SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Exterior Spaces

A GUIDE TO ENERGY EFFICIENT AND COST EFFECTIVE LIGHTING

This guide provides information on how to improve the quality, visual appeal and cost-effectiveness of lighting for external areas, by using energy efficient lighting technologies and techniques. By following this guidance, you can reduce the electrical energy consumption of exterior lighting by up to 60%, reduce maintenance costs and ensure that the lighting scheme is fit for purpose.

ENERGY EFFICIENT AND COST EFFECTIVE LIGHTING

Exterior lighting requirements can vary greatly, from car-park and security lighting, to lighting for road safety and the enhancement of building exteriors. Irrespective of the application, lighting should be energy efficient and effective, and require minimum maintenance.

LIGHTING REQUIREMENTS AND TECHNIQUES

The main objectives of external lighting should be to:

- enhance security and safety
- aid observation and the enjoyment of spaces at night
- enhance the appearance of buildings and outdoor areas

The main criteria for energy-efficient and effective lighting for external spaces are:

- colour appearance
- colour rendering
- application
- luminaire choice
- light distribution
- control
- maintenance
- lamp life

Image courtesy of Reddy Architecture on behalf of Eircom

COLOUR TEMPERATURE AND COLOUR RENDERING

Colour appearance (Figure 1) defines the appearance of a colour 'white' and is measured in kelvin (K). A colour temperature of less than 3,500 K is 'warm'; a colour temperature of 3,500 K is mid-white; and a colour temperature of 4,000 K and above is 'cooler'.

Application
Sandstone buildings are often lit with high pressure sodium lamps (2,200 K) to enhance the 'warm' colour of the stone.

Colour rendering (Figure 2) is the ability of a light source to give good colour representation of the colour it is illuminating. It is measured on a CRI (Colour Rendering Index) scale of Ra 0–100,where Ra 100 represents the best, which is equivalent to that provided by daylight. Currently, there is a move towards using 'whiter' light in urban environments. 'White' light is provided by a number of different technologies in addition to high pressure sodium lamps (e.g.LEDs, metal halide lamps and compact fluorescent lamps{CFLs}).

Application
Light sources with good colour rendering properties should be used in commercial and residential areas and where CCTV is used.
For industrial parks or other areas where there is not much pedestrian traffic, colour rendering can be reduced to allow for the use of more efficient light sources.

Fig. 2 *Coloured hat, lit with a low-pressure sodium lamp, Ra0, and a colour temperature of 1,800 K*

