement this with some local lamps?
- Consider the amount of natural daylight the room will receive, what aspect it is, whether north or south facing etc. For example, a north facing room will only receive the minimum amount of light even in summer. During winter months however, it could be practically dark after mid-day so more lighting fixtures with a higher illuminance level will be needed especially if it is one of your habitable rooms.
- The colour of the room surfaces should also be borne in mind. If the room is to be painted in dark colours you will also need to increase your light level as dark colours absorb light, whilst lighter colours help to reflect light.
- When adding a lamp shade to any fixed lighting consider the colour and how it will affect the light output.

- Consider the functionality of the room. A kitchen/diner will need brighter lights, such as spotlights, for the food preparation area. You don't want to be preparing food in a dimly lit room.
- In larger habitable rooms consider dimmable lights with dimming switches for your lighting so you can adjust the level as required.
- In all lighting designs it is recommended that you have layers of light - this will provide you with a level of flexibility to control your light and create a different ambience and feel in the room for different situations. For example, a good general light level plus mood lights for areas of interest and task lighting for reading, homework, cleaning and cooking where a brighter light output is needed.

The following points are simple ones to remember and implement when it comes to retrofitting and carrying out a simple upgrade of your lighting system at home;

- Compact Fluorescent (CFL) light bulbs provide a soft, warm, energy efficient light, with very long life and reduced operating costs. These can easily be purchased in local supermarkets and will usually replace any old style filament bulbs which can be found in general, mood and task lighting around your home.
- LED bulbs can also be used today as replacement for filament bulbs, provided LED illuminance level is the same if required. LED bulbs are more expensive than CFL replacements but are very long life and will have more reduced operating costs.
- LED type fittings can usually be used as replacements for fixed spotlights. In some instances you may have fittings which are suitable for LED lamps to be retrofitted, otherwise you will need to replace the complete fitting.
- Check the EU label rating on any replacement bulbs you can find this information on the light bulb packaging. The energy efficiency of the product is rated in energy levels ranging from A++ to E on the label. 'A++' stands for the most energy efficient and 'E' for the least energy efficient.



- Remember to check the type of base your current bulb has as you will need to match this with any replacement.
- The choice of low energy bulbs available on the market today is vast in terms of price but as a general rule we find well-known brand names are generally manufactured to a higher standard and give a longer service life.
- Assess if your rooms would benefit from added mood/task lighting i.e. for activities such as reading etc.
- Ensure there are enough local light switches in strategic places i.e. end of hallways, at doors to rooms etc.
- Be aware of your lighting habits – do you switch lights off when not required and when you leave a room.
- For your external lighting – assess whether a motion sensor would be beneficial so your lighting only operates when required.

6.3
Lighting Efficiency Opportunities – Non-Domestic

The following factors can be considered to contribute to inefficient lighting:

- Low-efficiency lamps.
- Low-efficiency lamp control gear.
- Lack of suitable controls.
- Quick wins are prioritised above whole life costs.
- Lack of knowledge of modern lighting technology.
- Poor performing and/or inappropriate luminaires.
- Poor application design (not designed for the right layout or purpose).

This section collates the lighting efficiency measures you can implement for your business – these are categorised into those measures that can be done immediately, those that can be done as part of a refurbishment or retrofit project and those that can be done with the implementation of a new lighting system.

Immediate Actions

- Replace old style incandescent lamps with CFLs or LEDs.
- Replace old T12 fluorescent lamps and luminaires with modern T5 fluorescent luminaires.

- Start an awareness campaign – use posters/stickers to promote good lighting practices.
- Train employees on how to use sensors, timers, and dimmers if these systems are installed.
- Check for defective lamps and replace.
- Install dimming ballasts if appropriate and if compatible with lighting system.
- Switch off lights that are not in use – work with employees to make this a habit.
- Turn off all lights at night with the exception of security lights and exit signs.
- Turn external lights off when not required – check current settings. Usually timeclocks will need to be manually changed for seasonal variations.
- Delay turning lights on in the morning until staff arrive.
- Reduce lighting when there is adequate daylight – you may be able to remove lamps from multi lamp fittings. Conduct trials to decrease lighting use where lights are not necessary or where daylighting can replace lights.
- Check all settings for timer controls, photosensors, and motion sensors.
- Clean luminaires – include all parts, lamps, attachments etc.
- Consider the decoration in a room – would it benefit from painting/cleaning.
- Clean windows and rooflights.
- Keep notes and records on maintenance requirements.
- Use benchmarking data to compare lighting energy consumption with similar building types.

Refurbishment/retrofit actions

All immediate actions listed above are also applicable here along with the following:

- Consider if the current level of lighting is really necessary and if the illuminance level can be reduced.
- Replace luminaire attachments (diffusers) as they age, if necessary.
- Evaluate opportunities to upgrade to more efficient lighting.
- Replace standard halogen lamps with high-efficacy CFLs or LEDs. Ensure illumination levels are the same if required.
- Replace electromagnetic ballasts on fluorescent lighting with electronic units.
- Replace inefficient Mercury Vapour luminaires with HP sodium, metal halide or high-wattage CFL lamps and luminaires.
- Consider fitting low-cost automatic controls (e.g. timer controls, dimmers, daylight sensors and/or motion sensors) especially in less frequented and transient spaces.
- Consider increasing local lighting levels at workbenches etc. and reducing background lighting levels (i.e. task/general lighting).
- Commission or re-commission timer controls, photosensors, and motion sensors.
- Establish a metering system to monitor lighting energy use.

New build actions

- Seek advice from experienced and qualified lighting design professionals. Insist on best practice energy efficiency as a primary design feature.
- Ensure life cycle costs are considered in addition to capital costs as part of the design.
- Ensure automatic controls are installed where possible (e.g. dimmers, occupancy, proximity and daylight sensors).
- Ensure current building control regulations for lighting efficiency and metering are all adhered to.
- Use LED lights where suitable and include in your emergency lighting system i.e. on exit and emergency signs.

6.4
Next Steps

When you are ready to take action for your business you can draw up an action plan – ideally this will include both short and long term actions and if possible each recommendation should be assigned to a member of your energy team. You may find that there are quite a number of low cost measures which generate energy savings just from optimising your existing lighting system including increasing awareness, changing lamps, responding to occupancy patterns, improving maintenance characteristics of the installation, and making full use of controls.

Opportunities to improve the efficiency of your lighting arise at different times, depending on the cost and complexity of the actions required. Factors include cost and complexity and also the age and condition of the existing installation. There are actions that can be taken immediately to improve efficiency, but for some businesses actions may best be taken when a lighting system requires maintenance, such as when lamps need replacement. Where possible carry out a trial period with a new lighting type - most suppliers these days are willing to provide sample fittings for you to test.

Using the information in this guide you should be able to draw up an action plan for your business.

Attached to this guide in Appendix C is a template action plan.

7 Monitoring and Targeting

7.1
Background
It is well documented that 'you can't manage what you don't measure'. Monitoring and targeting provides you with the know how to enable long term management of your energy use.

For your business, knowing and understanding your lighting system and the operational costs associated with same is a good start. These figures provide a base point from which you can monitor any savings from alterations/ improvements.

The true financial value of a monitoring and targeting system relies on energy cost reduction due to making full use of additional data about energy consumption.

7.2
Metering, Monitoring and Targeting (M,M&T) systems
Metering plays a central role in monitoring and targeting. For example;

- Automatic meter-reading (AMR) systems are very common today and have become less expensive and more cost effective in recent years. This eradicates the need for time-consuming and expensive manual reading that can provide irregular and inaccurate data.
- Portable electric data loggers - used only in cases where AMR systems are not practical or feasible.

Ideally, all types of energy consumption should be directly metered, but this is not always practical or cost effective. To comply with building regulations reasonable provision must be given to the installation of energy metering systems for new installations which measure 'at least 90% of the estimated annual energy consumption of each fuel to be assigned to the various end-use categories (heating, lighting etc)'.

Detailed guidance on this is given in **CIBSE TM39: Building Energy Metering**. **http://www.cibse.org/knowledge/cibse-tm-(1)/tm39-building-energy-metering**

Invest NI have recently published a Best Practice Guide to Metering, Monitoring and Targeting which can also be used as a reference tool.
http://secure.investni.com/static/library/invest-ni/documents/best-practice-guide-metering-monitoring-and-targeting.pdf

Minimum metering standards for lighting which are set in the NI building regulations come from the Non-Domestic Building Services Compliance Guide 2010. They state;

The recommended minimum standards for metering of general and display lighting in new and existing buildings are;

a) kWh meters on dedicated lighting circuits in the electrical distribution; or

b) local power meter coupled to or integrated in the lighting controllers of a lighting or building management system; or

c) a lighting management system that can calculate the consumed energy and make this information available to a building management system or in an exportable file format. (This could involve logging the hours run and the dimming level, and relating this to the installed load.)

It is generally cheaper to include metering as part of the design of a new building than to retrofit them at a later stage.

The simplest way for an average small business to comply with building regulations is to provide a separate lighting distribution board and install a simple check meter which will record kWh consumption. Your electricity is billed in kWh consumption from your supplier; this will allow you to apportion how much of this is attributed to lighting. Ultimately separate metering of the lights gives the best feedback and control on energy consumption rates.

