Energy efficiency in residential lighting

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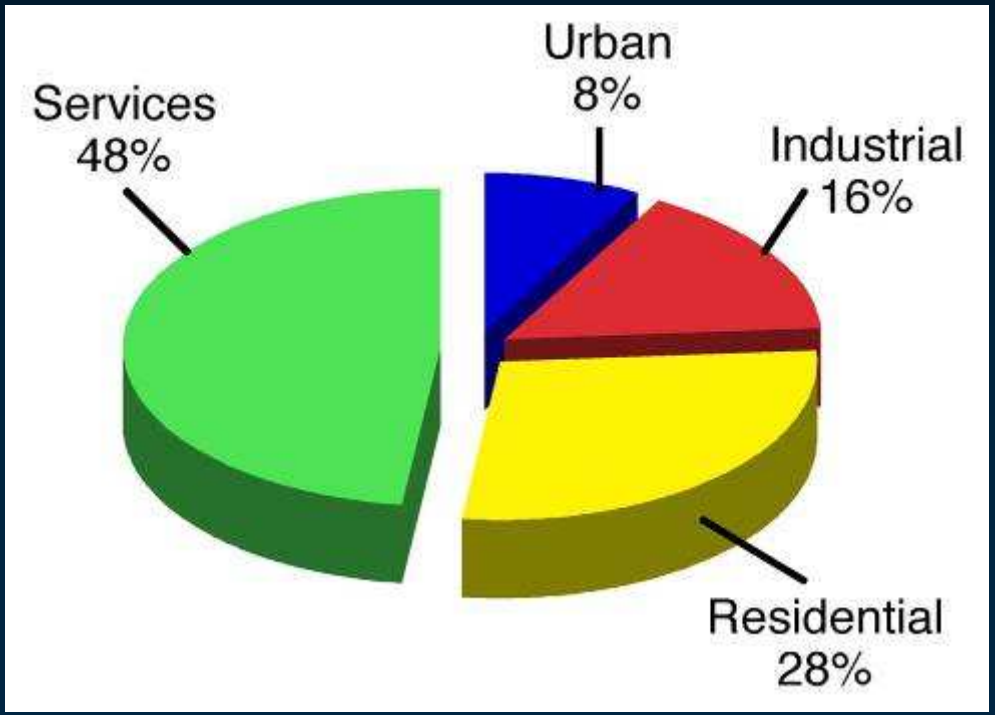
Residential energy consumption

- Residential buildings – an important energy consumer in EU
- **Lighting = Energy**: many than $30x10^9$ electric lamps in function around the world consume more than 2100 TWh annual (10-15% form the global energy production); 28% from this is consumed in Residential Lighting (Mills, 2003).



Lighting functions

The primary function of an electric lighting installation is to enable people to see, in order to live in their houses or to perform their professional tasks comfortably and safely. For avoiding an undesirable outcome from an electric lighting installation which achieves energy-efficiency at the cost of lighting, but makes people uncomfortable and puts their safety at risk, it is necessary to consider lighting quality as well as energy-efficiency when designing or evaluating lighting.

Residential lighting requirements

- **visual** - moving quickly and safely from one space to another, properly seeing people and objects
- **flexibility** in multipurpose spaces - living rooms and kitchens
- **comfortable rest** of stressed people
- **pleasant living environments**

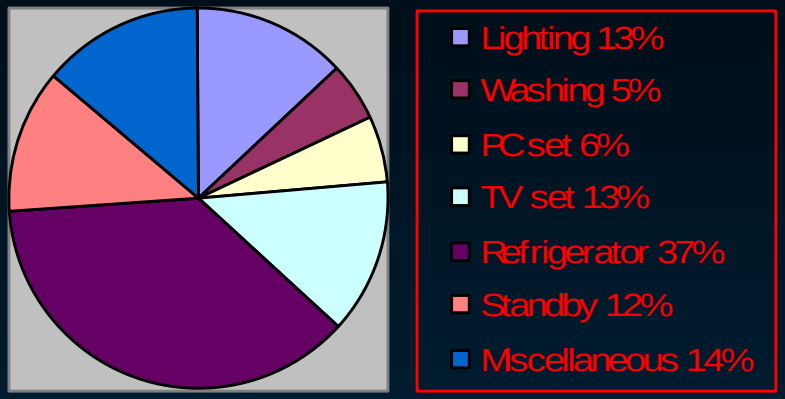
- improving energy - not conflict with such requirements
- economically justified - to be accepted by the residential market.

