



The importance of lighting.  
The quality of light.  
Enhancing life.

Intelligent lighting solutions make the difference.

# Enjoy the benefits of good lighting

Light is essential for life, provides and helps us to see the visual tasks. The importance of good lighting is unquestionable as lighting provides essential service to people in all places. Light will:

- > increase the visibility of every visual task and reduce fatigue in working environments
- > improve safety and usability of streets and roads for motorists, pedestrians and residents
- > motivate and stimulate learning and study in the educational world
- > improve productivity, promote safety and accuracy in the workplace
- > stimulate the amenity and experience of the retail environment
- > enhance the quality of urban and city social and cultural life
- > beautify the visual appeal of architecture and landscape

Light affects our mood; improves well-being and biological processes. Light stimulates productivity and accommodates the 24-hours-lifestyle, ensuring safety and comfort, even for the aging population.





Society places much importance on climate and energy protection. Lighting can play a central role in saving energy, resources and costs. New lighting technologies and controls can deliver savings of at least 40%.

Innovations transform the way of energy consumption and offer us entirely new lighting solutions for a comfortable and healthy lifestyle. Main components of the lighting systems are:

- > energy efficient luminaires and lamps with electronic ballasts
- > intelligent designs with intelligent lighting controls and the use of daylight
- > high-efficient LEDs which offers lighting scenarios never known before.

Over 80% of the signals the brain processes come through our eyes. And these signals are carried by light. So it is very important that we have adequate light of the right quality for every purpose.



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## Introduction

This Lighting Awareness Guide is offered by CELMA and ELC to provide authoritative information on the importance of light and lighting for people and places. The Guide indicates the key considerations required to make the right decisions in the selection and operation of the correct, efficient and sustainable lighting solutions.

The Guide will be a valuable source of information to all people involved in policy making and enforcement of lighting at local, state and EU level. This guide leads us through a bundle of different applications humans are experiencing and builds a bridge to lighting solutions. It lists applicable regulations, standards, and contacts where further guidance and information may be obtained.

## The European Lighting Industry

The European Lighting Industry is represented by its European Associations CELMA and the ELC. The European Lighting Industry (light sources, luminaires and components) consists of thousands of luminaires companies in Europe, most of them small and medium-sized enterprises.

CELMA is the Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union. CELMA represents 19 Manufacturers Associations from 13 EU countries, over 1,000 companies (majority of small and medium-sized enterprises), 107,000 people employed in Europe and generates 15 billion euros annual turnover in Europe. For more information about CELMA please visit [www.celma.org](http://www.celma.org).

The European Lamp Companies Federation (ELC) is representing the leading European lamp manufacturers. ELC has 8 member companies, represents 50,000 people employed in Europe and generates 5 billion euros annual turnover in Europe. The ELC is dedicated to promoting efficient lighting practice for the benefit of the global environment, human comfort and the health and safety of consumers. More information about ELC can be found at [www.elcfed.org](http://www.elcfed.org).



7:00 A.M. - THE DAY STARTS

## Light – the way you want it

Nearly 100% of the population in the industrialised world lives in homes. Good lighting in all rooms is essential. Kitchens, bathrooms, workshops and study rooms need glare and shadow free good colour directional light to perform the critical visual tasks safely and effectively. Lounges and bedrooms need a soft general light for relaxing, topped up with local lights for reading.

Significant influences of lighting are:

- > Dimmable lights that offer flexibility in all rooms
- > Efficient light sources like fluorescent and LED reduce power consumption
- > Pleasing and efficient luminaires that offer proper atmosphere for every mood



## Tailored light for City and streets

More than 98% of people know their city or village by night. The face of a city at night plays an important role for residents and visitors. First requirement is visibility and orientation on the roads and streets for motorists and pedestrians for safety and movement. Accidents are costly and fear of crime restricts people's mobility. Furthermore there is a drive to improve the well-being of people and to sharpen city profiles in global competition. Better light can heighten appeal, shape image, provide security – and offers massive potential for savings.