Adhering to regulations will provide the minimum metering requirements. However, developments in metering technology have seen the introduction of monitoring and targeting software packages which accompany and complement metering systems. Furthermore, advances in equipment mean modern systems use wireless technology which is easy to install and retrofit into existing buildings. These smart metering systems physically interface with existing distribution equipment on the site and feed consumption data to a central computer.

It is important to note that while a lot of the M&T software packages that come supplied with AMR hardware may provide you with consumption charts and profiles, not all will provide you with the ability to set targets. Periodic monitoring and reporting will quickly highlight factors which affect your consumption and allow you to address them immediately.

Savings of 5–10% of energy use are typically achievable with effective metering supported by monitoring and remedial action.

Metering systems which are proven to have this full monitoring and targeting function are eligible for application to the Carbon Trust 0% interest loan scheme. More information on the loan scheme and eligible technologies can be found on the **Carbon Trust website**; **http://www.carbontrust.com/client-services/northern-ireland/loans-eligibility**

7.3
Benchmarking
Benchmarking is a tool that supports continued business improvement – it is a level of performance with which we can compare ourselves. Today, it is increasingly commonly used when assessing energy efficiency.

Benchmarking can play an important role in the effective use of advanced metering data. Once you have gathered your reference data for your existing lighting consumption comparisons can then be drawn between this data and a relevant benchmark. Having an understanding of your consumption profile relative to industry standards can provide a valuable reference for what can be achieved.

CIBSE Guide F Energy Efficiency in Buildings 2012 provides the most comprehensive set of energy benchmarking data for different applications. The most common type of benchmarking provided in this document is annual kWh consumption per m^2 (gross floor area) for both fossil fuel and electricity consumption. Typical practice and good practice consumption figures are provided for a wide range of sectors which allows you to benchmark your consumption against the most relevant sector figure. For some applications such as offices, hotels and mixed use/industrial buildings consumption figures have also been provided for end use services e.g. lighting benchmarks detailing typical practice and good practice figures in annual kWh consumption per m^2.

More often than not in existing buildings where there is no separate metering of services the only benchmarking is simply the overall thermal fuel and electricity figures. If you have been able to create an accurate lighting profile with estimated consumption for your current lighting system you can use this data to compare to the industry benchmark for your sector.

Attached to this guide are sector specific guidelines which detail standard lighting benchmarks for hospitality and industrial businesses.

7.4
Management of Consumption
To summarise - there are four main steps when it comes to the process of monitoring and targeting;

1. Data Collection – Your electricity bill will give you the total kWh consumption for your business. To establish the kWh consumption for your lighting system it is preferable to use any metering data whether it be AMR or manual. As a last resort you can use the estimation of your electricity consumption as per the Lighting Profile process in Chapter 1.

2. Data Analysis – If you can collate separate metering data for your lighting system, then a direct comparison can be made, such as the actual kWh used for lighting versus the ‘good practice’ and ‘typical’ benchmark values for lighting. Targets can be set and it may be possible to identify any potential savings and make improvement plans.

3. Reporting – This will include periodic consumption reports which should provide a summary of usage and details of where targets have been met and/or exceeded.

4. Action – No M,M&T system is truly useful unless action is taken to make effective use of the data that you have been provided with.

Your business approach to Metering, Monitoring and Targeting should form part of any company energy policy strategy and should have the full commitment of your energy team and management.

8 Implementation and Finance

8.1
Background
Investing in an energy saving project makes good business and environmental sense. There are a number of support options available for businesses in Northern Ireland when it comes to implementing energy saving technologies.

When assessing the economic viability of your preferred lighting solution you should always establish what support is available, what your business is eligible for and factor in the following where applicable;

- Loans
- Grants
- Tax Incentives

This section provides some details on the current services available for businesses in Northern Ireland. It is always worth keeping up to date with current offers as these are often not widely marketed and are subject to changes according to funding etc.

8.2
Loans
CARBON TRUST 0% INTEREST LOAN
Interest free business loans are available to business sites in Northern Ireland for organisations wishing to invest in low carbon equipment and energy saving projects. Full details on eligibility and the application process for the loan scheme are provided on the Carbon Trust website and are summarised as follows;

- Any business in Northern Ireland can apply (except public sector organisations).
- To be eligible you must be either Incorporated businesses trading for at least 12 months and Non-Incorporated businesses trading for at least 36 months (this will include charities, friendly societies, clubs and the like).
- Your business can borrow between £3,000 and £400,000 interest free to buy energy-saving equipment – Multiple loans are available up to the maximum loan amount.
- You can get £1,000 of loan for every 1.5 tCO2 saved per annum for a project.
- The savings you make on energy bills should offset your loan repayments, meaning the low carbon equipment will pay for itself - the size of loan and your repayments will be assessed individually by the Carbon Trust.
- The minimum expected savings for an eligible project are 4.5 tCO2 and £3,000 capital expenditure.
- Loans are Government-funded and unsecured.
- Loans are easy to apply for and arrangement fees are not charged.
- You will receive a conditional offer within 24 hours of your application being processed and you can track its progress online.
- You have up to four years to repay your loan.

8.3
Tax Incentives
The Enhanced Capital Allowance (ECA) Scheme is a key part of the Government's programme to manage climate change. The scheme enables businesses to claim a 100% first year capital allowance on investments in certain energy saving equipment that meets published energy-saving criteria, against the taxable profits of the period of investment.

For a product to be eligible for ECAs e.g. boiler, compressor, variable speed drive etc. it must meet specific energy saving eligibility criteria. A full list of all current eligible products categorised into specific technologies is found on the Energy Technology List (ETL). In order to claim an ECA, a product from this list needs to be selected at the time of purchase.

The ETL comprises two lists: the Energy Technology Criteria List (ETCL) and the Energy Technology Product List (ETPL). The ETCL defines the performance criteria that equipment must meet to qualify for ECA scheme support; the ETPL is the list of products that have been assessed as being compliant with ETCL criteria. However, lighting equipment is an exception to the rule and is not listed on the ETPL.

On the ECA Energy Technology List lighting falls into three categories;

- Lighting Controls - products that are specifically designed to switch electric lighting on or off, and/or to dim its output.
- High Efficiency Lighting Units - products that are specifically designed to provide efficient illumination.
- White Light Emitting Diode Lighting Units - products that are specifically designed to provide white light by means of solid-state lighting devices.

For each of the categories a criteria document has been provided which lists eligibility and performance criteria. Investments in lighting products can only qualify for Enhanced Capital Allowances if the products meet the

eligibility criteria set out within these documents. Businesses should look at the standards set for each of these categories and then liaise with suppliers and manufacturers to ensure that the products they are purchasing meet the criteria.

Below is a working example of a hypothetical situation for replacing an existing lighting system with a proposed low energy alternative;

1st step
Calculating the tax allowance for ETL-listed equipment will be business-specific based on the following:

- The value of your capital expenditure - **£9,500**
- Enhanced capital allowance (ECA) tax relief for ECA equipment is **100%**
- The rate of corporation or income tax for your business – **20%**

ECA Tax Allowance = Capital expenditure x 100% x Rate of corporation tax

ECA Tax Allowance = £9,500 x 100% x 20% = £1,900

2nd step
To calculate the payback period for ETL-listed equipment you will also need:

- The unit price (£/kWh) of the energy your business consumes.
- Current energy usage (kWh) and running cost (£) for your equipment.
- Current maintenance costs incurred by your business for your equipment.
- Estimated energy usage (kWh) and running cost (£) for the ETL proposed equipment solution(s), which the manufacturer or supplier should be able to help you with.
- Estimated annual maintenance costs incurred by your business for the ETL-listed equipment (your manufacturer or supplier should be able to help you with estimates).
- Overall annual cost saving = (existing equipment running cost + maintenance cost) minus (proposed equipment running cost + maintenance cost).
- Installation costs associated with new equipment.
- **Electricity average unit cost £0.1182/kWh**
- **Current lighting electricity consumption = 70,921kWh = £8,382.86**
- **Current lighting maintenance costs = £1,500**
- **Estimated electricity consumption for proposed lighting = 42,645kWh = £5,040.64**
- **Estimated lighting maintenance costs for proposed lighting = £600**
- **Overall annual cost saving = (£8,382.86 + £1,500) - (£5,040.64 + £600) = £4,242.22**
- **Installation cost for proposed lighting = £2,000**

$$\textbf{Payback Period} = \frac{\left(\text{Capital expenditure} - \text{Tax Allowance}\right) + \text{Installation Cost}}{\text{Annual Saving}}$$

$$\textbf{Payback Period} = \frac{(£9{,}500 - £1{,}900) + £2{,}000}{£4{,}242.22} = 2.3 \text{ years}$$

If you consider the above calculation without the ECA tax allowance i.e. a replacement lighting system which is not found on the ETL the simple payback calculation would equal 2.7 years – that is a difference in the expected payback period of five months.

It is clear that it is economically beneficial to choose energy saving technologies which are included on the energy technology list. Always consult with your supplier/ manufacturer and let them know you are looking for approved ECA products.