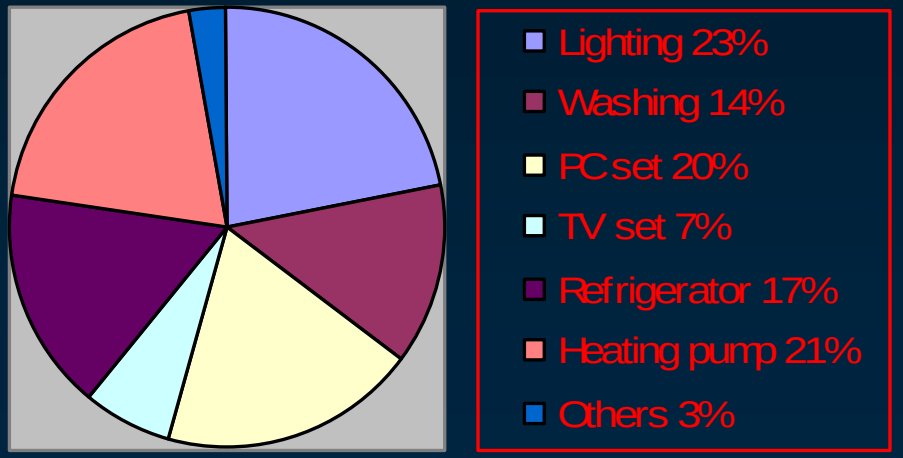
- elder people affected by limited physical capabilities - more quantity and quality of light.

quality of lighting must be high

Home appliances

Example of mapping of the end-use consumption in a home – Denmark [4]