Significant influences of lighting are:

- > Lighting heightens the visual impact of architecture and grabs attention
- > Well lit streets and parks improve safety and orientation
- > Innovative luminaires and lighting management reduce the energy consumption



8:30 A.M. - IN THE OFFICE

## Optimizing performance

15% of people work in offices. There are wide varieties of office workplaces: from an executive office of a CEO to a sales office in a workshop of a handcraft shop, from an open plan office in an insurance company to a stock control office adjacent to production lines in a factory. Most of these workers are mainly operating with a computer display screen. Here, lighting has an important role; to stimulate, motivate and give a feeling of well-being and the production of high quality work. Loss of alertness and absenteeism can be very costly.

Research shows that dynamic lighting over the working day is much appreciated. It supports, stimulates and motivates workers throughout the working day.

Significant influences of lighting are:

- > Stimulating light level for the task, activity and the room
- > Proper glare-free lighting and good modelling
- > Motivating visual environment over working time



1:30 P.M. - AT THE INDUSTRIAL WORKPLACE

## Improving productivity

8% of people are employed in an industrial workplace. Very often their job involves dealing with a demanding visual task. Making mistakes can lead to lost business and profit to the enterprise. It is crucial that lighting supports the worker to avoid mistakes and to support the performance level required during the entire work period.

Good Lighting improves safety and security. It supports the visibility of form and function and creates flexible spaces adapting to the tasks at hand. Recent research shows that dynamic lighting gives additional support to the well-being of the worker and a better condition during their entire working period. It helps to maintain productivity.

Significant influences of lighting are:

- > Appropriate illuminance and uniformity at the visual task
- > Supporting contrast and colour rendering
- > Adjustable lighting for higher demands



## Enhance concentration

35% or more of the population in Europe are attending education courses. Each course or subject is challenging to both young and not so young pupils. In the class rooms they have to concentrate, interact and perform during the full duration of the lessons. The better they perform the better are the results and the teachers participate in their success.

Research results show that by dynamic lighting the performance increases.

Significant influences of lighting are:

- > Proper illuminances on horizontal and vertical task areas like desks, boards or faces
- > Avoiding of disturbances from glare and poor contrast
- > Change in colour temperature stimulates alertness



*5:00 P.M. - CONSULTATION AT THE HOSPITAL*

## Feeling calm and comfortable

About 20% of people are treated in a hospital at least once in a year. Tailored lighting concepts help patients feel well looked after, while lowering the costs for energy consumption and maintenance.

The beneficial effect that colour and dynamic lighting have on human beings is confirmed by modern science. While the focus in the past was on optimal lighting for diagnosis and therapy, the emphasis today is increasingly on making use of the psychological and aesthetic impact of light.

Significant influences of lighting are:

- > Tailored illuminance for each treatment
- > Relaxed atmosphere to calm the patients
- > Balanced lighting levels day and night



## Healthy motivation and relaxing

Nearly 60% of people are practicing sports at least once per week and many Europeans recharge their batteries with wellness treatments. Proper lighting ensures a sense of well-being – including at night, when many recreational athletes wish to train or relax. Artificial lighting needs to be carefully planned, taking into account of the nature of the sports, the speed of movements and the location of performers and spectators.

Sport is also a popular form of recreation for non-participants. An increasing number of sporting events are televised and this demands high directional light levels with low glare and no obtrusive light emission.

Significant influences of lighting are:

- > Orientation of luminaires and direction of light to allow proper sporting and TV broadcast
- > Light level and colour appropriate also for fast sports
- > Lighting atmosphere to motivate and to relax respectively



## Stimulating choice and pleasure

97% of people have to go shopping. It is often fun, but can be a nearly daily necessity. Lighting defines the atmosphere. It inspires customers with ever-changing designs and helps staff to give better service. Furthermore, it contributes substantially to the success of the business. The main visual tasks are to recognize the goods, select the right item and to make the right purchasing decision.

Research shows that glittering light attracts customers and glare free light entices them to stay and shop for longer time.

Significant influences of lighting are:

- > Appropriate atmosphere for the type of shop and goods
- > Light level, colour rendering, and direction of light to ease the choice
- > Guidance through lighting

## Lighting and energy

Daylight when available is free. Electric lighting is needed when daylight is insufficient but it consumes electrical energy. In the EU, lighting accounts for 14% of all electricity used – 430 TWh per year.