For full details of the scheme, how to claim and a current list of eligible products on the Energy Technology Product List please refer to the **ECA website**; **https://etl.decc.gov.uk/etl/site.html**

You will also find tax relief details on the **HM Revenue and Customs website**; **http://www.hmrc.gov.uk/incometax/relief-capital.htm#1**

8.4 Grants

NORTHERN IRELAND SUSTAINABLE ENERGY PROGRAMME

The government together with energy suppliers via the **Northern Ireland Sustainable Energy Programme (NISEP)** provide grants for businesses and households in Northern Ireland to implement energy-saving measures. Schemes usually run in conjunction with the financial year - 1 April – 31 March.

For full details of the NISEP programme and the current programme of grants available check the Utility Regulator NI website; **http://www.uregni.gov.uk/publications/show/category/sustainability**

(The Utility Regulator is responsible for regulating the electricity, gas, water and sewerage industries in Northern Ireland, promoting the short- and long-term interests of consumers.)

Currently there are seven electricity suppliers in Northern Ireland and most of these provide energy saving advice services for their customers. Also, if you are applying for a NISEP funded grant it will be managed and operated by one of these suppliers and you should find full details of eligibility criteria and how to apply on the supplier's website. It is important to note that you do not have to be a customer of this supplier to be eligible to apply for a NISEP grant. By accessing the Utility Regulator website you can identify which supplier is managing which grant programme.

Below are some quick links to electricity supplier websites;

- **Power NI**
  http://powerni.co.uk/saving-energy/business-saving-energy/
- **Energia**
  https://www.energia.ie/Business/NI/Energy-Efficiency/Energy-Efficiency-Grant-Scheme
- **Electric Ireland**
  https://www.electricireland.ie/ei/business-energy-services/energy-consultancy/grant-information.jsp
- **Airtricity**
  http://www.airtricity.com/uk/business/energy-management
- **Budget Energy**
  http://www.budgetenergy.co.uk/Energy-Saving-Advice.aspx
- **LCC Power**
  http://www.lccpower.com/
- **Firmus Energy**
  http://www.firmusenergy.co.uk/

INVEST NI RESOURCE EFFICIENCY GRANT

Invest NI will periodically open calls for applications for Capital Grants of up to £40,000 to support those SME businesses already being supported by Invest NI to purchase/install new equipment to reduce their water and materials costs.

Invest NI will issue calls for proposals through its client teams and applicants must return applications by the specified date. If applications do not present the information requested they will be held back until the next call for proposals or until such times as all the information requested is provided.

Applicants will be required to assess and state the level of energy savings associated with projects as well as define the likely water and material savings in the application form.

All projects will be assessed to determine their potential economic impact through an appraisal of suitability/appropriateness of the project, eligibility of project costs, displacement, viability and availability of balance of funding.

To keep up to date with available funding support from Invest NI check the **Find Funding** section of the **Invest NI website** or speak directly with your Invest NI Client Executive; **http://www.investni.com/support-for-business/funding-for-business.html**

9 Signposting Data

The following section provides signposting for sources of details and advice on lighting energy saving measures for businesses in Northern Ireland.

9.1
Invest NI Sustainable Development Team
Invest NI can provide tailored support to qualifying businesses to assess and reduce energy, water and materials costs. Please do not hesitate to contact Invest NI for further assistance to support your company in becoming more energy efficient.

Invest Northern Ireland –
Sustainable Development Team
Telephone: 028 9069 8868
Email: sustainabledev@investni.com

Invest NI offers the following support to businesses in NI;

- Impartial advice and information is delivered by Technical Advisors (Invest NI and external) and also through the Invest NI website (**www.investni.com**) and the Northern Ireland business information portal **www.nibusinessinfo.co.uk**
- Invest NI provides a wide portfolio of support for Northern Ireland businesses with a total annual expenditure of more than £30k on water, energy, waste and raw materials. The aim of this support is to improve the competitiveness, productivity and sustainability of local businesses through identification and achievement of cost savings in the consumption of water, energy and raw materials.
- These companies can also access up to five days free technical consultancy to help them take forward projects that will reduce the cost of water, energy or materials in a timely and cost effective way.
- This technical support can address a wide range of questions to help firms progress suitable projects to the point of implementation. For example: identification of cleaner processing technologies; opportunities for using renewable energy or improving energy efficiency; accessing more sustainable water sources; minimising product losses; reviewing packaging requirements or use; environmental or energy management systems; equipment specification and identification of suppliers of more efficient equipment.
- Finance from Invest NI to help companies install new equipment is also available: Interest-free energy efficiency loans of between £3k and £400k are available through the Carbon Trust. The size of loan available will depend on the energy saving potential of any particular project. Please see: **http://www.carbontrust.com/client-services/northern-ireland**
- Invest NI will periodically open calls for applications for Capital Grants of up to £40,000 to support those SME businesses already being supported by Invest NI to purchase/install new equipment to reduce their water and materials costs.
- Invest NI also provides "industrial symbiosis" services which generates opportunities to identify and match excess resource in one business - like waste, transport, storage, skills, production capacity or energy with another where it could be profitably used. Industrial symbiosis activities include business workshops to identify potential matches between business participants along with follow-up visits and engagements with individual businesses to progress matches.
- Support is mostly provided on a "De Minimis Aid" basis. This is aid that may be provided to businesses by EU member states without the Member States having to notify the EU of the provision of the aid. Under the current rules an upper threshold of €200k of aid can be provided to any business in a rolling three year period. For further information see Commission Regulation (EC) number 1998/2006 of 15 December 2006 or visit the EU Europa website **www.europa.eu**

Invest NI has already helped local companies save millions of pounds through tailored advice, consultancy, industrial symbiosis and interest-free loans to help them buy energy efficient equipment. Tailored advice and training is provided on resource efficiency issues and workshops are run across Northern Ireland on energy and waste matters. Invest NI can also signpost you to online information to help your business implement resource efficiency savings.

9.2
Enhanced Capital Allowances
nibusinessinfo.co.uk
Also delivered by Invest NI – this is a free service offering online advice and guidance for businesses in Northern Ireland. This service is delivered on behalf of the Northern Ireland Executive.

The site is simple to use, up to date and practical, providing guidance on regulations and links to access government services. It also has a number of useful online tools, calculators, and best practice case studies; and provides access to funding options, as well as wider support.

There is an extensive separate section on 'environment and efficiency' which includes technology specific advice on lighting and energy efficiency. There are also a number of sector specific energy advice sections which you may find useful.

ENERGY SAVING TRUST
The Energy Saving Trust is a non-profit organisation funded mostly by the British Government in order to promote the sustainable use of energy and reduction of carbon dioxide emissions.

Through their partnerships they offer free, impartial advice to organisations and households on how to reduce carbon emissions, use water more sustainably and save money on energy bills. They work with governments, local authorities, third sector organisations and businesses.

Activities include:

- delivering or managing government programmes.
- testing low-carbon technology.
- certification and assurance for businesses and consumer goods.
- developing models and tools.

For more details go to the Energy Saving Trust website;
http://live.est.precedenthost.co.uk/businesses/northern-ireland

9.3
Other Sources

Invest NI:
Provides information on Invest NI Sustainable Development services.
http://www.investni.com/support-for-business/operating-efficiencies.html

nibusinessinfo.co.uk
Provides information on support and services available for your business –including environment and efficiency advice.
http://www.nibusinessinfo.co.uk/content/environment-efficiency

Carbon Trust:
Provides information on implementation and finance services for organisations.

Provides sector and technology specific energy saving advice.

http://www.carbontrust.com/resources/guides/energy-efficiency/lighting
http://www.carbontrust.com/client-services/northern-ireland

Lighting Industry Association:
Provides information on different lamp types and lighting controls
http://www.thelia.org.uk/

Energy Saving Trust:
Provides free impartial advice to households and organisations on the sustainable use of energy and reduction of carbon dioxide emissions.
http://www.energysavingtrust.org.uk/northernireland/

10 Good Practice Case Studies

The following are example case studies of companies which have implemented lighting efficiency measures and have been able to realise energy consumption cost savings.

10.1
BE Aerospace
BE Aerospace Kilkeel is the largest aircraft seating manufacturer within the BE Aerospace network, the world's leading producer of aircraft cabin interior products with 10,000+ employees and more than 35 major facilities around the world, designing, developing and manufacturing products for commercial aircraft and business jets.

The company had become increasingly aware of the cost of energy to their business and following audits carried out with support from Invest NI and the Carbon Trust the condition and inefficiency of existing systems were highlighted.

Lighting had previously been identified by the company as an area for possible energy savings and the company used the Invest NI programme to gain an independent review of these systems. As part of this process a complete lighting survey was carried out to identify efficiency improvements that could be made with replacement lighting and any associated control systems.

Existing Lighting;
The majority of the BE Aerospace plant had a mixture of switchstart and high frequency batten fluorescent light fittings installed. As part of the factory's maintenance programme the conventional T8 lamps were being replaced, when required, with more energy efficient triphosphorous T8 lamps which was a good start for lighting improvements. However, it was agreed that given the improvements in lighting technology the existing lighting systems were dated and inefficient plus there was an insufficient level of control which was leading to unnecessary wastage and electricity consumption: 80% lighting was wasted across the production areas.

