



## Further Outlook: Rising Temperatures

### How energy efficient lighting can help to fight climate change

The oceans will warm, and glaciers will melt, causing sea levels to rise and salt water to flood low-lying coasts.

Weather patterns become more erratic with heat waves and periods of unusually warm weather followed by severe downpours, heavy snowfalls and flooding. In addition, computer models indicate that many diseases will surge as the earth's atmosphere heats up.

This is, how experts<sup>1</sup> describe the future of our children and grandchildren caused by global warming. If we are not able to stop the rapid increase of greenhouse gases such as carbon dioxide, these forecasts will come true. Commitments have been made by European governments to reduce carbon emissions by 8 percent.

One measure to achieve this objective is to save electricity, as the generation of electric power is a major contributor to the greenhouse effect. The right selection of lamps can contribute significantly to combat the number one threat to our environment.

Please read the following pages carefully and learn how our environment will benefit from using existing, energy efficient lighting technology.

#### INSIDE

Some facts about electricity.....	2
Light sources and environment.....	3
Today's light sources: function, types and application .....	4
Instruments and options to cut energy consumption .....	6
The language of light: some definitions .....	7

<sup>1</sup>Epstein, Paul R., Is Global Warming Harmful to Health?, *Scientific American* 08/2000

## SOME FACTS ABOUT ELECTRICITY

### Electricity generation and consumption in Western Europe

Our modern society requires a growing quantity of electricity for its industry, public facilities and domestic uses. Electricity consumption per capita increased by more than 20% from 5340 kWh/capita in 1985 to 6470 kWh/capita in 1997.

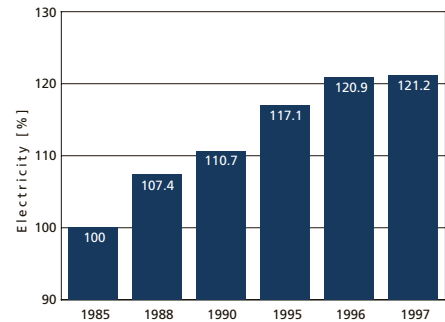
Since 1985, electricity consumption in the European Union has increased by 2,2% per year. The share of electricity in total energy demand - with contribution of solids, oil, natural gas, electricity and renewable energy forms - for two important sectors, industry and domestic, increased from 21.5% in 1985 to 26.2% in 1997<sup>2</sup>.

Growing demand in electricity is closely linked to the generation of greenhouse gases by power stations in particular through combustible fuels.

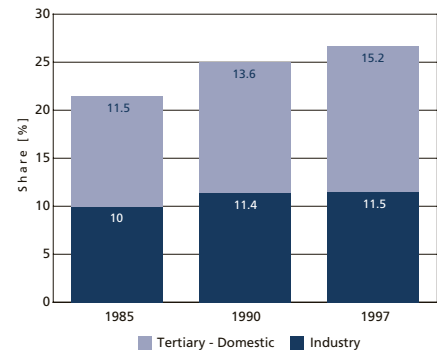
According to the International Energy Agency<sup>3</sup> the contribution of combustible fuels to the overall production of electricity in European OECD countries was close to 52% in the year 2000.

As lighting accounts for up to 20% of the electricity consumption it is obvious to analyse the potential of energy efficient lighting with respect to reduction of energy consumption and emission of greenhouse gases.

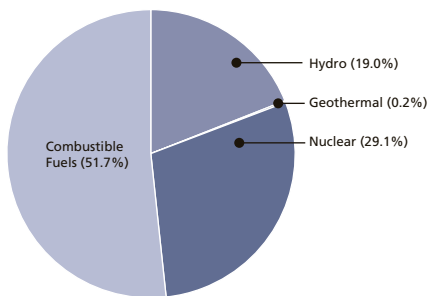
Electricity Consumption Per Capita in the European Union