### Significant measures to reduce energy consumption

The most effective measure is to use lighting only when it is needed. Lighting should be controlled by:

- > dimming, to use appropriate light levels
- > daylight control, to reduce electric lighting when daylight is available
- > occupancy detection, to permit people who are present to make use of lighting

These most important measures are exploited best when the lighting is properly designed, installed, operated and maintained in the best way. From the beginning experts should be included in the process to gain energy efficient lighting solutions which serve people at work and in their life.

### Better design for people

The lighting requirements are made for people. Both, new lighting and refurbished lighting shall be looked at with expertise.

New products offer significant improvements in efficiency and substantial energy savings

- > by employing new technologies

This measure can save up to 15% energy. It is already implemented by the enforced EU Regulations 244/2009 and 245/2009.

The lighting system approach further increases the energy savings:

- > by optimised scheme design
- > by correct installation, operation and maintenance
- > by employing “energy use (kWh)” based measures to involve the user

These measures can save more than 40%.

Note: “installed load (W/m<sup>2</sup>)” based measures will make little savings <10%.

Separate metering of the lights involves user participation and gives the best feedback and control on energy consumption rates.

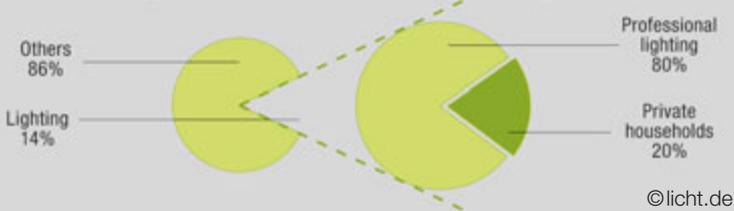
### Quick switch makes sense

Climate change occurs naturally but mans’ activities on earth speeds up the process by emission of the greenhouse gas CO<sub>2</sub>. In the EU lighting is responsible for about 180 Mt CO<sub>2</sub> of emissions per year. More than 60% of the electric lighting in current use is inefficient. There is a huge opportunity to reduce the energy consumed by lighting. However, currently the refurbishment rate of indoor and outdoor lighting systems is slow at about 5%. EU Policy and Member State actions are needed to accelerate the rate of change to more effective and efficient solutions.

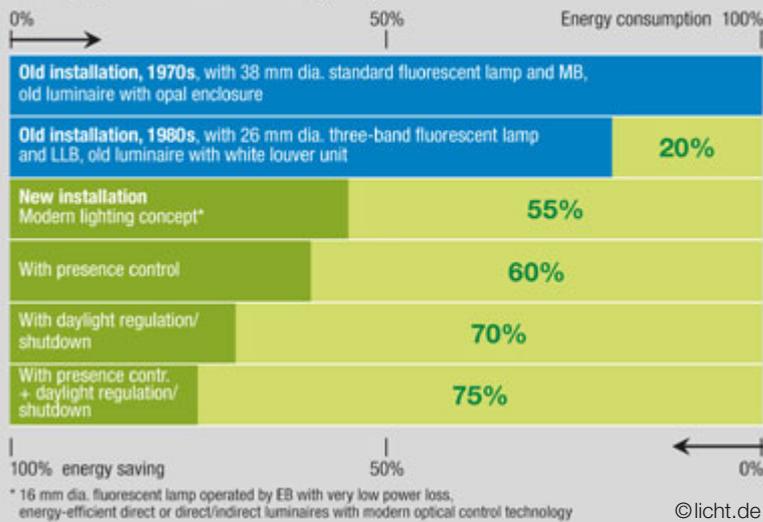
- > Think ecologically
- > Act economically
- > Secure future

*By providing the right light in the right place and used at the right time, lighting will contribute substantially to the EU efforts to achieve the Lisbon agreed energy saving and carbon reduction targets.*