New Lighting;
BE Aerospace used these findings and their own knowledge to implement a lighting replacement project across the site. Lighting was upgraded with the latest energy efficient fitting which operates with a DALI compact fluorescent lamp which is ideal for higher level mountings. The replacement lighting easily substituted the old inefficient lights while maintaining the high level light outputs required for the manufacturing processes. With the new lighting system this was also the perfect opportunity to introduce automatic controls. The new light fittings required no control cabling and each luminaire had daylight and presence sensing – automatically changing lighting levels to suit the environment.

Benefits;

1. (CFL) Compact fluorescent lamps are thinner tube lamps which run at higher output than traditional fluorescent tubes.

2. Modern high-frequency ballasts reduce energy use and heat output, eliminate flicker and hum, and extend lamp life and dimming.

3. The inclusion of programmable DALI ballast and CS425 sensors into the light fitting, which as a combined unit can detect natural daylight as well as physical movement, has seen significant energy consumption and cost savings.

4. Decrease in the number of light fittings across the production areas from 1,075 to 616.

This project was thought to have paid for itself within the estimated three year payback period.

10.2
Enniskillen Hotel
The Enniskillen Hotel opened its doors in December 2011. The building was completely renovated and now includes 35 modern bedrooms, conferencing and banqueting facilities, a comfortable bar area and a whiskey room which houses a collection of speciality and rare whiskeys.

The light fittings in the hotel prior to work being carried out were halogen bulbs and fluorescent tubes. Management employed Belfast Energy Partners Ltd to carry out energy efficiency improvement works which included the installation of a biomass boiler and a full lighting retrofit using LED technology.

The newly refurbished Enniskillen Hotel has used Philips LED luminaires throughout, achieving significant energy savings compared to the previous lighting installation, and with a projected return on investment within 1.6 years.

"With energy prices continuing to rise we wanted to ensure we took all sensible measures to minimise energy consumption without compromising on aesthetics," explained Director David Cadden. "Having already used Philips LED lighting products at our Lusty Beg Island Hotel, using them again for the Enniskillen Hotel was an obvious choice," he added.

The new lighting was supplied and installed by Belfast Energy Partners Ltd. Ray Cunningham recalled: "We worked closely with the hotel to design the lighting and calculate the projected energy savings, which enabled the hotel to qualify for an interest-free loan from the Carbon Trust. Our calculations showed that electricity consumption would be reduced by 138,857 kWh per annum, compared to the original lighting, with financial savings of £19,440 a year. There will also be ongoing savings of over £2,000 per annum on lamp replacement, because of the long life of the LED light sources."

LuxSpace downlighters with a mix of 4W and 6W MASTER LED spot lamps have been used in bedrooms, kitchens and common areas. Colour temperatures of 2700K and 3000K have been selected to create the right ambience in each space. LuxSpace luminaires have also been installed in the main function room, where they are combined with Color Kinetics colour changing fittings and chandeliers from Philips' Consumer Luminaires division. The lighting in the function room is controlled through a Dynalite control system, enabling dimming and selection of a wide range of scenes for different events.

"LED lighting is a no-brainer as far as we're concerned as the financial savings are immediate. It has effectively absorbed the inflationary rises in electricity prices so we have been able to improve the lighting without increasing our running costs," David Cadden concluded.

THE ENNISKILLEN HOTEL

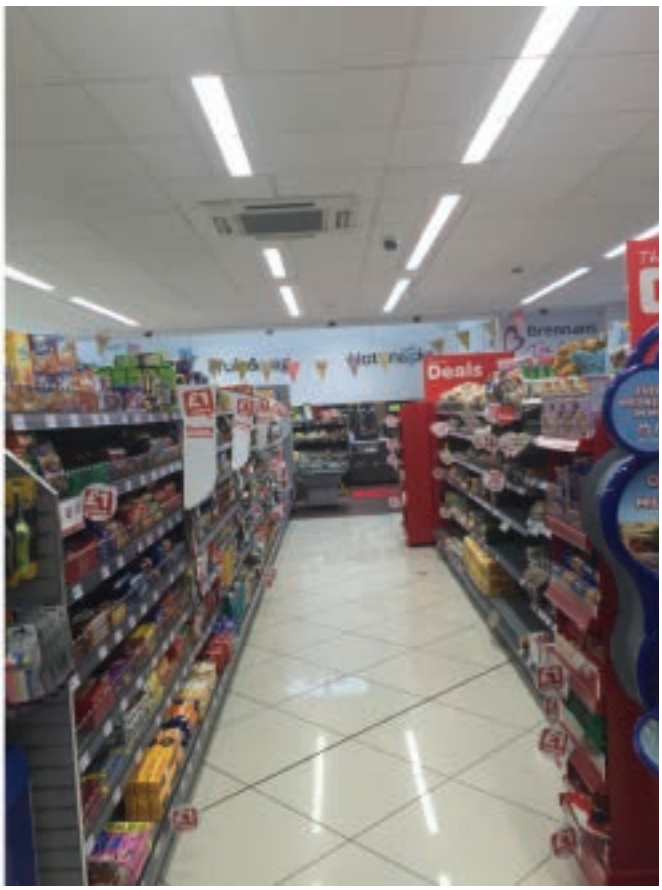
10.3
Brennan's Spar
Brennan's provide a clean, bright, modern, stylish environment, with a good range of products and friendly, efficient service.

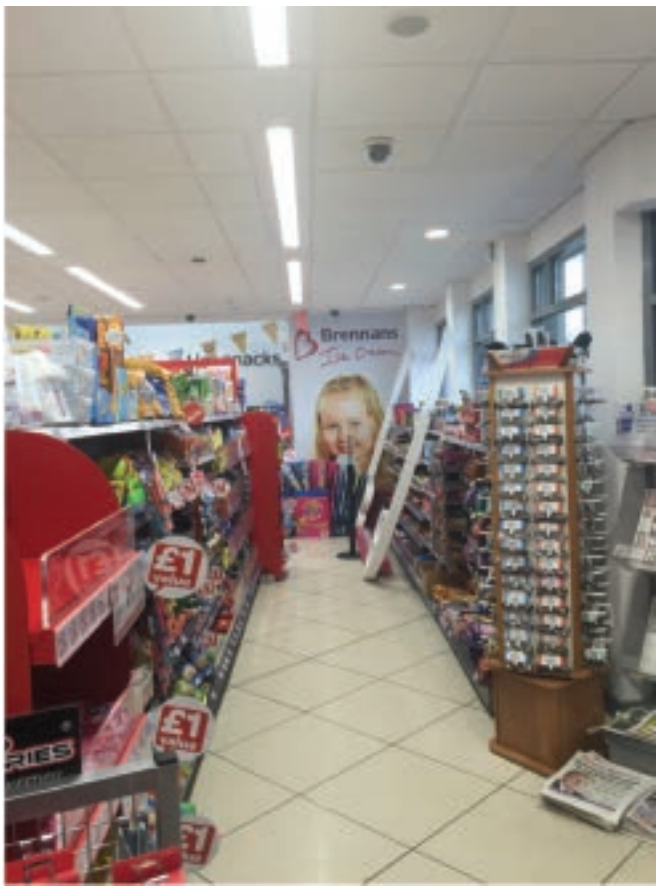
Their amenities include a food-to-go and deli counter in-store, offering an extensive breakfast, lunch and dinner menu, including home-made dishes as well as freshly made sandwiches.

Brennan's Spar shop in Loughinisland implemented a complete new LED lighting system throughout their shop. The new installation done in conjunction with BE Partners utilises high quality Philips LED lighting units and some Aurora high bay fittings.

The payback for this project was just over two years;

ENERGY CONSUMPTION BEFORE -	155,601 kwh
ENERGY CONSUMPTION AFTER -	76,520 kwh
PAYBACK 2.2 YEARS	





Appendices

Appendix A
Glossary of Lighting Terms

Ballast
An auxiliary piece of equipment required to start and to properly control the flow of current to gas discharge light sources such as fluorescent and high intensity discharge (HID) lamps.

Dali
Dali stands for Digital Addressable Lighting Interface and is a controls protocol agreed by all the major manufacturers in the lighting industry. It is set out in the technical standard IEC 62386. The AG-Dali is a working group set up by the manufacturers and institutions in the field of digital lamp and luminaire control to promote Dali technology and applications.

CCT - Colour Temperature
A numerical measurement of the colour appearance of a light source measured in degrees Kelvin (K). It also refers to the way colour groups are perceived (psychological impact of lighting). A low colour temperature implies warmer colour (more yellow/red) light while high colour temperature implies a cooler light (more blue).

Control gear
A 'package' of electrical or electronic components including ballast, power factor correction capacitor and starter. High-frequency electronic control gear may include other components to allow dimming etc.

Efficacy
How efficiently a light source converts electricity into light is described by efficacy, with units in lumens per Watt. The higher the efficacy value the more efficient the light source uses electricity. This may either be: lamp efficacy lm/W using lamp lumens, or luminaire efficacy L lm/W using lamp lumens multiplied by the luminaire light output ratio which indicates the losses within the luminaire.