Coloured hat, lit with LEDs, Ra 60 and a colour temperature of 3,800 K

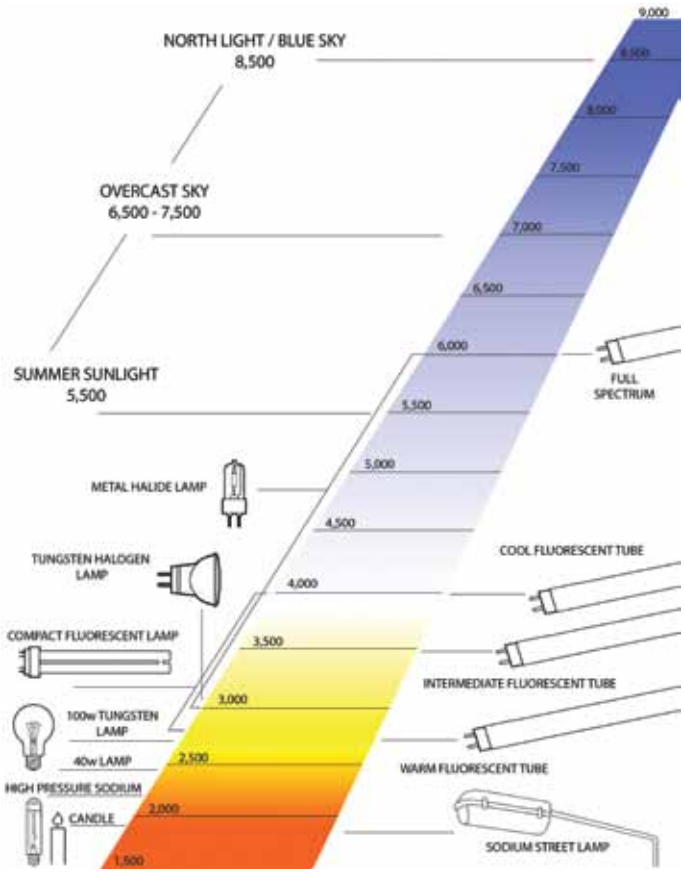


Fig. 1 *Colour temperature (K) of various light sources*

APPLICATIONS IN EXTERIOR SPACES

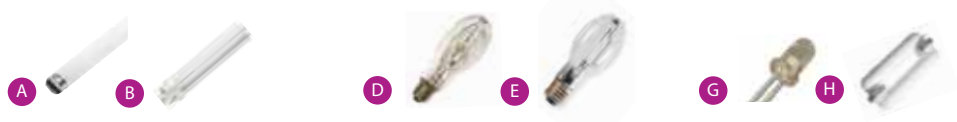
The most appropriate lamp choices for different exterior spaces are shown below; general light levels are given for preliminary guidance. Further details of the properties of each of the recommended lamp types are given in the Lamp Comparison Chart (page 8). More detailed guidelines on lighting for the wide range of exterior applications are available from the Chartered Institution of Building Services Engineers' Lighting Guide 6: The Outdoor Environment. Policy Guidelines on the Floodlighting of Monuments are available from the Department of the Environment, Community and Local Government.

1 ARCHITECTURAL FEATURES (30–100 LUX)

A 'flood' light, placed away from a building or object, provides appropriate coverage but can cause light pollution, light ingression into windows and glare. It may be better to use illumination sources mounted against the building or object. LED luminaires with the appropriate lenses would provide the most energy efficient and effective method. Always try to 'light what is seen'.

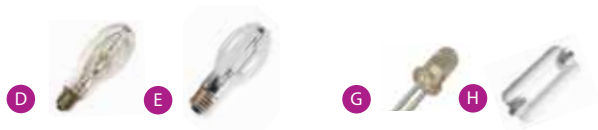
2 PUBLIC AMENITY AREAS (20–75 LUX)

This includes open and multi-storey car-parks, pedestrian underpasses, public toilets and general open-area lighting. Use tubular or compact fluorescents or LEDs in luminaires with the appropriate light distribution and high light output. Use suitable colours of 'white' to enhance visual perception and high colour rendering where CCTV cover is required. Where high colour rendering is not essential, high pressure sodium (SON) could be used.



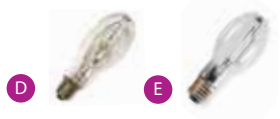
3 PRECINCT/PEDESTRIAN AREAS (20–75 LUX)

Use 'Post Top' omni-directional luminaires or luminaires that reflect light off a reflector to provide a 'softer' general level of light within precinct or open areas. When using buildings for mounting luminaires, use asymmetrical-style floodlights.



4 SPORTS AND RECREATIONAL (100 LUX MINIMUM)

The most appropriate distribution pattern should be used as lighting requirements can vary from sport to sport. Standard floodlights are appropriate where the ball is struck high and needs to stay visible, e.g. football and rugby games. Use asymmetric floodlights for areas where the ball is kept low, e.g. hockey (see illustration to right).



5 STREETS AND ROADS (5–20 LUX; SIGNS AND HOARDINGS 100–500 LUX)

Requirements differ in the case of streets and roads. Single-lane and multi-lane roads in cities, towns, housing estates and country locations should be adequately illuminated to comply with regulatory standards for each type of area.

The general rule is to effectively provide the required light-level standard, by following the guidance outlined in this document.

6 SECURITY LIGHTING (5–20 LUX)

The energy-effective method to illuminate areas of higher security risk is to use either discharge lighting operated by photocells during the hours of darkness, with timers to automatically switch off during non-operational periods, or 'instant' start (when connected to a presence detector). For car-parks and the perimeter of commercial premises, asymmetrical luminaires are appropriate. For 'instant' start applications with either integrated or remote presence detectors with photocells, compact fluorescent, inductive or LED light sources should be used.