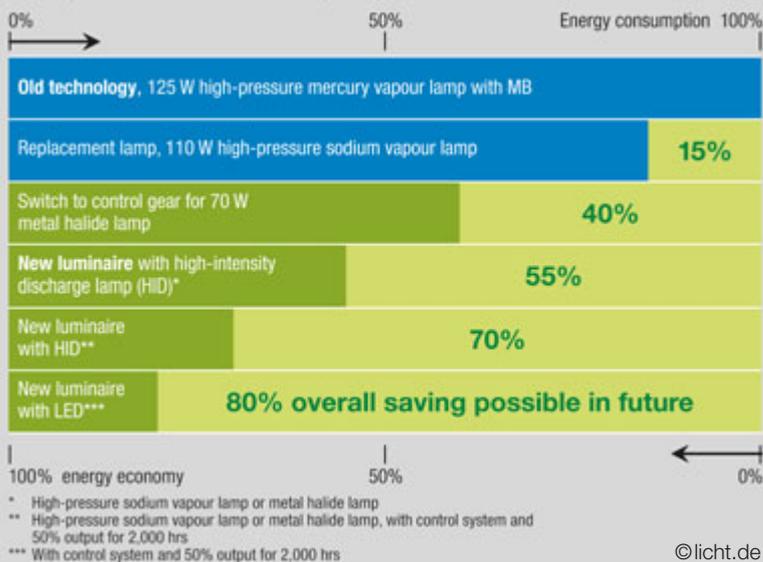
### Electrical energy consumption in the EU: percentages per year



### Savings potential of interior lighting



### Savings potential of exterior lighting



## Lighting and sustainability

Lighting solutions, products and schemes, employ materials and use energy. As both of these are of finite quantity it is very important to take this into consideration in the lighting design.

Product life cycle considerations and hazardous substances are mandatory in the EU WEEE and RoHS Directives and apply to all lighting solutions. Life cycle considerations help to conserve and optimise material usage and manufacturing processes.

### **Raw materials...**

- > lighting uses a wide selection of materials
- > depletion of raw materials is a fact of life
- > conserving raw materials has to be a priority
- > employing sustainable materials is the future

### **Processing...**

- > avoid or minimize the use of hazardous substances
- > design solutions with no or minimum waste
- > use sustainable components, products and manufacturing methods
- > minimize packaging and transport

### Sustainability: life cycle analysis of a lighting system

90% of energy is consumed during product application



- > Save energy
- > Conserve raw materials
- > Optimize design

#### Usage...

- > operate system as designed
- > service replaceable parts
- > make scheduled maintenance requirements

#### End of life...

- > consider waste-less disposal
- > design for disassembly and recycling

#### Electrical waste

Electrical waste is the fastest growing waste stream. Lighting equipment is electrical waste and must be handled according to the WEEE Directive. We need to minimize the end of life lighting equipment waste by taking actions to

- > design new products for easy disassembly
- > collect end of life products (target 85%)
- > apply treatment
- > re-use serviceable parts
- > recycle the materials (target 90% of the collected parts)

The key to sustainability is “Eco-design” of products and systems.

Biggest factor =

Transport



Lighting solution



Recycling



## Better light – for people and the environment



### Visual environment

The visual environment gives us our first impression and sets our mood. Lighting can enhance, beautify and stimulate our visual environment. These desires are equally important indoors and outdoors, day or night.

Good and appropriate lighting will give people much pleasure and satisfaction by

- > providing balanced surface brightness in indoor places
- > glare free work place lighting
- > shadow free light in indoor sports places such as bowling greens and badminton courts
- > beautify and model the features of sculptures
- > enhance the night time expression of building facades
- > reduce the fear of crime at night on residential roads

Incorrectly used light can cause annoyance, glare and hazard and can waste energy and valuable resources. It is important to reduce light pollution by restricting obtrusive light emissions at night by

- > avoiding sky glow (to permit us to have a dark sky at night and let us see the stars)
- > minimizing spill light (cut out waste light particularly emission from buildings at night)
- > stopping light trespass (to give people darkness for good sleep and health)

### Emergency lighting

It is essential to provide emergency lighting for people in public and work places to ensure visibility for safety and safe movement on escape routes to a place of safety during evacuation of the people in the event when there is no daylight available and the supply to the normal lighting has failed.