Illuminance
The total density of visible light i.e. this is the quantity of light falling on a unit area of a surface; one lumen per square foot equals one footcandle (lm/ft^2), while one lumen per square meter equals one lux (lm/m^2).

Kelvin
The Kelvin unit is the basis of all temperature measurement. In lighting, Kelvin is the unit of measure for colour temperature used to indicate the overall colour of the light produced from a source. See correlated colour temperature.

Kilowatt Hour (kWh)
The standard measure of electrical energy and the typical billing unit used by electrical utilities for electricity use. A 100-watt lamp operated for 10 hours consumes 1000 watt-hours (100 x 10) or one kilowatt-hour. If your supplier charges £0.14/kWh, then the electricity cost for the 10 hours of operation would be 14p (1 x £0.14).

L70
L70 is a term used to specify a lumen maintenance factor for a light source. Lumen maintenance compares the amount of light emitted by a source when it is new with the amount emitted at a specific time in the future. The L70 figure is the time taken for the light emitted by the source to drop to 70% of its 'as new' value. For example, if a luminaire produced 1,000 lm when new and produced 700 lumens after 30,000 hours it would have a L70 lumen maintenance of 30,000 hours.

70% is not the only measure used in the lighting industry – some use L50 or L80 to specify lumen maintenance factor.

Lamp
The lighting industry term for a complete light source package, typically referred to by consumers as a "bulb".

Light Emitting Diode (LED)
A solid state device that directly converts electrical impulses into light.

Lighting Energy Numeric Indicator (LENI)
A numerical indicator that expresses the total amount of energy used by a lighting system per square metre per year (kWh/m^2/year).

Light output ratio (LOR)
The percentage of light emitted from the light source that makes it out of the luminaire. An LOR of 70 means 30% of the light from the lamp is lost inside the reflector and light fitting.

Lumen Output
The lumen output is (approximately) the amount of light produced by a product. This may be either related to the lamp or the luminaire. The lumen output of a luminaire may be considered to be the lumen output of the lamp reduced by the losses within the luminaire (the light output ratio). The luminaire losses are related to optical materials used (diffusers, reflectors, prisms) and also to any thermal losses due to the ambient temperature internal to the luminaire.

Luminaire
The general term for the fitting into which a lamp is installed. This will always include a lamp holder with the electrical connection to the lamp and may also include shades, reflectors or diffusers along with decorative, protective and/or safety features. A luminaire is often referred to as a fixture.

Luminous flux
This expresses the total quantity of light radiated per 1 second by a light source. The unit of luminous flux is the lumen (lm).

Luminous intensity
This is defined as the flux of light emitted in a certain direction. The unit of luminous intensity is the candela (cd).

Lux
Lux also known as 'illuminance', is a standardised unit of measurement of light intensity. One (1) lux is equal to one lumen per square metre.

Maintenance factor
Ratio of the average illuminance on the working plane after a certain period of use of a lighting installation to the initial average illuminance obtained under the same conditions for the installation.

Parasitic energy consumption (WP,t)
Parasitic energy consumed in period t, by the luminaire emergency lighting charging circuit plus the standby control system controlling the luminaires when the lamps are not operating (unit: kW·h).

Parasitic power (Ppi)
Input power consumed by the charging circuit of emergency lighting luminaires and the standby power for automatic controls in the luminaire when lamps are not operating (unit: W).

Ra - Colour Rendering
Every light source is characterised according to how well it shows colours. This is described by the Ra number where the higher the number the more accurately colours are shown.

Uniformity
The ratio of the minimum illuminance to the average illuminance over a specified area.

Watt
A unit of electrical power. Lamps are rated in watts to indicate the rate at which they consume energy (See kilowatt hour).

Appendix B
Lighting Profile Example

CREATING A LIGHTING PROFILE FOR YOUR BUSINESS

The following steps can be used to collate some basic information on your current lighting system and help identify what your lighting is costing you. This analysis is most useful to businesses which do not have separate metering for their lighting systems. This will be especially useful when it comes to assessing any proposals for a new lighting system.

1. The first step is to identify what your current electricity spend is. Organise a full 12 months' worth of electricity data – it is not important to have Jan – Dec but rather as long as it covers 12 consecutive months so you have all seasonal variations covered. If you tabulate the data you will have a good reference point for any future energy saving measures you implement. (If you have an online billing account with your electricity supplier this can be done quite easily and results can usually be exported to Excel.) Determine the total kWh consumed over the 12 months period and the total costs incurred over the same period and calculate the average unit cost of electricity in £/kWh.

2. For the actual lighting survey first schedule a list of all the rooms in your building.

3. Identify the lamp types in each room – note these on schedule.

4. Identify the wattages, the number of lamps in a light fitting and the number of lights in each room.

5. Calculate the total wattage per room. Divide this by 1,000 to express your answer in kW. (This will be important when calculating running costs).

6. Estimate as accurately as possible running hours per room*.

7. If you multiply the total kW by the daily running hours you will have your daily electricity consumption in kWh for each room.

8. Total the kWh consumption for all the rooms and multiply this by the average unit cost of electricity for your company. This will give you a daily running cost for your current lighting system.

9. Identify the number of working days for your company – take out any weekends if they are not applicable and any statutory or holiday closures. Multiply your number of working days by the daily running cost which will give you an annual running cost for your lighting system.

10. At this stage you may wish to add in any maintenance costs associated with your lighting system – for example lamp changes – do any high level lamps need to be changed using a working platform? Is this done in house? Are there any areas where you have to clean lamps regularly? Do you pay for disposal of old lamps? All lamp, labour and incidental costs associated with maintenance and upkeep should be added in here to give a true reflection of annual running costs.

11. This can then be used to benchmark against your current electricity spend and identify what percentage of your bill is currently attributed to lighting.

*This step by step guide is a simple method for creating your lighting profile by estimating your current costs and consumption. Depending on the type of business you have when estimating running hours it may be necessary to factor in any reductions attributed to automatic lighting controls such as motion sensors and daylight harvesting. In these instances it may be quite difficult to estimate very accurate running costs.

This method has been created for those installations where it is not possible to meter lighting consumption separately. If your lighting is separately metered we would recommend using actual recorded data rather than the method described above.

Appendix B
Lighting Profile Example

Room	Type	Wattage	No. Lamps	No. Fittings	Total Load W	Total Load kW	Running hours per day	Daily kWh consumption
Reception	Compact Fluorescent Downlight	26	2	10	520	0.520	8.5	4.42
Office 1	T8 Fluorescent - 4ft	36	4	4	576	0.576	8.5	4.90
Office 2	T8 Fluorescent - 4ft	36	4	4	576	0.576	8.5	4.90
Office 3	T8 Fluorescent - 4ft	36	4	4	576	0.576	8.5	4.90
Office 4	T8 Fluorescent - 4ft	36	4	4	576	0.576	8.5	4.90
Conference Room	T8 Fluorescent - 2ft	18	4	8	576	0.576	8.5	4.90
Corridor	2D Fluorescent Surface	28	1	8	224	0.224	12	2.69
Staff Room	T8 Fluorescent - 5ft	58	2	2	232	0.232	12	2.78
Male WC	Compact Fluorescent Downlight	18	1	4	72	0.072	12	0.86
Female WC	Compact Fluorescent Downlight	18	1	4	72	0.072	12	0.86
Production Floor	Metal Halide	250	1	18	4500	4.500	12	54.00

90.10 daily kWh consumption

0.1182 £/kWh average unit cost of electricity

10.65 £ daily running cost

240 no. of working days

2,555.96 £ annual running cost
800.00 £ annual maintenance cost

3,355.96 £ TOTAL annual running cost
21,624.00 kWh TOTAL annual consumption

189,951 kWh Total annual electricity consumption

11.38% Lighting consumption as % of total

22,452.21 £ Total annual electricity cost

14.95% Lighting cost as % of total

Appendix C
Lighting Action Plan

				NOTES

Sector Guides

Hospitality Sector Supplement

Introduction

Maximising the efficiency of your lighting system by implementing effective energy saving measures will reduce your energy consumption and costs – adding to your bottom line. Given the ever rising cost of electricity this has become increasingly important to businesses in Northern Ireland.

This Hospitality Sector Supplement accompanies A Practical Lighting Efficiency Guide for Businesses in Northern Ireland. This supplement has been produced with specific advice and guidance for hospitality organisations such as hotels, guest houses, bars and restaurants.

Lighting design criteria for Hospitality Sector

Lighting Levels

The following information is taken from the Society of Light and Lighting Code for Lighting 2012 (a guide on how to interpret the British Standard recommendations and how to implement them in practice).

Area/Task	Minimum Average Illuminance (lux)	Specific Requirements
Reception/ Cashier Desk, Porters Desk	300	
Kitchen	500	There should be a transition zone between kitchen and restaurant
Restaurant, Dining Room, Function Room	–	The lighting should be designed to create the appropriate atmosphere
Self Service Restaurant	200	
Buffet	300	
Conference Rooms	500	Lighting should be controllable
Corridors	100	During night time lower levels are acceptable

Colour Appearance

The colour appearance of artificial light can be categorised as below;

Colour appearance	Correlated colour temperature
Warm	Below 3300 K
Intermediate	3300 to 5300 K
Cool	Above 5300 K

When you consider environments such as restaurants and pubs, the ambience they are trying to achieve dictates that they use lighting which appears warm and which will usually falls below the 3300k range.