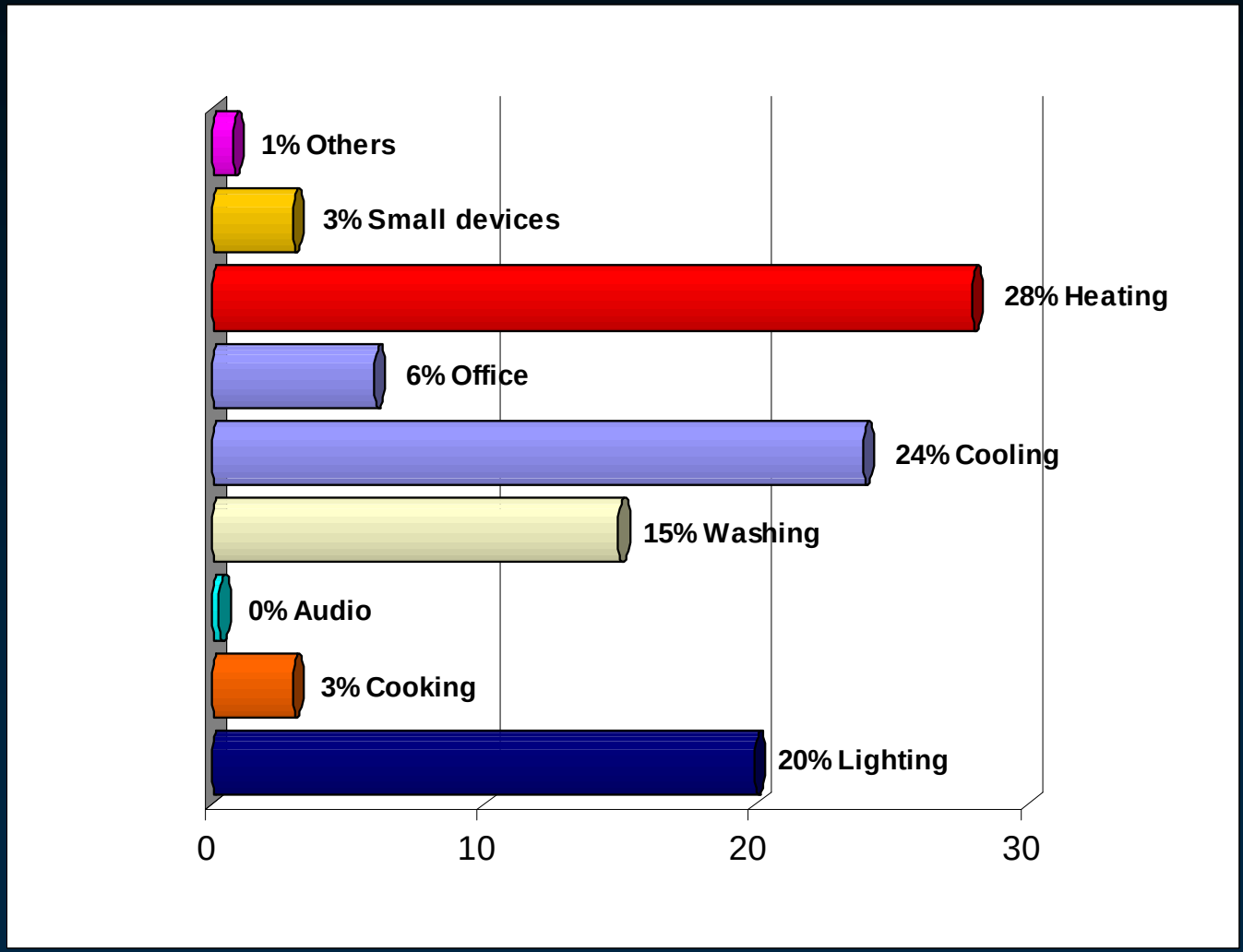




Energy consumption of some household electric appliances – Romania [2]

Home appliances

CREFEN survey - 2007

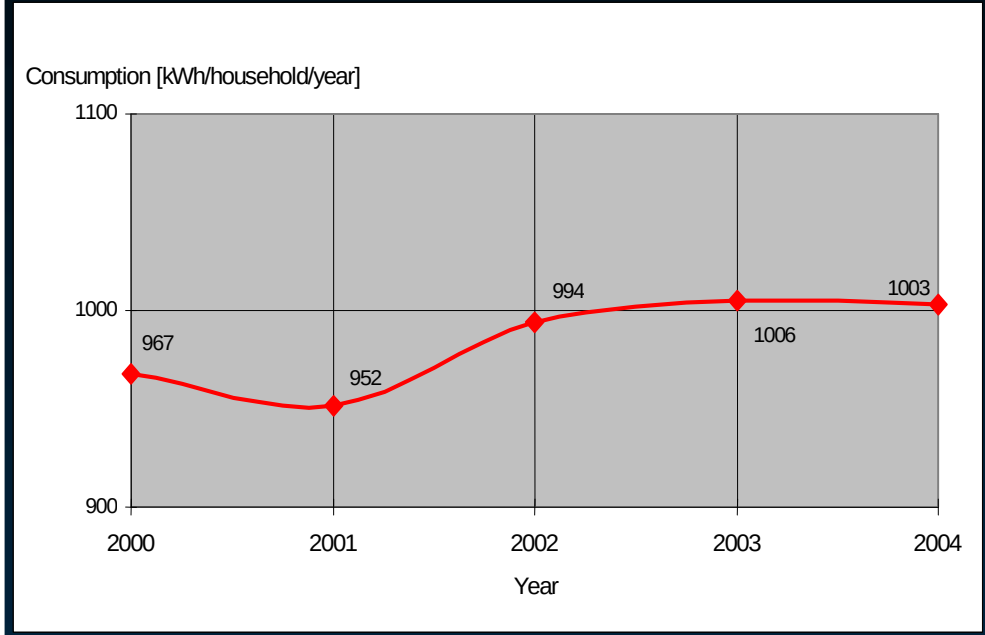


Home lighting consumption

A relatively recent study [13] establishes that lighting for kitchen, living room, bathroom and exterior areas consumes approximately 50% of the total lighting consumption. 25% of the lamps installed in homes consume 75% of the total lighting energy.