- > Experiencing light quality
- > Achieving Convenience
- > Reducing costs

*The importance of lighting is well understood and there are overwhelming benefits to the 500 million people in the EU.*

## Creating lighting solutions

### Designer's role

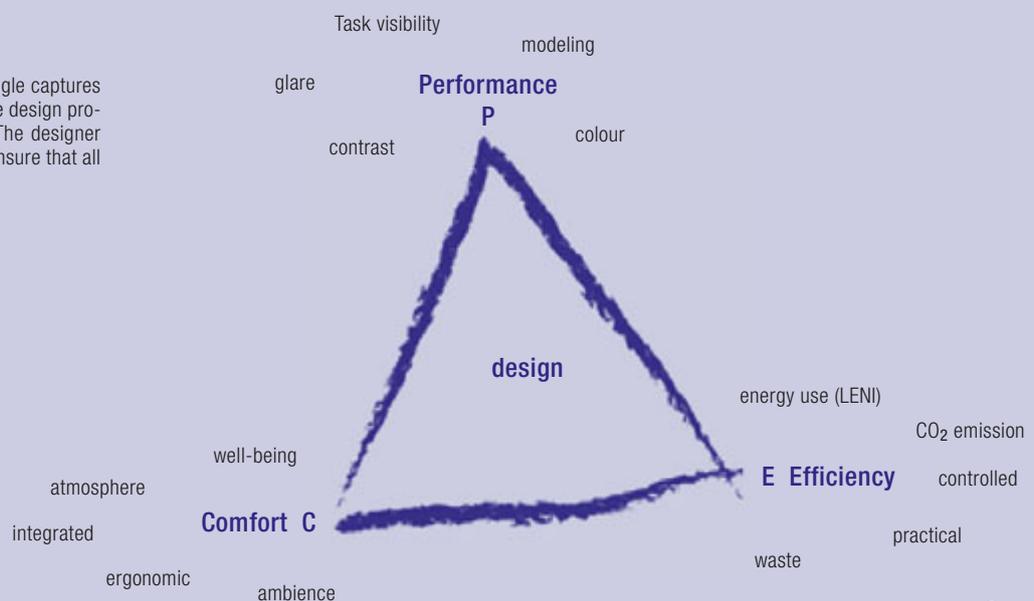
<b>Understand</b>	consider task, area, subject and place
<b>Meet requirements</b>	functions, amenity, standards, regulations
<b>Select equipment</b>	conforming to EU legislations and standards, environmental and architectural requirements
<b>Calculate</b>	manual or software aided
<b>Plan</b>	layout, installation, control strategy, use
<b>Cost</b>	supply, installation, use, maintenance

### Contractor's role

<b>Installing scheme</b>	according to design
<b>Commissioning</b>	set up scheme for hand over
<b>Training</b>	instruct end user on use, operation and maintenance

### Lighting design

The CELMA Lighting Awareness Triangle captures design considerations. Skilful scheme design provides successful lighting solutions. The designer can make use of the holistic tool to ensure that all influencing factors are considered.



# Glossary

## What is light?

Light is visible electromagnetic radiation. Furthermore it has to be considered in all its implications for human life.

- > Light plays a primarily physiological role in our lives by enabling vision and visual performance
- > Light also has a psychological impact in defining our comfort and sense of well-being
- > Light has a chronobiological effect on the human organism, setting and synchronizing our „biological clock“.

Light has many important characteristics, such as luminance, intensity, spectrum and direction.

Light is produced by daylight and electric light. There are a wide variety of lamps available and these have ratings, lumen output, efficacy, colour, life and circuit.

## Lighting terminology

**Brightness** – is what the eye detects and the brain interprets as light as effected by adaptation.

**Colour appearance** – The apparent colour emitted by a light source, measured by correlated colour temperature and described as warm, intermediate, cool or cold.

**Colour rendering** – The ability of the light from the light source to reveal the colours of an object. It is determined by the spectrum of the light source. Measured by colour rendering index ( $R_a$ ) and the higher the number the better, up to a maximum of  $R_a = 100$ .

**Contrast** – subjective experience of comparative brightness between areas of luminance seen simultaneously.

**Glare** – The discomfort or impairment of vision experienced when there is excessive contrast in the field of vision.

**Illuminance** – The amount of light falling on an area divided by the size of that area. (also known as the “density of the light”) measured in lux, varies from 0.2 lux by moonlight to 500 lux for office lighting to 100,000 lux by bright sunlight.