LUMINAIRES AND LIGHT DISTRIBUTION

It is important to consider the difference in the light distribution required for each application. The asymmetrical floodlight (mounted horizontally) enables lower-wattage lamps to be used while providing equivalent illumination levels; it also reduces unnecessary light pollution.

Floodlight type	Distribution pattern	Characteristics
Standard symmetrical floodlight 	Symmetrical  	• lamp positioned in centre of luminaire • difficult to control glare • energy-wasteful • causes light pollution
Asymmetrical floodlight 	Asymmetrical  	• lamp positioned at one end of luminaire • better control of glare • only lights area required • minimises light pollution

Glare

Glare is a by-product of inappropriate distribution and in most cases can be avoided. There are few cases where glare is acceptable. For areas where the requirement is to be 'seen' as a destination, reflective surfaces within the luminaire can provide this feature. For general illumination, it is more appropriate to distribute the light to surfaces that require illuminating (Figure 3).

Luminaire choices for outdoor areas to minimise glare and light pollution	
Precinct areas	Open car-parks
 	

Fig.3 *Illustration of light distribution, with glare and without glare*

CONTROLS

Effective lighting controls can provide the right amount of light at the right place and at the right time.

1 	**Photocells** Respond to the availability of daylight and activate lighting when it gets dark; are also available with time-delay functions	4	**Dimmers** Can provide energy savings by reducing the amount of light required for low-usage periods	4a 	Fluorescent dimmer
2 	**Timers** Can operate lighting at pre-determined times and are programmable for times of day and days of the week; can also be set to account for longitude and latitude,thus adjusting automatically for hours of darkness			4b 	Metal halide and high pressure sodium dimmer
3 	**Presence detectors** Passive infra-red (PIR) controls are appropriate where lighting is required instantly; a suitable lamp type is required			4c 	LED dimmer

Refer to the Lamp Comparison Chart for compatible light sources and their accompanying control gear.

Voltage controls for streetlights

A reduction of mains input voltage reduces the lamp current and therefore the luminous flux emitted by a lamp. Voltage controllers are available for most lamp types, including fluorescent, metal halides, high pressure sodium and low pressure sodium on electro-magnetic ballasts. Mercury vapour and high pressure sodium lamps display almost identical reductions in luminous flux against corresponding reductions in voltage. The reduced voltage can significantly increase lamp life and reduce maintenance costs. Lighting must be checked versus the appropriate standards prior to installation of voltage control.

Voltage controllers are appropriate

- ✓ Bypass roads and motorway junctions
- ✓ Private facilities (car-parks, yards, etc)
- ✓ Long carriageways of low night-time traffic flows
- ✓ Typical night-time voltages of 230V+
- ✓ Locations where there is excess lighting

Voltage controllers are not appropriate

- ✗ Unmetered supplies
- ✗ Conflict areas (pedestrian/traffic conflict)
- ✗ Areas of high night-time traffic flows
- ✗ If current voltage is already low
- ✗ Lighting is just achieving lighting recommended standards

Fig. 4 *Voltage control unit, Lighting Energy Controller (LEC) Type A,voltage supplied to the lighting circuits can be reduced up to 35V, in decrements of 2.5V.*

Application

A study was carried out by Cork County Council on a street lighting circuit consisting of 24 streetlights with photocell control over a week, with the lamps on approximately 8.5 hours per day. It revealed energy savings of 30%. The voltage control unit (Figure 4) was connected within the junction box.

A study by Kildare County Council revealed that,with the use of a voltage controller, the lighting level dropped by 1 illuminance class. This is acceptable when traffic flow volumes are in accordance with Institution of Lighting Engineers Technical Report 7. The finding indicates that in this instance the voltage controller can be switched in at all times except periods of peak traffic flow between 5pm and 7pm.