Electricity Share of Total Energy Demand

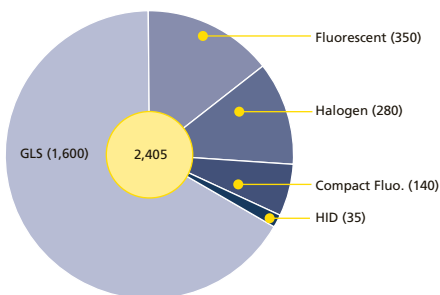


### OECD Europe Electricity Supply Jan-Dec 2000



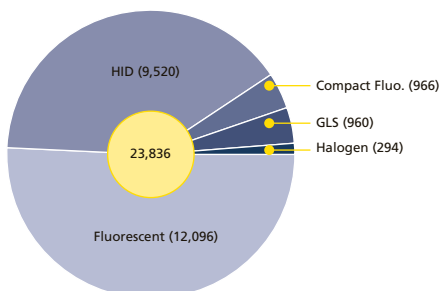
### Annual Lamp Sales in Western Europe

(Millions of Units)



### Annual Light Output in Western Europe

(Light output [Tlmh])



## Electricity and light

- Every year, more than 1.6 billion incandescent lamps are sold in Western Europe alone which represents 67% of the total annual lamp volume. However, due to their low efficacy, their contribution to the total annual light output in Europe is only 4% (960 billion lumen hours).
- In contrast to the low efficient incandescent lamps 350 million straight fluorescent lamps – that is only 15% of all lamps sold per year - account for more than 12000 billion lumen hours or 51% of Western Europe's annual light output.
- Tungsten halogen lamps make up 12% of all general lighting lamps sold per year. Their contribution to the total light output is only 290 billion lumen hours or just 1%.
- 140 million energy saving compact fluorescent lamps, only 6% of all light sources sold per year, achieve 970 billion lumen hours. This is the same light output as generated from 1.6 billion incandescent lamps.
- High intensity discharge lamps (HID) are only sold in relatively low quantities of 35 million per year (1% of all lamps sold). However, due to their high wattages and lumen packages their total annual light output is 9520 billion lumen hours or 40%.

<sup>2</sup> European Union, 1999 Annual Energy Review

<sup>3</sup> International Energy Agency, Monthly Electricity Survey, December 2000

## LIGHT SOURCES AND ENVIRONMENT

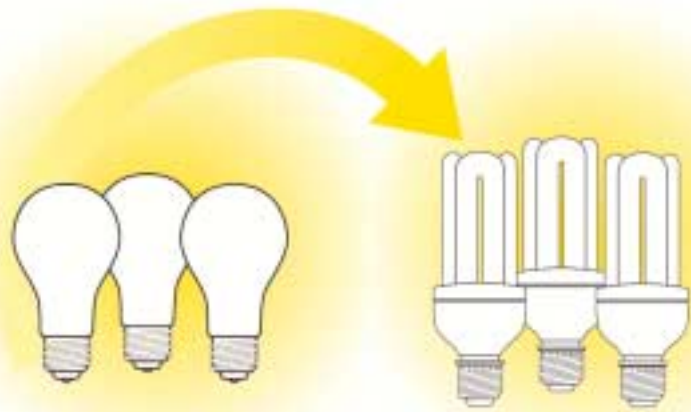
When one discusses the environmental aspects of lamps, two major factors have to be considered:

Emission of greenhouse gases by power generation and hazardous substances in light sources.

### Light sources and CO<sub>2</sub> - emissions

- In 1997, the 200 participating nations at the Kyoto conference made commitments to reduce greenhouse gases by 5.2% worldwide before 2012 compared to the 1990 emission level.
- Europe's Kyoto-target has been set to a reduction of 8% over 1990 emission.
- Most of the measures to cut emissions in the timeframe 2008-2012 must be made with technologies already existing today.
- As generation of greenhouse gases is proportional to the combustion of fossil fuels, promoting energy efficient solutions will be the main task on Europe's way to achieving its objective.
- Lighting plays a significant role when it comes to save energy. Up to 20% of the electricity supply in Europe is consumed by lighting for offices, households, industrial and commercial buildings as well as street lighting.
- Recent studies in the UK indicate that cost-effective lighting can contribute to a substantial reduction of CO<sub>2</sub> - emissions.
- The challenge for policy makers will be to influence millions of individual purchasing decisions that have a dramatic impact if taken all together.