Colour Rendering

Colour rendering is the ability of a light source to reveal the colours of an object. It is measured by the colour rendering index (Ra). (The higher the number the better, up to a maximum of 100).

Lighting design guidelines recommend a CRI of 80 for those hospitality areas detailed previously - providing moderate to good colour rendering appearance.

Typical lighting in Hospitality Businesses

First impressions for your patrons can be effected by good lighting. Providing the correct ambience and directing the customers eye to particular amenities and features helps create a relaxed and welcoming atmosphere.

Luminaire Types

With this in mind we find that the lighting systems found in hospitality businesses differ from area to area depending on the function and are a variable mixture of general lighting with localised and display lighting, i.e.

- **General lighting systems –** a lighting system designed usually as a ceiling mounted arrangement which is functional and effective. Usually found in areas such as Reception/Lobby, Meeting rooms, Kitchens where tasks are being performed.
- **Local lighting systems for general ambience plus task lighting –** in this case a smaller ceiling arrangement may provide a background / ambience lighting with localised lighting in areas where tasks are performed. As above supplementary lighting may also be provided in areas such as Reception/Lobby and Meeting Rooms to provide an aesthetically pleasing yet effective lighting system.

- **Localised lighting systems –** only localised luminaires are used to provide the necessary lighting levels. These will be required in task areas and in general areas to provide the correct lighting levels. This type of lighting is usually found in guestrooms, bars and restaurants where lamps are placed around the space to provide the correct ambience and in the case of guestrooms lamps will be placed at bedside lockers, mirrors etc to provide the correct ambience plus practical lighting for guests.
- **Display lighting –** lighting which is installed purely to promote or highlight a product or space. This will usually be supplementary to the normal lighting system. Display lighting can be used to highlight a particular feature and can be found throughout the building usually in public areas.

TYPE	CHARACTERISTICS	Luminous Efficacy (lm/W)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Areas found: Guest Rooms, Bar/Restaurant					
Incandescent / Filament 	• Poor efficacy • Very short lamp life • Excellent colour rendering • Low capital cost • No requirement for control gear • Currently being phased out	10 - 18	2,600	100	1,000
Areas found: Reception/Lobby, Guest Rooms, Public & Corridor Areas, Meeting Rooms, Bar/Restaurant					
Tungsten Halogen 	• Addition of halogen gas to standard filament increases efficacy • Still less efficient than discharge lamps • Low voltage versions require transformer	5 - 27	2,700 – 3,200	100	2,000 – 16,000
Areas found: Reception/Lobby, Guest Rooms, Public & Corridor Areas, Meeting Rooms, Bar/Restaurant					
Compact Fluorescent 	• Long lamp life • Good efficacy ratings • Good energy savings when replacing incandescent lamps • Very good colour rendering • Light output can diminish over time • Electronic control gear required	50 - 85	2,700 – 6,500	80 - 90	8,000 – 20,000
Areas found: Reception/Lobby, Meeting Rooms, Kitchen					
Tubular Fluorescent 	• Long lamp life • Good efficacy ratings • Very good colour rendering • Electronic control gear required	60 - 105	2,700 – 6,500	80 - 95	12,000– 60,000

TYPE	CHARACTERISTICS	Luminous Efficacy (lm/W)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Areas found: Reception/Lobby, Guest Rooms, Public & Corridor Areas, Meeting Rooms, Bar/Restaurant					
Light Emitting Diodes (LED) 	• Very long lamp life • Low maintenance • Low energy consumption • High efficiency level • Small dimensions available • Provides instant light • Wide operating temperature range • Rapidly developing technology • Not as suitable for areas where high lighting levels are required • High capital cost	50 - 120	3,000 – 8,000	70 - 90	50,000

Lighting Controls

The most effective controls systems available for hospitality businesses are;

- Occupancy sensors for area less frequented such as stores, general back of house areas and toilets. In some cases, sensors may be employed within guestrooms. Another common area for this type of installation would be hotel guestroom corridors. Very often, instead of providing controls which simply turn lights on and off with occupancy, a background level of lighting may be more desirable for the comfort of guests. In this instance rather than switch off after a set time the lighting will dim to a predetermined level (say 10% lighting output) so guests never have to enter a completely darkened area.
- Guestroom key cards – controlling power supply for each room individually through the use of a keycard provides the hotel and the guest with the best level of control for guestrooms. The hotel can be sure that lighting is only operating when the room is occupied and the guest is free to control the level of lighting within the room as desired.
- Central control for lighting – more specifically usually for guestrooms via a building management system, allowing reception to control when lighting becomes operational. Is usually done in conjunction with the booking system.
- Manual Switches – local manual switches are usually provided as the norm and can also be used to provide a good level of control. Where applicable switches should make use of other light resources such as windows/rooflights etc. With appropriate separate switches, lighting can be controlled in accordance with the level of natural daylight available i.e. those closest to the windows would not need to be switched on during bright days. While manual controls are the cheapest to install the biggest downfall is the reliance on the user to turn lights off when they are not required.
- Dimming/Scene setting functions – also manual switching and are usually found in areas such as bars and restaurants to provide the correct ambience. Are also common in meeting rooms and function rooms.
- Housekeeping – 'switch off' policy. Required in businesses where no automatic lighting controls exist and operation is based on manual control only. Raising awareness of the lighting requirements and the profile of lighting energy use will be required to encourage and maintain good practices.
- Daylight Harvesting - Daylight can replace artificial lighting for much of the day in areas with sufficient glazing and also provides an attractively lit space for guests. Daylight sensor controls (photocells) can be used to ensure that lights are not left on unnecessarily when there is adequate daylight or to automatically dim lights to a pre-determined level.
- External Lighting – Ensure external lighting is sufficiently controlled – either via a timeclock, a photocell or a combination of both. Review these controls periodically with particular reference to daylight saving time changes in March and October.

Typical Efficiency Improvements

Promote Energy Awareness

Promote energy awareness with staff – create a 'switch off' policy on lighting, so that only lighting that is being used is left on. Staff awareness can be raised by placing stickers above light switches and posters in staff areas (available from the Carbon Trust). Lights in unoccupied areas should be switched off either automatically or manually. However it is important to consider any health and safety implications and it would be advisable to seek professional advice if you have any doubts.

Lamp Replacements

- Replace tungsten light bulbs with CFL or LED types which can be used in the same fitting. These type of fixed task lighting units are usually very common in hospitality applications and can be found in guestrooms, corridors, bar, lounge, restaurant etc. There may be ample scope to replace quite a few of these throughout your premises. You can save between 75% and 90% of energy associated with these lamps with these direct replacement solutions.

  Note: ensure that LED replacements have the same illuminance levels as previous lighting system if required.

- Replace older T12 fluorescent with T8 type tubes. Savings of around 20% are achievable. T12 lamps can be directly substituted with T8 lamps to existing luminaires with switch-start control gear, but not with quick start electromagnetic control gear. Request T8 lamps with triphosphor or multiphosphor coating as these give better performance.
- Replace T8 fluorescent with T5 type lamps with estimated savings of up to 50% and better colour rendering while maintaining the same lighting levels.

Light Fitting Replacements

- Replace old switchstart fluorescent lighting with new high frequency types. Savings of around 10% - 15% are possible.
- Replace traditional mains/low voltage downlights (typically 50W and 35W) with more efficient CFL or LED types. Savings of up to 90% are achievable with LED replacement types provided LED replacements have the same lighting levels as previous lighting system if required.
- Replace any external tungsten halogen lighting with more efficient metal halide or LED types.

Maintenance

For hospitality businesses, lighting is essential for providing an inviting, warm and pleasurable visitor experience. Specific lighting improvements like those listed above are essential for an energy efficient lighting system. However, ongoing maintenance of the system is also very important.

Typical maintenance for lighting should include;

- Clean glazing - windows, skylights etc should be able to harvest as much daylight as possible.
- Clean light fittings including any lamps and attachments.
- Replace any expired or failing lamps immediately.
- Any controls and timers should be regularly checked to ensure they are operating as intended.

Monitoring for the Hospitality sector

The following benchmarks are taken from CIBSE Guide F Energy Efficiency in Buildings and show the good practice and typical delivered energy benchmarks for lighting consumption in 3 types of hotels.

Type 1:	Luxury hotel
Type 2:	Business or Holiday hotel
Type 3:	Small hotel

	Delivered energy for stated hotel type - (kWh/bedroom) per year					
	Type 1		*Type 2*		*Type 3*	
	Good Practice	Typical	Good Practice	Typical	Good Practice	Typical
Lighting	40	70	35	65	35	55

Industrial Sector Supplement

Introduction

Maximising the efficiency of your lighting system by implementing effective energy saving measures will reduce your energy consumption and costs – adding to your bottom line. Given the ever rising cost of electricity this has become increasingly important to businesses in Northern Ireland.