GLOBAL POSITIONING SYSTEM (GPS) STREET LIGHTING CONTROLS

A fully integrated street luminaire control system using GPS technology is available and can reduce the energy consumption of lighting networks by up to 40%. A GPS system is comprised of one or more controllers, one or more communication hubs, a dedicated PC for setup and programming, and a web-based software system for network management from a centralised location. Figure 5 shows how these systems are set up.

This system once installed can be used to remotely configure the lighting scheme for an entire area or street by switching the luminaires off if unnecessary or dimming during times of infrequent use if the relative components are used. As each luminaire has its own unique 'address', it is possible to gain maximum energy-saving benefits from this method of control.

Features

- flexible and scalable design
- easy, cost-effective installation
- powerful and intuitive to use
- each module has a unique address
- secure communication

Benefits

- reduction in energy usage
- instant performance and energy usage data
- full control
- reduced CO_2 emissions
- reduced maintenance costs
- fast payback on investment

Fig. 5 *Each component in a GPS networked control system and how they interface*

MAINTENANCE AND LAMP REPLACEMENT

Existing Lamp Type	Replacement Lamp Type	Benefits
Standard high pressure mercury 	H type high pressure sodium 	Plug-in HPS lamps (2,200 K) may be considered. – energy saving of 12–16% – increased light output of 55–67% – Ensure that ballasts / wattages are compatible – Check the colour rendering of the high pressure sodium lamp to make sure it is sufficient
Standard high pressure mercury 	HPI Plus 'S' metal halide 	Plug-in metal halide lamps S type (white) can be retrofitted with equal-wattage lamps to mercury control gear. These lamps will provide approximately 45% more light. – higher colour rendering – cool white appearance – Ensure that wattages are the same
Standard metal halide 	Ceramic metal halide (CMH) 	– equal energy use – equal life – higher efficiency (lumens/W) – improved colour rendering – improved colour stability throughout the lamp's life
Standard metal halide/ High pressure sodium 	LEDs 	– up to 5 times the lamp life – up to 50% energy savings – New luminaire required

Note: Always use reputable suppliers and products that comply with all national and EU lighting regulations and standards. Trial new products for suitability before widescale upgrades. Refer to ***www.seai.ie/TripleE*** *for best in class energy efficient products.*

Maintenance checklist

- Long-life versions of lamp types should always be chosen as they will significantly reduce maintenance requirements.
- Carry out group or bulk maintenance of lamps and fittings at appropriate intervals.
- Keep lamps, luminaires, sensors and surfaces free from dust and dirt. Cleaning schedules should be carried out every 3–6 months depending on the site and rate of dirt build-up.
- Luminaires should be easily accessible for lamp replacement.
- Standings for vehicles or ladders in landscape situations are required if rigid columns are used.

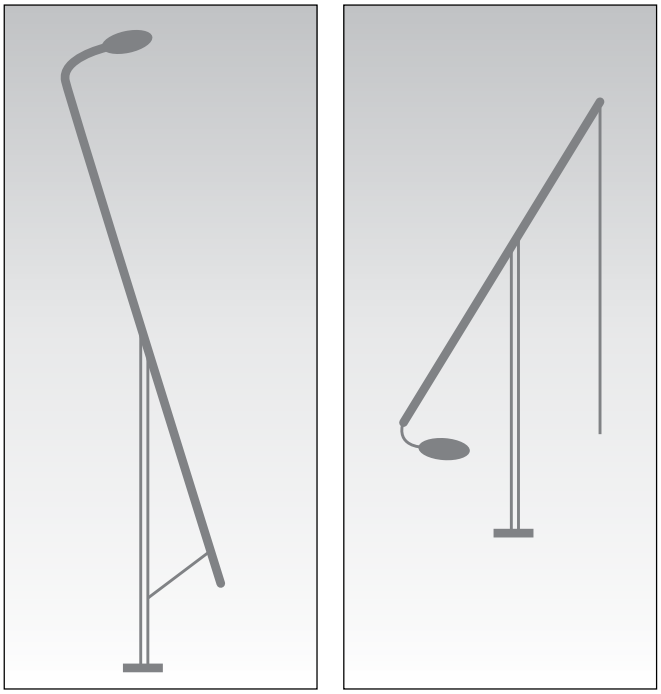
Columns and masts

Floodlights at ground level minimise maintenance but are more prone to vandalism. Floodlights on fixed columns overcome possible vandalism problems but are more difficult to maintain.