**Luminance** – The measured brightness of a luminous or illuminated surface. Measured in  $\text{cd}/\text{m}^2$ .

**Luminous efficacy** – The ratio between the luminous flux emitted by a light source to the power consumed by the source. Measured in  $\text{lm}/\text{W}$  and the higher the value the more efficient is the source up to maximum 680  $\text{lm}/\text{W}$ .

**Luminous flux** – The rate light is emitted by a light source. Measured in  $\text{lm}$ .

**Luminous intensity** – The amount of luminous flux radiated in a particular direction. Measured in  $\text{cd}$ .

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



## Electric light sources

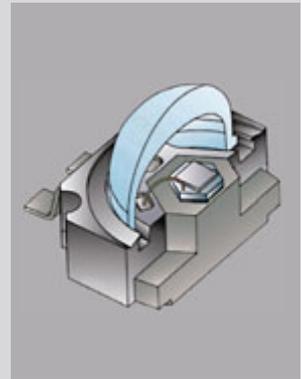
**Incandescent lamps** – are electrical light sources which radiate light as a result of a heated tungsten filament. They are typical thermal radiators: only around five percent of the energy they consume is converted to light; the rest is dissipated as heat.

Rating: 1 W to 5 kW  
 Efficacy: 10 to 25 lm/W  
 Life: 100 to 4000 hours  
 Colour: warm light with  $R_a$  100  
 Circuit: HV and LV (needs transformer)  
 Other: with „Halogen“ that extend life and efficacy  
 Output: dimmable



be obtained from blue LEDs by applying an internal luminescent coating. LEDs offer a lot of advantages, e.g. long life, no maintenance, IR/UV-free light, low energy consumption, colour stability and shock resistance.

Rating: 0.1 to 18 W  
 Efficacy: 40 to 120 lm/W  
 Life: 25,000 to 50,000 hours  
 Colour: intermediate to cold light,  $R_a$  80  
 Circuit: driver for DC power  
 Other: clustered for high output (phosphor or RGB mix)  
 Output: dimmable



**Discharge lamps** – generate light by sending an electrical discharge through an ionised gas or metal vapour. Depending on the gas with which a lamp is filled, it either radiates visible light directly or converts UV radiation to light through interaction with a fluorescent coating on the inside surface of the tube or bulb. The operating pressure inside a discharge lamp is either low (low pressure discharge lamps) or high (high-pressure discharge lamps).

Rating: 5 W to 2 kW  
 Efficacy: 40 to 120 lm/W  
 Life: 5,000 to 30,000 hours  
 Colour: warm to cool light,  $R_a$  90  
 Circuit: ballast, starter  
 Other: clear or phosphor coat; low and high pressure  
 Output: dimmable (low pressure fluorescent)



## Impact on Human Being

**Biorhythm** – Non-specific term for a natural rhythm of biological cycles in living organisms.

**Circadian rhythm** – A biological rhythm occurring at intervals of around 24 hours (from the Latin circa = approximate, dies = day), e.g. the sleep/wake rhythm in human beings. Light is the most important cue for synchronising circadian rhythms.

**Internal clock** – Also known as the master clock, it synchronises the body with the external day/night cycle. It is located in the suprachiasmatic nucleus (SCN). Light is thus the most important synchroniser for the internal clock. It uses hormones and neurotransmitters (e.g. Serotonin) to regulate the many tiny clocks in body cells that have no direct contact with the environment.

The human biological clock – setting for a diurnal rhythm of around 24 hours – can be altered, however, by exposure to light, especially light at the shorter end of the wavelength scale.

**Seasonal affected disorder (SAD)** – Pathological depression which is generally due to lack of light in the winter months and which can be treated by light therapy. The symptoms subside automatically in spring.

**LEDs, Electronic semiconductor** – which, when energised, emit red, green, yellow or blue light. White light can



## Lighting standards

### Lighting application standards

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European application standards contain fundamental lighting requirements for planning energy efficient lighting schemes (e.g. correct illuminance, uniformity, brightness, glare limit, colour criteria, etc). Local regulations may apply.