This Industrial Sector Supplement accompanies A Practical Lighting Efficiency Guide for Businesses in Northern Ireland. This supplement has been produced with specific advice and guidance for industrial organisations comprising manufacturing and engineering.

Lighting design criteria for the Industrial Sector

Lighting Levels

The following information is taken from the Society of Light and Lighting Code for Lighting 2012 (a guide on how to interpret the British Standard recommendations and how to implement them in practice).

This is a diverse and broad spanning group so it is not possible to cover every type of business within this guide. Information on lux levels is provided for some of the most popular types of businesses in Northern Ireland.

Lighting levels should be designed around the tasks within the area: not having the correct lighting level could lead to an unsafe working environment.

Area / Task	Minimum Average Illuminance (lux)
BAKERIES	
Preparation / Baking	300
Finishing, glazing and decoration	500
CERAMICS, tiles, glass, glassware	
Drying	50
Preparation, general machine work	300
Enamelling, rolling, pressing, shaping simple parts, glazing, glass blowing	300
Grinding, engraving, glass polishing, shaping precision parts, manufacture of glass instruments,	750
Grinding of optical glass, crystal, hand grinding and engraving	750
Precision work e.g. decorative grinding, hand painting	1000
Manufacture of synthetic precious stones	1500
CHEMICAL, plastics and rubber	
Remote-operated processing installations	50
Processing installations with limited manual intervention	150

Area / Task	Minimum Average Illuminance (lux)
CHEMICAL, plastics and rubber (continued)	
Constantly manned work stations in processing installations	300
Precision measuring rooms, laboratories	500
Pharmaceutical production	500
Tyre production	500
Colour inspection	1000
Cutting, finishing, inspection	750
ELECTRONIC, electronic industry	
Cable and wire manufacture	300
Winding: • large coils • medium-sized coils • small coils	 300 500 700
Coil impregnating	300
Galvanising	300
Assembly work: • rough, e.g. large transformers • medium, e.g. switchboards • fine, e.g. telephones, radios, computers • precision, e.g. printed circuit boards	 300 500 750 1000

Area / Task	Minimum Average Illuminance (lux)
FOOD STUFFS and luxury food industry	
Work stations and zones in: • breweries, malting oor, • for washing, barrel filling, cleaning, sieving, peeling • cooking in preserve and chocolate factories • work stations and zones in sugar factories, • for drying and fermenting raw tobacco, fermentation cellar	200
Sorting and washing of products, milling, mixing, packing	300
Work stations and critical zones in slaughter houses, butchers, dairies, mills, on filtering floor in sugar refineries	500
Cutting and sorting of fruit and vegetables	300
Manufacture of delicatessen foods, kitchen work, manufacture of cigars and cigarettes	500
Inspection of glasses and bottles, product control, trimming, sorting, decoration	500
Laboratories	500
Colour inspection	1000
CEMENT, cement goods, bricks, concrete	
Drying	50
Preparation of materials	200
General Machine Work	300
Rough Forms	300
METAL WORKING and processing	
Open dye forging	200
Drop forging	300
Welding	300

Area / Task	Minimum Average Illuminance (lux)
METAL WORKING and processing (continued)	
Rough and average maching: tolerances >0.1mm	300
Precision maching; grinding: tolerances <0.1mm	500
Scribbling; inspection	750
Wire and pipe drawing shops; cold forming	300
Plate machining: thickness >5mm	200
Sheet metalwork: thickness <5mm	300
Tool making; cutting equipment manufacture	750
Assembly: • rough • medium • fine • precision	 200 300 500 750
Galvanising	300
Surface preparation and painting	750
Tool, template and jig making, precision mechanics, micro-mechanics	1000
PAPER and paper goods	
Edge runners, pulp mills	200
Paper manufacture and processing, paper and corrugating machines, cardboard manufacture	300
Standard bookbinding work, e.g. folding, sorting, gluing, cutting, embossing, sewing	500
TEXTILE manufacturing and process	
Work stations and zones in baths, bale opening	200
Carding, washing, ironing, devilling machine work, drawing, combing, sizing, card cutting, pre-spinning, jute and hemp spinning	300
Spinning, plying, reeling, winding	500

Area / Task	Minimum Average Illuminance (lux)
TEXTILE manufacturing and process (continued)	
Warping, weaving, braiding, knitting	500
Sewing, fine knitting, taking up stitches	750
Manual design, drawing patterns	750
Finishing, dyeing	500
Drying room	100
Automatic fabric printing	500
Burling, picking, trimming	1000
Colour inspection; fabric control	1000
Invisible mending	1500
Hat manufacturing	500
WOOD WORKING and processing	
Automatic processing e.g. drying, plywood manufacturing	50
Steam Pits	150
Saw Frame	300
Work at joiners bench, gluing, assembly	300
Polishing, painting, fancy joinery	750
Work on wood working machines, e.g. turning, fluting, dressing, rebating, grooving, cutting, sawing, sinking	500
Selection of veneer woods	750
Marquetry, inlay work	750
Quality control, inspection	1000

Colour Appearance
The colour appearance of artificial light can be categorised as below;

Colour appearance	Correlated colour temperature
Warm	Below 3300 K
Intermediate	3300 to 5300 K
Cool	Above 5300 K

In general a mid white or cool white i.e. anywhere above 3500K on the scale provides the crisp colour for visual perception and tasks in industrial applications.

Colour Rendering
Colour rendering is the ability of a light source to reveal the colours of an object. It is measured by the colour rendering index (Ra). (The higher the number the better, up to a maximum of 100).

Where accurate colour judgement is required then a Ra of 80 – 90 is recommended.

Typical lighting in Industrial Businesses
Lighting for the industrial sector is about providing a safe and comfortable working environment for the workforce. The wrong lighting can make carrying out tasks difficult while the right lighting is thought to contribute to productivity.

Luminaire Types
The type of luminaires found in industrial applications not only differ according to the type of business, but also within a company across the various tasks being carried out. For example a typical business may have a manufacturing/process area, storage, offices etc which all need to be considered separately. Typically lighting systems will comprise of general lighting with some applications requiring localised task lighting – for more detailed work.

In general, lighting systems will usually be categorised as one of the following;

- High Bay – High bays are used to illuminate industrial areas with higher ceiling height anywhere from 6 to 12m. High Bay Lighting is able to provide the required light uniformity, low glare and clarity. It is best for workshops, warehouses, production factories, assembly lines and most industrial and lighting applications. Suitable lamp technology includes LED, induction, metal halide and fluorescent. Mounting options are fixture dependent. Traditional high bays can be secured by a pendant or hook while fluorescent high bays are secured with a chain or cable.
- Low Bay – Used to light areas with lower ceilings, low bay lights have diffusers at the bottom of the fixtures. These diffuse the light, cutting down on the harsh reflections that lower ceilings can cause. Low bay lighting is also useful for applications requiring a higher concentration of light e.g. laboratories, basements, workshops, garages — any place where the ceilings are low but which still require good lighting levels. For shops and low-level warehouses, consider choosing pulse start metal halide low bay lights. Low bay installations can include T5 lamps, T8 lamps, induction, metal halide and high pressure sodium.
- Cleanroom - In applications where hygiene is crucially important, such as hospitals, pharmaceuticals and food production facilities, suitable fittings are required. These are usually fluorescent or LED type luminaires and can be fully enclosed/recessed /surface mounted as required.
- Warehouse/Storage – For illuminating warehouses and other large storage spaces, fluorescent tubular lights are usually the most common source. In areas where colour rendering is important metal halides are also popular. On the other hand where colour rendering is not important sodium type lamps are often used. These can be either high or low bay types.
- Task Lighting – this type of lighting will usually be used to supplement the general lighting arrangement and will be found in areas where visual perception work is carried out. This can include anything from machine operation to detailed manual tasks. Task lighting should be tubular/compact fluorescent or LED types.

Lighting for Abnormal/Hazardous Areas
Some industrial application may have abnormal conditions resulting in the presence of gases, dusts, water jets etc. Depending on the type of environment, you may need to choose light fittings in accordance with the IP (Ingress Protection), IK (Impact Resistance) and/or ATEX (Hazardous Area) scales. In these instances you should seek specialist advice to ensure you are getting the most suitable solution for your environment. A summary of these is shown below;

Ingress Protection
The ingress protection (IP) code denotes protection against dust, solid objects and moisture provided by the luminaire enclosure. If no code is marked the luminaire is deemed to be IP20.

First digit of code denotes protection against dust and solid objects		Second digit of code denotes protection against moisture	
IP2X	Fingers or similar objects	IPX0	No special protection
IP3X	No entry of 2.5mm ø probe	IPX1	Dripping Water
IP4X	No entry of 1mm ø probe	IPX2	Vertically dripping water
IP5X	Dust proof (no dust deposit)	IPX3	Spraying Water
IP6X	Dust tight (no dust entry)	IPX4	Splash proof
		IPX5	Water Jet
		IPX6	Heavy downpours
		IPX7	Temporary immersion
		IPX8	Submersion to declared depth

ATEX classification
The IP rating is not sufficient as a safety criterion in areas with particularly hazardous or explosive atmospheres. Equipment for use in these environments is classified according to the expected conditions using the ATEX group category, as shown in the table below.