### A SIMPLE CALCULATION: The potential of energy saving lamps:



**IF**

160 million European households replace 1 incandescent lamp 60 W with 1 energy-saving compact fluorescent lamp 11W and operate them 3 hours per day

**THEN**

7800 million kWh in electrical energy will be saved, which is 2% of total energy used for lighting in Western Europe

In addition, Western European CO<sub>2</sub> - emission will be reduced by 4600 million tons of CO<sub>2</sub> - a reduction in the generation of greenhouse gases of ,33%.

### MAKE THE SWITCH



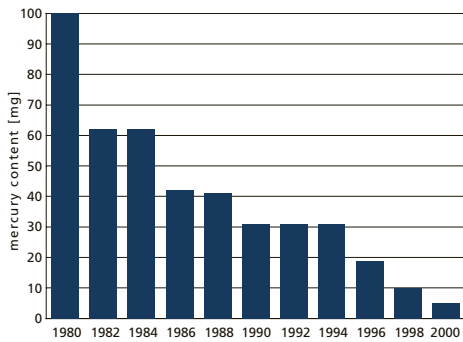
If 50% of Europe's street lights were switched from High Pressure Mercury lamps to more efficient High Pressure Sodium lamps and Compact Metal Halide lamps this could potentially save up to 4.5 million tones (Mtons) of unnecessary CO<sub>2</sub> emissions each year.

This is equivalent to the CO<sub>2</sub> consumption of over 200 million trees per year - over 20% of the surface area of Belgium.

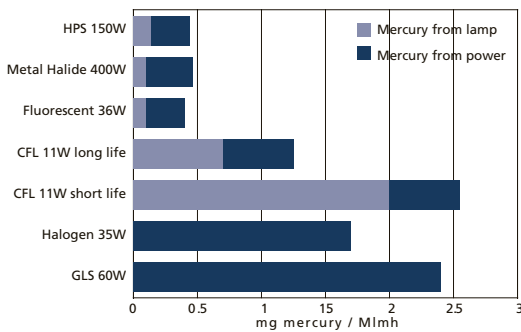
### Did you know?

- that every day more CO<sub>2</sub> is released in the atmosphere than can be bound by nature in 1000 years.
- that CO<sub>2</sub> -concentration increased more than 25% in the last 130 years.
- that CO<sub>2</sub> -concentration will double by 2030 if our energy consumption increases steadily, like it does at the moment.
- that the increasing concentration of greenhouse gases will result in a rise of average temperatures between 1.5 and 4.5°C by the year 2050.
- that European power stations release an average of 0,590 kg CO<sub>2</sub> to generate 1 kWh of energy

## Mercury Reduction in Linear Fluorescent Lamps



## Amount of Mercury for Different Lamp Types



## Mercury in lamps

Fluorescent and compact fluorescent lamps need a small amount of mercury to produce light in the most energy-efficient way. However, in the past decades, lamp manufacturers put considerable efforts into the reduction of hazardous substances such as mercury and at the same time optimisation of lamp performances. Technical progress and improved components have enabled the amount of mercury to be reduced without compromising light output or lamp life.

Important for a possible environmental impact of mercury is its mass balance over the life cycle of different lamps.

Taking into account the amount of mercury released from power stations during electricity generation the figure indicates that all gas discharge lamps reduce the total amount of mercury compared to filament lamps which themselves are mercury free.

This has to do with the fact that fluorescent and compact fluorescent lamps use much less electricity to produce the same amount of light.

Another advantage of mercury containing lamps is that recovery of mercury can be controlled by lamp - recycling techniques.

However, mercury mobilised from the generation of electrical energy used by low energy-efficient filament lamps is emitted to the atmosphere and cannot be captured.

For more details see the ELC-brochure "Environmental Aspects of Lamps"<sup>4</sup> and ELC Comments on the Commission Consultation Document for the Development of an EU Mercury Strategy (5 May 2004).