Hinged columns offer an appropriate alternative to fixed columns and reduce maintenance issues such as the need for lifting equipment.

There are two types of hinged columns: (1) The bottom-hinged column, which requires a special tool to unlock as well as lowering space (Figure 6). (2) The centrally, counter-balanced hinged column, which only requires a rope and spanner. The column is unfastened near the base (Figure 7a) and pulled with a connected rope until the head is at a position (Figure 7b) where the luminaire can be maintained.

Fig. 6 *The bottom-hinged column requires a bespoke tool, but with smaller columns is easily maintained by a single person*



7a ***7b***

Fig. 7 *Tilt action of the centrally counter-balanced hinged column*

LAMP TECHNICAL DETAILS

A **Fluorescent tubular lamps**

Use types T8 (26mm) with electronic high-frequency ballast or T5 (16mm) with high colour rendering and an appropriate colour appearance. There are many advantages to specifying electronic high-frequency ballasts when using fluorescent tubes. They optimise the lamp life by up to 50% on standard tubes, and dimming versions are available, as are rapid-start for instantaneous light, or soft-start in which there is a moment's delay. All ballasts consume electricity, but electronic high-frequency ballasts consume less than wire-wound equivalents.

B **Compact fluorescent lamps**

Compact fluorescent lamps are only available with high colour rendering,with a choice of different colour appearances.

C **Mercury lamps**

Mercury lamps are not as efficient as other forms of high-intensity discharge lamps, but are inexpensive and provide 'white' light. They also require a warm-up period.

D **Metal halide discharge lamps**

Metal halide (HID) lamps have good efficiency and may be used where good colour rendering and differing colour appearances are required. Remember that, if turned off during operation, metal halide lamps require a warm-up and re-strike period of up to 15 minutes.

E **High-pressure sodium (SON) lamps**

High-pressure sodium discharge lamps combine high efficacy with long life and are commonly used in floodlighting applications where colour rendering is less important. Lamps require a warm-up and re-strike period, and are therefore not suitable for frequent switching.

F **Low-pressure sodium (SOX) lamps**

Low-pressure sodium discharge lamps have the highest efficacy and are commonly used to light footpaths and minor road applications. They have zero colour-rendering properties. These lamp types should not be used where colour rendering is important. Lamps require a warm-up and re-strike period. and are therefore not suitable for frequent switching.

G **Light Emitting Diodes (LEDs)**

See corresponding section.

H **Induction Lamps**

Induction lamps have extremely long life and do not have electrodes or filaments. In induction lamps the electrical energy is supplied to the gas discharge by means of a high frequency electromagnetic field. As fluorescent powders are used within the vessel, colour rendering is good with differing colour appearances available.

Accelerated Capital Allowance and TripleE Register

The Accelerated Capital Allowance (ACA) scheme offers incentives for approved lighting products. Further information and details of manufacturers and suppliers of eligible products are available at www.seai.ie/aca. The Triple E Products Register www.seai.ie/TripleE is a new benchmark register of best in class energy efficient products. It is planned in the future to extend the product range beyond that covered by the ACA.

Tungsten halogen lamps

Tungsten halogen lamps start instantly, but have a short life and consume high amounts of energy. They are not recommended for exterior spaces.

Light-Emitting Diodes (LEDS)

There are many efficient LEDs, but there are also many that are not efficient. The scale of efficiency varies considerably. A standard of 40 lumens per watt (lm/W) and a life-cycle of 35,000 hours is the suggested minimum. However, this only covers the light emitted from the LED component and not whether the LED includes a 'lens' or an appropriate 'driver'. Therefore, a better understanding of how these three components integrate is essential if you want to achieve the best ultra-low-energy lighting solution.When assessing the performance of a product, you need to understand the factors that affect its capability. An 'LED' product comprises, essentially, three main components: a LED chip (semi-conductor), an optical lens, and a power driver.