ATEX Category	Level of protection required	Environmental Conditions for use
1	Very High	An explosive atmosphere of gas/vapour/haze/dust is continuously present or present for long periods (> 1000 hours/year)
2	High	An explosive atmosphere of gas/vapour/haze/dust is likely to be present (between 10 and 1000 hours/year)
3	Normal	An explosive atmosphere of gas/vapour/haze/dust is unlikely to occur or could occur for a short period (< 10 hours/year)

Impact Resistance
Mechanical impact is identified by the energy needed to qualify a specified resistance level, which is measured in joules (J).

IK Rating	IK01	IK02	IK03	IK04	IK05	IK06	IK07	IK08	IK09	IK10
Joules of energy	0.15j	0.23j	0.35j	0.5j	0.7j	1.0j	2.0j	5.0j	10.0j	20.0j

Typical Lamps

TYPE	CHARACTERISTICS	Luminous Efficacy (lm/W)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Areas found: Low Bay and High bay applications for industrial areas, general lighting for storage / warehouses					
Compact Fluorescent 	• Long lamp life • Good efficacy ratings • Good energy savings when replacing incandescent lamps • Very good colour rendering • Light output can diminish over time • Electronic control gear required	50 - 85	2,700 – 6,500	80 - 90	8,000 – 20,000
Areas found: Low Bay and High bay applications for industrial areas, general lighting for storage / warehouses – (may require appropriate reflectors), Cleanrooms, Laboratories					
Tubular Fluorescent 	• Long lamp life • Good efficacy ratings • Very good colour rendering • Electronic control gear required	60 - 105	2,700 – 6,500	80 - 95	12,000– 60,000
Areas found: Low Bay and High bay applications for industrial areas, general lighting for storage / warehouses, Cleanrooms, Laboratories					
Light Emitting Diodes (LED) 	• Very long lamp life • Low maintenance • Low energy consumption • High efficiency level • Small dimensions available • Provides instant light • Wide operating temperature range • Rapidly developing technology • Not as suitable for areas where high lighting levels are required • High capital cost	50 - 120	3,000 – 8,000	70 - 90	50,000
Areas found: Low Bay and High bay applications for industrial areas - usua					
Metal Halide 	• Very good efficacy • Good Colour rendering • Long lamp life • Unless modern hot re-strike control gear is used the re-strike time can take up to 10mins	75 - 140	3,000 – 5,600	65 - 95	8,000 – 20,000

TYPE	CHARACTERISTICS	Luminous Efficacy (lm/W)	Colour Appearance (Kelvin)	Colour Rendering (Ra)	Life (hours)
Areas found: Low Bay and High bay applications for industrial and storage areas where good colour rendering is not important					
High Pressure Mercury 	• Cheaper than sodium lamps • Long lamp life • Not very efficient • Average colour rendering • Electronic control gear required • Long startup and re-strike time	35 - 60	3,400 – 4,000	35 - 60	9,000 – 24,000
Areas found: General lighting for storage / warehouses where good colour rendering is not required					
High Pressure Sodium 	• Good efficacy rates • Long lamp life • Moderate – good colour rendering available • Long startup and re-strike time	50 - 130	2,000 – 2,500	25 - 80	8,000 – 30,000
Areas found: General lighting for storage / warehouses where good colour rendering is not required					
Low Pressure Sodium 	• Highest efficacy ratings • Long lamp life • Very poor colour rendering • Usually found in street lighting • Long startup and re-strike time	100 - 200	1,800	N/A	6,000 – 16,000
Areas found: Low Bay and High bay applications for industrial areas					
Induction 	• Virtually maintenance free • Very long lamp life • High capital cost • Specialist lamp so not as readily available	62 - 70	2,700 – 4,000	85	10,000– 60,000

Lighting Controls
The most effective controls systems available for industrial businesses are;

- Occupancy sensors – These can be implemented in 3 main ways;

1. For staff/office areas occupancy sensors can be used in individual rooms to automatically turn lighting on and off when required.
2. For an industrial application lighting can be zoned or individually controlled – e.g. if you have a large open area where work based activities only take place in certain areas or at certain times it is possible to only have the required areas lit at any one time – eliminating unnecessary wastage.
3. For storage and warehouse applications – especially those not in continuous use it is possible to reduce lighting consumption to as little as 10%. If a person / forklift enters an area the lighting will activate. If no motion is detected after a pre-determined time the lighting can dim down to as low as 10%, after another pre-determined time the lighting can then switch off altogether. This type of control can be very effective – e.g. if only half an aisle is used – then only half the aisle will be lit.

- Manual Switches – local manual switches are usually provided as the norm and can also be used to provide a good level of control e.g. switches should be provided locally and where applicable make use of other light resources such as windows / rooflights etc. With appropriate separate switches, lighting can be controlled in accordance with the level of natural daylight available i.e. those closest to the windows would not need to be switched on during bright days. While manual controls are the cheapest to install the biggest downfall is the reliance on the user to turn lights off when they are not required. For factory applications it is usually good practice to have every row on a different light switch to give required flexibility in response to natural lighting levels.
- Housekeeping – 'switch off' policy, this will be required in businesses where no automatic lighting controls exist and operation is based on manual control only. Raising awareness of the lighting requirements and the profile of lighting energy use will be required to encourage and maintain good practices.
- Daylight Harvesting- Daylight can replace artificial lighting for much of the day in areas with sufficient glazing – the common type in industrial applications are rooflights. Daylight sensor controls (photocells) can be used to ensure that lights are not left on unnecessarily when there is adequate daylight or to automatically dim lights to a pre-determined level.
- External Lighting – Ensure external lighting is sufficiently controlled – either via a timeclock, a photocell or a combination of both. Review these controls periodically with particular reference to daylight saving time changes in March and October.

Typical Efficiency Improvements
The Carbon Trust states that Industry produces 125Mt CO2 - 25% of UK total emissions. Efficiency improvements should be assessed on an individual company basis but could include any of those below.

Promote Energy Awareness
Promote energy awareness with staff – create a 'switch off' policy on lighting, so that only lighting that is being used is left on. Staff awareness can be raised by placing stickers above light switches and posters in staff areas (available from the Carbon Trust). Lights in unoccupied areas should be switched off either automatically or manually. However it is important to consider any health and safety implications and it would be advisable to seek professional advice if you have any doubts.

Lamp Replacements

- Replace older T12 fluorescent with T8 type tubes. Savings of around 20% are achievable. T12 lamps can be directly substituted with T8 lamps to existing luminaires with switch-start control gear, but not with quick start electromagnetic control gear. Request T8 lamps with triphosphor or multiphosphor coating, as these give better performance.
- Replace T8 fluorescent with T5 type lamps with estimated savings of up to 50%, better colour rendering while maintaining the same lighting levels.
- Replace high pressure mercury or sodium lamps with metal halide types, lamp wattage may remain the same but the metal halides will generally provide a much better colour rendering and better light output.

Light Fitting Replacements

- Replace old switchstart fluorescent lighting with new high frequency types. Savings of around 30% are possible.
- Replace high pressure sodium, high pressure mercury or metal halide high/low bay fittings with fluorescent (tubular or compact) type luminaires – this will be beneficial for applications where you may wish to introduce dimming or presence detection lighting control.
- Replace most industrial type lighting (high/low bay, cleanroom, warehouse and storage) with alternative LED types. Speak to a specialist about finding the right LED solution for your application. It is vitally important that the correct lighting level is maintained for a given task/area should LED be installed.

Maintenance

For industrial businesses lighting maintenance is essential for maintaining the desired lighting levels. Specific lighting improvements like those listed above are essential for an energy efficient lighting system however the ongoing maintenance of the system is also very important.

Typical maintenance for lighting should include;

- Clean glazing - windows, skylights etc should be able to harvest as much daylight as possible.
- Clean light fittings including any lamps and attachments.
- Replace any expired or failing lamps immediately.
- Any controls and timers should be regularly checked to ensure they are operating as intended.

Monitoring for the Industrial sector

The following benchmarks are taken from CIBSE Guide F Energy Efficiency in Buildings and show the good practice and typical delivered energy benchmarks for lighting consumption in different types of industrial environments. The stated categories for industrial buildings (Types 5–8) and the corresponding benchmarks are taken from Energy Consumption Guide ECG018(7). Benchmarks relate to gross floor area. ECG018 uses three levels of performance: 'typical', 'improved' and 'new building'; the 'new building' performance level from ECG018 is used as the 'good practice' performance level in these tables.

Type 5:	Distribution and Storage
Type 6:	Light Manufacturing
Type 7:	Factory Office
Type 8:	General Manufacturing

(Note: Types 1-4 refer to office type buildings)

	Delivered energy for stated building type - (kWh/m²) per year							
	Type 5		*Type 6*		*Type 7*		*Type 8*	
	Good Practice	Typical	Good Practice	Typical	Good Practice	Typical	Good Practice	Typical
Lighting	5	25	15	50	20	60	20	45

If you require this leaflet in an alternative format (including Braille, audio disk, large print or in minority languages to meet the needs of those whose first language is not English) then please contact:

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