## TODAY'S LIGHT SOURCES: FUNCTION, TYPES AND APPLICATION

Today's light sources are grouped according to their principle of light generation and their relevant characteristics into three categories:

- Filament lamps
- Gas discharge lamps
- Semiconductor lamps

### Filament lamps:

**Light is emitted by heating a tungsten wire filament until it glows.**

**Incandescent lamps**, often referred to as GLS lamps (general lighting services lamps).

- Incandescent lamps are the world's most popular light sources: However, they are not at all energy-efficient. Only 5% of the electric energy is transformed into light and 95% of the energy they consume is given off as heat. A typical value for their efficacy is about 10 lm/W.
- Light output (in technical terms luminous flux measured in lumen [lm], see chapter "The language of light") and lamp life are closely related. The higher the temperature and with that the light output, the shorter the lamp life. Standard incandescent lamps in Europe are typically designed for a lamp life of 1000 hours.



Clear standard incandescent lamp

**Tungsten halogen lamps** are a refinement of incandescent technology – very compact in size, with improved light quality.

- Tungsten halogen lamps are more energy efficient than standard incandescent lamps (typical efficacy 20 lm/W) and offer a lamp life between 2000 and 5000 hours.
- The most popular tungsten halogen types are so-called low voltage lamps typically operated at 12V. Although a transformer is needed to apply the low voltage to the lamps, these light sources have become the preferred choice for accent, display and decorative lighting in all areas of general lighting.



Low voltage halogen bi-pin lamp

<sup>4</sup> ELC, Environmental Aspects of Lamps, Brussels, 2001

## Gas discharge lamps:

**Electrons emitted from a hot cathode excite – on their way to the anode – gas atoms causing them to emit ultra-violet radiation or visible light.**

**Fluorescent lamps** are low pressure discharge lamps with phosphor coating converting ultra-violet radiation into visible light

- Fluorescent lamps are very energy efficient with efficacies up to 105 lm/W.
- Like every discharge lamp, they must be operated by a ballast controlling the lamp current, and they need a starting device.
- Electronic Control Gear operate the lamps more efficiently than conventional ballasts, and at the same time provide more comfort such as flicker free operation, instant, flicker free start or end-of-life control.



Linear fluorescent lamp

**Compact fluorescent lamps** are often referred to as energy saving lamps – similar applications as standard incandescent lamps.

- Compact fluorescent lamps are up to 7 times more efficient than incandescent lamps (efficacy from 40 to 85 lm/W).
- Compact fluorescent lamps with integral electronic ballast and screw base are a direct replacement for incandescent lamps.
- For new installations a wide range of compact fluorescent lamps for operation with separate ballast are on the market.
- Electronic Control Gear operate the lamps more efficiently than conventional ballasts, and at the same time provide more comfort such as flicker free operation, instant, flicker free start or end-of-life switch-off.



Compact fluorescent lamp with integral electronic ballast



Compact fluorescent lamp for operation with separate ballast

### High intensity discharge (HID) lamps

consist of product families of mercury vapour lamps, metal halide lamps and high pressure sodium lamps.

- HID lamps are powerful and energy efficient light sources for many professional applications in industrial, commercial and public lighting.
- They are available in a wide range of types and wattages from 35 to 3,500 Watt
- Their efficacy ranges from 40 lm/W for mercury lamps to 150 lm/W for high pressure sodium lamps.
- They must be operated by a ballast controlling the lamp current, and they need, with the exception of mercury lamps, a starting device.



Metal halide lamps, elliptical shape, coated and tubular shape, clear

**Induction lamps** are new types of electrodeless fluorescent lamps that start through magnetic induction.

- Light quality and efficacy of an induction lamp is similar to a fluorescent lamp (efficacy up to 80 lm/W).
- As these lamps contain no electrodes they have an extremely long lamp life of up to 60,000 hours.



Types of induction lamps: ENDURA (OSRAM), QL(Philips), Genura (GE)

### Semiconductor lamps (Light emitting diodes-LED):

**LED generate visible light of a very specific colour– from blue to red - when the semiconductor material is biased by a voltage.**

Although in the market for over 30 years as indicator or signal lamps, their application in general lighting was prohibited by two facts: LED were only available in coloured versions and their efficacy of less than 10 lm/W did not make them an energy - efficient choice.