LED chip

LEDs, being solid-state components, are difficult to damage with external shock, unlike fluorescent and high-intensity discharge lamps. A LED's light output and life-cycle is based on the LED operating at +20^{0}C; both lumens and life will be affected when the operational temperatures change. For example, at -20^{0}C, the LED may perform to 160% of the light output when measured at +20^{0}C. Products without a sufficient heat sink will often overheat and fail prematurely. Heat sinks tend to have as many grooves as possible to facilitate the flow of hot air away from the LEDs. The area of heat exchange will directly affect the lifespan of the LED street light.

Optical lens

LEDs are a directional light source and can be provided with or without primary lenses. Secondary optical systems include lenses, reflectors and diffusers. Each combination will affect efficiency and is application-specific. Most LED street lights have a lens on the LED panel that is designed to cast its light in a rectangular pattern. This is an advantage compared to traditional street lights, which typically have a reflector on the back side of a HID lamp; in this case, much of the luminance of the light is lost. Most high-intensity white LEDs currently on the market use phosphor material to convert monochromatic light from a blue or UV LED to broad-spectrum white light.

Power driver

The system specification should clearly state (a) the power requirements that are allowed for at the project design stage and (b) that the correct driver (control gear) type, current and voltage are matched to the LED luminaire or module.

Always scrutinise these three main components. Insist on verification of the results/performance data you receive – for example, a 'lux cone' or a light distribution curve will enable you to establish if the product has sufficient illumination or the appropriate light distribution for the application.

The energy efficiency specified by SEAI's Triple E register is based on the whole LED unit. The LED units comprising LED chip, optics, heatsink, and associated control driver must achieve L70 lifetime rating – that is, they must maintain 70% of the initial lumens output after the manufacturers' stated hours of continuous operation and a minimum of 40 lumens per circuit watt.

Well-designed lenses integrated within the final product and spreading the light in a controlled way will deliver higher levels of lighting for larger area lighting (Figure 8) or small localised areas (Figure 9). The development of effective lenses and higher-output chips will continue to help in attaining the desired lighting effect.

Application

Tralee Town Council and ESB Electric Ireland replaced existing lamps with LEDs in Tralee Town Square in order to provide:

- **comparable or better lighting levels in the selected area**
- **consistent and evenly distributed light in the selected area**
- **dramatic savings in power consumption and maintenance costs**
- **an ability to customise the lighting levels**

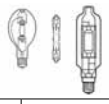
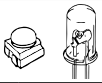
The replacement of 19 x metal halide and high-pressure sodium units with 17 LED units provided an overall saving of 68%. Existing supplementary lighting was retained.

Cashel Town Council reduced Christmas lighting energy consumption by 90% with just a slight reduction in light levels by using LEDs. The long lamp life will decrease maintenance costs by a substantial amount over the traditional incandescent lighting.