<i>Standard</i>	<i>Lighting segment</i>
EN 12464-1	Indoor Workplace
EN 12464-2	Outdoor Workplace
EN 12193	Sports lighting
EN 13201 (Part 1 to 4)	Road lighting
EN 1838	Emergency lighting
EN 50172	Emergency lighting systems
EN 15193	Energy requirements for lighting in buildings
EN 13032 (Part 1 to 3)	Photometry, data transfer and presentation

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### Lighting product standards

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Conformity to product safety standards permits CE marking and with additional conformity to performance in some cases can secure ENEC quality marking.

<i>Lamps</i>	<i>Safety</i>	<i>Performance</i>
Linear fluorescent	EN 61195	EN 60081
Compact fluorescent	EN 61199	EN 60901
High pressure sodium	EN 62035	EN 60682
Metal Halide	EN 62035	EN 61167
LED-module	EN 62031	in preparation

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<i>Control gear</i>	<i>Safety</i>	<i>Performance</i>
Fluorescent	EN 61347	EN 60929 / EN 60921
HID	EN 61347	EN 60923
Filament lamp	EN 61347	EN 61047
LED	EN 61347	EN 62384
Capacitors	EN 61048	EN 61049
Starting device	EN 61347	EN 60927

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<i>Luminaire and system</i>	<i>Safety</i>
Luminaire construction	EN 60598
EMC emission	EN 55015
EMC immunity	EN 61547
Electric track	EN 60570
Road light columns	EN 40
Harmonics	EN 61000-3-2
Photobiological safety	EN 62471

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All IEC, ISO, CEN and CENELEC standards are obtainable from the EU Member State Standards Organisation.



## Lighting legislation, guides and contacts

Standards give measures of safety, compatibility and performance for products. Lighting standards recommend the requirements for safety and adequacy. Lighting standards set the design and operating criteria for good practice.

### European Legislation affecting lighting

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There are several EU Directives and Regulations that apply to lighting. These are European Laws that are implemented via EU Member State Laws. Several demand mandatory conformity and some are open to national adjustments.

- > Eco-Design requirements of Energy related Products (ErP)
- > Energy Labelling of EcoDesign Products
- > Low Voltage Directive (LVD)
- > Electro Magnetic Compatibility (EMC)
- > Waste Electrical and Electronic Equipment (WEEE)
- > Energy Performance of Buildings Directive (EPBD)
- > Restriction of Hazardous Substances (RoHS)
- > Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
- > Energy Service Directive (ESD) with the National Energy Efficiency Actions Plans (NEEAPs)
- > EU EcoLabel
- > Green Public Procurement (GPP)

*A full list of all EU legislation affecting lighting can be found on the CELMA website.*

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### Guides & Contacts for help and advice on lighting matters

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There are International, European and National lighting professional organisations who publish lighting codes and guides that supplement the standards. These guides give practical advice on requirements and solutions, and are mainly written in local language. Most of these organisations give help and advice on lighting matters.

- > International: CIE – [www.cie.co.at](http://www.cie.co.at)
  - > Europe: CELMA – [www.celma.org](http://www.celma.org) & ELC – [www.elcfed.org](http://www.elcfed.org)
  - > Example of other organizations in EU countries:
    - > France: AFE – [www.afe-eclairage.com.fr](http://www.afe-eclairage.com.fr)
    - > Italy: AIDI – [www.aidiluce.it](http://www.aidiluce.it)
    - > Germany: licht.de – [www.licht.de](http://www.licht.de) & LiTG – [www.litg.de](http://www.litg.de)
    - > UK: SLL – [www.sll.org.uk](http://www.sll.org.uk)
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## **CELMA**

*Federation of National Manufacturers Associations for  
Luminaires and Electrotechnical Components for  
Luminaires in the European Union*

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*The list of the CELMA members' Lighting  
Manufacturers Associations in the various  
EU countries can be found on the CELMA  
website:  
[www.celma.org](http://www.celma.org)*

## **ELC**

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*The list of the ELC members' companies  
can be found on the ELC website:  
[www.elcfed.org](http://www.elcfed.org)*