- LED are available in many colours (including white) and shapes with efficacy of up to 30 lm/W.
- Because of their small size of only a few mm and their extremely long lamp life of up to 100,000 hours they have started to substitute conventional lamps in some applications areas of general lighting.



Radial LED, 3 mm Ø

## INSTRUMENTS AND OPTIONS TO CUT ENERGY CONSUMPTION

Lighting can contribute to a significant reduction in energy use, if voluntary and mandatory measures to transform the market are combined in a meaningful way. Today, existing opportunities are not fully utilised.

Some of the key instruments available to transform the market are described below. They have been first published in the study “Energy-Efficient UK Lighting”<sup>5</sup> containing a variety of options to encourage the sale of more energy-efficient lighting products. The specific proposals to accelerate the use of energy saving lighting products can certainly be used as a basis for Europe.

### Voluntary agreements

These are quite widespread in Europe and include quantified efficiency improvements within a specified timetable.

Possible elements of a voluntary lighting agreement

The lighting industry could:

- withdraw T12 fluorescent lamps, halo-phosphor coatings and high-loss ballasts,
- withdraw poor performing luminaires or set minimum standards,
- assist with communication harmonisation and standardisation for advanced lighting controls,
- develop a labelling scheme for luminaires and/or lighting systems to enable users to select energy efficient solutions (similar to the labelling of household appliances including light sources for domestic application).

The governments should support some of the following:

- promote energy efficient lighting that uses high frequency electronic control gear.
- assist with education/training for manufacturers and installers in energy efficiency to produce and sell energy efficient products; and the design of efficient lighting systems.
- promote public sector procurement initiatives to support new lighting technologies
- tighten Building Regulations to ensure that energy efficient products are used and cannot be traded off.
- avoid measures that increase the price of energy efficient products, like the end-of-life fee on compact fluorescent lamps.

### Product subsidies and tax relief

This could include subsidies on lighting products to manufacturers, retailers and customers to favour more energy efficient lighting products.

The use of subsidies needs to be integrated into an overall plan that leads to a self-sustaining market in low cost energy efficient products.

Tax relief on energy saving measures has been introduced in some countries and could be extended further including energy efficient lighting.

### Public awareness and advertising

An awareness campaign that promotes the benefits of energy efficient lighting and that sells energy efficient lighting could be supported. Campaigns are needed for both the domestic and non-domestic market.

### Energy efficiency labelling

The labelling scheme for lamps has become effective 31st December 2000. As there is considerable variation in energy efficiency of luminaires (similar to lamps), a labelling/classifying scheme for luminaires should be considered. In the USA, a voluntary labelling scheme for luminaires has been successfully introduced by NEMA (National Emergency Medicine Association).

### Support of manufacturers, retailers and installers

The lighting industry could be supported to develop and market energy efficient products through

- Seminars and workshops for luminaire manufacturers (particularly the smaller ones) to develop product ranges based on compact fluorescent lamps.
- Exhibition support to promote their energy efficient lighting products to retailers, architects and facility managers etc and possible selected consumer exhibitions.
- Testing services related to luminaire efficiency.
- Support for the development of halogen lamps particularly for domestic purposes with lamp efficacies of 30 lm/W.

### Procurement initiatives

Widely used in Scandinavia, procurement initiatives can:

- bring new energy efficient products to the market place (technology procurement).
- promote existing products to achieve price reductions from the economies of scale of production in an aggregated procurement exercise.

It could be a good idea to encourage the public sector on an European basis to purchase only the more energy efficient lighting products.

### Mandatory instruments

a) Building Regulations

Building regulations are used to improve the energy efficiency

The ELC's activities connected with the implementation of the Framework Directive for Eco Design of Energy Using Products will show that more concrete initiatives are being taken in this area. [www.elcfed.org](http://www.elcfed.org)

<sup>5</sup> Brescu Building Research Establishment, Energy-Efficient UK Lighting, April 1998

of buildings. However, most definitions at present in various countries concentrate on lamps and largely ignore lighting controls and luminaire efficiency. Therefore, consideration should be given to:

- a harmonisation of existing standards on a European level including luminaire efficiency such as installed power density per 100 lux,
- lighting controls on medium and large schemes,
- luminaire efficiency,
- regulations for new and existing buildings.