Fig. 8 *22W to 200W*

Fig. 9 *15W*

LAMP COMPARISON CHART

Lamp Type	Luminous Efficacy (lm/W)	Colour Temperature (K)	Colour Rendering (Ra)	Life (hours)	Maintenance	Controls	Application
A) Fluorescent Tubes - EHF 							
T8 (Triphosphor) – 58W	91	2,700 – 6,500	85	12,000 – 24,000	M	1 2 3 4a	1 2 5 6
T5 (HE) – 35W	82	3,000 – 6,500	85	16,000>	M	1 2 3 4a	1 2 5 6
T5 (HO) – 49W	75	3,000 – 6,500	85	16,000	M	1 2 3 4a	1 2 5 6
B) Compact Fluorescent - EHF 							
1 2	75	2,700 – 4,000	82	12,000>	M	1 2 3	2 5 6
'D' Type – 13W	69	2,700 – 4,000	85	12,000>	M	1 2 3	2 5 6
'T' Type – 18W	72	2,700 – 4,000	85	12,000>	M	1 2 3	2 5 6
'2D' Type – 25W	73	2,700 – 4,000	85	12,000>	M	1 2 3	2 5 6
C) Mercury - EM 							
80W (E27)	41	4,200	48	12,000>	M	1 2	1
125W (E27)	44	4,200	46	12,000>	M	1 2	1
250W (E40)	47	4,100	45	12,000>	M	1 2	1
400W (E40)	51	3,900	45	12,000>	M	1 2	1
D) Metal Halide - EM 							
Standard							
70W	70	3,000 – 4,200	75	10,000	M	1 2	1 2 3 4 5
150W	77	3,000 – 4,200	80	<20,000	M	1 2 4b	1 2 3 4 5
250W	72	3,000 – 5,000	85	<20,000	M	1 2 4b	1 2 3 4 5
400W	75	3,700 – 5,200		<20,000	M	1 2 4b	1 2 3 4 5
Ceramic (CDM-CDO)							
250W	81	2,800	85	9,000	M	1 2 4b	1 2 3 4 5
E) High Pressure Sodium (SON) 							
70W (E27)	67	2,000	25	12,000+	M	1 2 4b	1 2 3 4 5
100W (E40)	74	2,000	25	12,000+	M	1 2 4b	1 2 3 4 5
150W (E40)	86	2,000	25	12,000+	M	1 2 4b	1 2 3 4 5
250W (E40)	98	2,000	25	12,000+	M	1 2 4b	1 2 3 4 5
400W (E40)	111	2,000	25	12,000+	M	1 2 4b	1 2 3 4 5
F) Low Pressure Sodium (SOX) 							
Standard	132	1,800	0	8,000 – 18,000	H M	1 2	5
Economy	173	1,800	0	18,000	M	1 2	5
G) LED 							
White	40 (min)	2,700 – 6,000	50 – 80	50,000 – 100,000	L	1 2 3 4c	1 2 3 5 6
Colour	10 – 60	n/a	n/a	50,000 –100,000	L	1 2 3 4c	1 5
H) Induction 							
85W	67	3000 – 4,000	80	60,000	L	1 2	2 3 6

KEY
EHF – Electronic High Frequency
EM – Electromagnetic
Maintenance – H = High Maint.<10,000 hours M = Medium Maint.= 10,000-20,000 hours L = Low Maint. = 20,000+ hours
Controls – (refer to 'Controls' section) Application – (refer to 'Applications' section)

SEAI PUBLIC LIGHTING WORKING GROUP

Energy Use in Public Lighting

An analysis of energy used in local authorities shows that the typical percentage of energy used in Public Lighting accounts for between 15% and 35% of the total energy consumed. There are an estimated 420,000 street lights in Ireland consuming an estimated 205 GWh annually.

SEAI is facilitating a Public Lighting Working group, bringing together principal stakeholders and leaders in energy efficiency to develop methods to overcome these barriers.

Membership includes:

- Local Authorities
- National Roads Authority
- Industry Experts
- Local Energy Agencies
- CCMA – County and City Managers' Association.

Potential Energy Efficiency Opportunities

There are several technology and management upgrade opportunities that are appropriate in public lighting:

- Initial estimates indicate a potential 22% energy savings using current best technology available, rising to 30% for authorities who have not actively managed lighting. This equates to €6 – €10 million of potential energy savings nationally, with significant additional savings potential from reduced maintenance costs.
- Utilisation of energy performance contracting where the supplier is paid for light delivered rather than energy, driving efficiency.
- Trimming (reduced operating hours) and Dimming (reduced lighting levels when conditions permit, e.g. during periods of low traffic density).
- Improve housekeeping, addressing outdated technologies (MBF – mercury based lighting) or excess lighting levels not managed appropriately.
- Further technology upgrades available including electronic ballasts (with a typical 4 year payback).
- Roll out of energy efficiency pilot projects at a national level.
- Much of Ireland's Public Lighting is located in remote locations, some of which have renewable energy resources that could be exploited on a small or micro scale to augment / replace grid connected electricity.

Outputs delivered by the Public Lighting Working Group

The Working Group has delivered a number of outputs to support energy efficiency in public lighting including:

- Report on the findings of the Working Group
- This external lighting guide giving best practice solutions for new and retrofit lighting schemes.

This guidance material can be found at www.seai.ie/publiclighting

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