#### b) Building energy rating schemes

Building energy rating schemes can effectively set minimum standards and energy efficient lighting should receive its due importance in these schemes. They could be used in utility tariff setting and property taxes to favour energy efficiency and so energy efficient lighting.

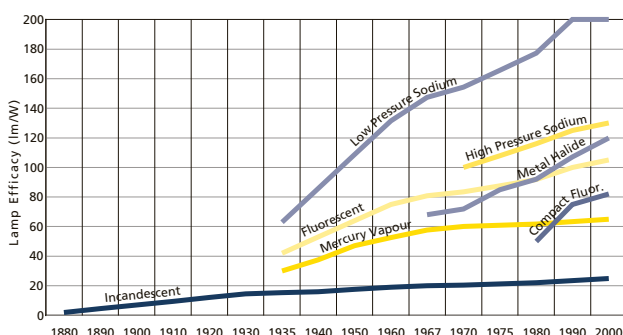
#### c) Present EC initiatives

- The lamp labelling initiative has been adopted as of 31 December 2000.
- A ballast agreement has been adopted under Directive 2000/55/EC of the European Parliament and of the Council of September 18, 2000 on energy efficiency requirements for ballasts for fluorescent lighting (Office Journal L 279, 01/11/2000 p. 0033-0039).

### A final word

- The intention of this paper is to discuss the right combination of measures for maximum reduction of electricity use in Europe by promoting energy efficient lighting products such as compact fluorescent, fluorescent and HID lamps together with the most energy saving technology in control gear and luminaires.
- For many years, the European lamp manufacturers have developed more energy-efficient light sources than the well known incandescent lamp for all fields of application. The graph below clearly demonstrates the progress in the development of energy saving lamps.
- The European lighting industry offers products to cut CO<sub>2</sub> and other power station related emissions by reducing energy consumption and is well prepared to cooperate in the development of initiatives to meet Europe's Kyoto target.

Development in Lamp Efficacy Over Time



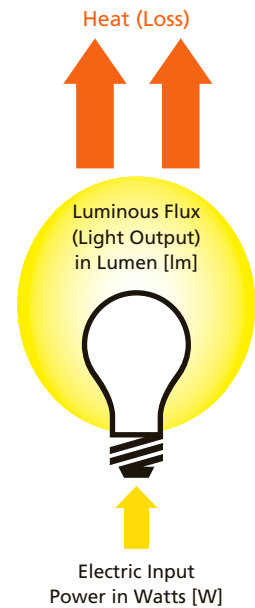
## THE LANGUAGE OF LIGHT: SOME DEFINITIONS

What is a lumen? How do we describe the efficiency of lamps? These and other basic lighting parameters are explained below.

### Watt [W]

The electrical energy a light source consumes is measured in Watt [W]. Part of the power input is transformed into light (visible radiation), while the rest is considered as loss (heat).

*For example, incandescent lamps transform 95% of the electric power input into heat and only 5% into light.*

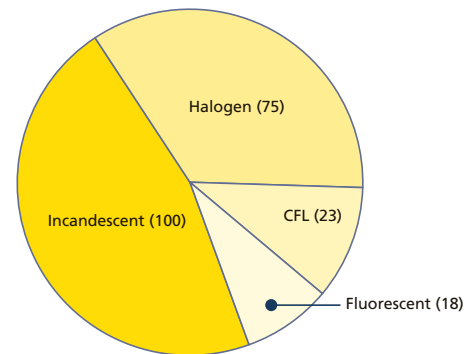


### Luminous flux [lm]

The luminous flux (light output) quantifies the total amount of light emitted by a light source. The unit lumen [lm] in which the luminous flux is measured, is typically used to rate the output of lamps.

*For example, the flame of a candle generates about 12 lumen. A standard 60W incandescent lamp is rated at 720 lumen. A compact fluorescent lamp 11 W is rated at 600 lumen*

Energy Consumption of Lamps with Equal Light Output



### Efficacy "lumen per watt" [lm/W]

Efficacy describes light output in relation to power input and is expressed in lumen per Watt. The higher the efficacy value, the more energy-efficient are lamps or lighting systems.

*This can be compared with the way a car's efficiency is rated in litres of petrol consumed per 100 kilometres (l/100 km).*

### Energy consumption [kWh]

The amount of electric energy consumed by a lamp in a certain period is expressed in kWh (kilowatt-hours).

*For example a 100W incandescent lamp consumes in 10 hours one kWh (10 hours  $\times$  100W = 1000Wh or 1 kWh). Rates for electricity are generally based on energy consumption.*

## LAMP TYPES, PERFORMANCE AND APPLICATION

Lamp type	Wattage range [W]	Range of luminous flux [lm]	Range of lamp efficacy [lm/W]	Typical efficacy [lm/W]	Main application
<b>Filament lamps: Incandescent and tungsten halogen lamps</b>					
Incandescent	15 - 200	90 - 3100	6 - 15	12	Standard light source for domestic application
Tungsten halogen, mains voltage	25 - 2000	260 - 44000	10 - 25	15	Domestic and commercial application
Tungsten halogen, low voltage	5 - 150	60 - 3200	12 - 25	19	Domestic and commercial application, accent lighting
<b>Gas discharge lamps: Fluorescent lamps</b>					
T12 fluorescent, 38 mm tube diameter	20 - 65	1050 - 4400	52 - 70	65	Industrial and commercial, old generation of fluorescent tubes
T8 fluorescent, 26 mm tube diameter	18 - 58	1300 - 5200	75 - 95	85	Industrial and commercial, standard for office lighting,
T5 fluorescent, 16 mm tube diameter	14 - 80	1300 - 7000	80 - 105	95	Industrial and commercial, new generation of fluorescent tubes
<b>Gas discharge lamps: Compact fluorescent and electrodeless lamps</b>					
Compact fluorescent with integral ballast	3 - 23	100 - 1500	34 - 65	60	Domestic, energy efficient replacement of incandescent lamps
Compact fluorescent with external ballast	5 - 57	250 - 4800	50 - 85	70	Commercial lighting, downlights and wall sconces
Electrodeless lamps (ENDURA, QL, Genura)	23 - 150	1100 - 12000	48 - 80	75	Industrial lighting, where maintenance is difficult
<b>Gas discharge lamps: High intensity discharge lamps</b>					
Mercury vapour lamps	50 - 1000	1600 - 58000	32 - 60	50	Street lighting, old generation
Metal halide lamps	35 - 3500	3300 - 320000	75 - 105	90	Industrial and commercial lighting, floodlighting, accent lighting
High pressure sodium lamps	50 - 1000	3500 - 130000	70 - 150	100	Street lighting, today's standard solution
Low pressure sodium lamps	18 - 185	1800 - 32000	100 - 200	150	Street lighting, mainly UK and Belgium
<b>Semiconductor lamps: Light emitting diodes</b>					
LED	0,02 - 0,25	0,01 - 2,8	10 - 30	15	Industrial and commercial lighting, security lighting and also new applications



### CONTACT US

Secretary-General  
ELC Federation asbl/vzw  
Diamant Building  
Boulevard Reyers 80  
B-1030 Bruxelles  
Belgium  
Info@elcfed.org  
Tel: +32 (0)2 706 86 08  
Fax: +32 (0)2 706 86 09  
www.elcfed.org

### Our members:

	Aura Light AB www.auralightgroup.com		NARVA Lichtquellen GmbH www.narva-bel.de
	BLV Licht- und Vakuumtechnik GmbH www.blv-licht.de		OSRAM GmbH www.osram.com
	GE imagination at work G.E. Lighting Europe Ltd www.gelighting.com		Philips Lighting BV www.lighting.philips.com
	Leuci SpA www.leuci.com		Sylvania Lighting International (SLI) www.sylvania-lighting.com