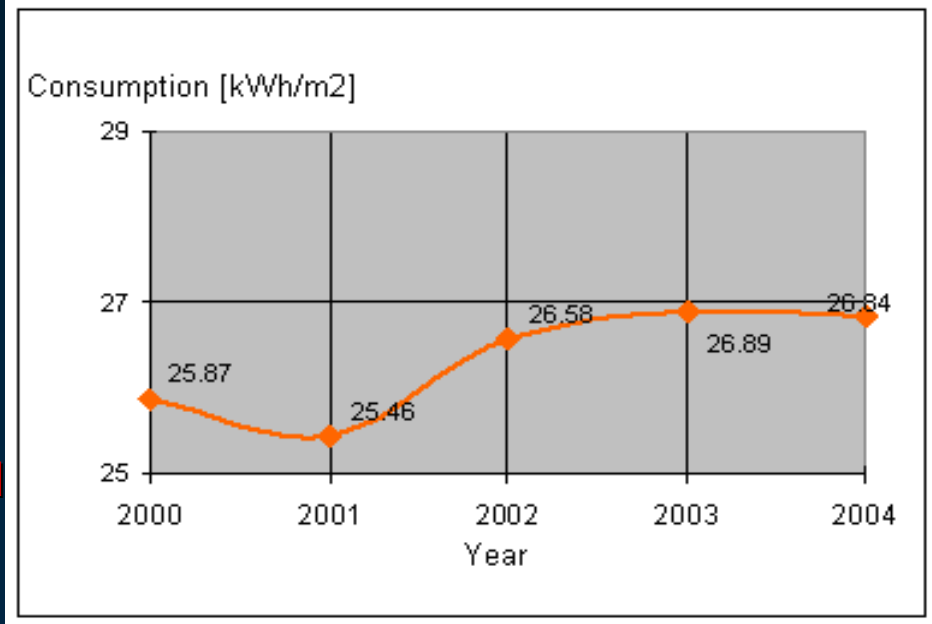
Approximately 20% of energy is consumed by portable lighting luminaires, powered thgrough wall outlets.

Analysis of electric lighting energy consumption in the residential sector in Romania



Average energy consumption
2000-2004

Household consumption per m²
the average value of 37.39 m² per household has been considered



The mounting of a single CFL in each household of Romania would lead to a decrease of the household electric energy consumption of around 45,246 MWh/year.

The estimation has been realized on a theoretical evaluation, based on 2,036,000 MWh/year (the household electric lighting energy consumption - 2004) divided to 9 (average number of lamps per household in Romania) and then to 5 (the ratio between the electric energy consumption of a CFL and a GSL with the same luminous flux).

This value corresponds to a saving in the CO_2 emissions of about **2.5 kTones CO_2** (1 kWh = 0.0536 kg CO_2 according to the average values considered for European countries).

Barriers

Two natural barriers to implement an energy efficient lighting

Economical

level of people income versus the cost of modern lamps

Educational

lack of lighting knowledge and media programmes.

Energy strategies

The energy efficiency of a lighting installation depends on:

- components of the system - lamps, ballasts , luminaires
- its time of use
- control system;
- daylight availability
- proper design
- maintenance program

Light sources

Incandescent, tungsten-halogen, florescent and compact fluorescent lamps

Tungsten-halogen sources provide whither light, longer life and higher efficacy than standard incandescent lamps.

Fluorescent lamps – linear, ring, quadrant shapes - available in versions with very good color rendering properties, are appropriate in kitchens, bathrooms, utility rooms and any other space.

Compact fluorescent lamps - economic energy-efficient alternative to standard incandescent lamps

- high initial cost
- complains about colour qualities of light emitted compared to incandescent lamps.

Customer Complains

- CFLs do not give ENOUGH lighting
  - * Start up time
  - * Wrong info about equivalence
- CFLs do not give GOOD lighting

CFL's disadvantages [9]

- CFLs are often physically larger than the incandescent bulbs
- A less optimal lighting pattern
- The light is generally cooler
- May produce an annoying 120 Hz (or 100 Hz) flicker.
- Ordinary dimmers cannot be used
- Should not be used with illuminated switches, electronic timers, or any other
- Light output may depend somewhat on mounting orientation
- Some CFLs come on instantly while others may have a delay of a up to a second or more
- There will usually be a warm-up time of a few seconds
- Light output will decline slightly
- Operation at cold temperatures may result in reduced light output
- Should not be use in an unenclosed fixture outdoors
- Operating in enclosed fixtures or various orientations may result in reduced reliability
- There may be an audible buzz from the ballast
- May produce Radio Frequency Interference
- Will break as easily as a 25 cent incandescent.

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LIGHT FAIR Las Vegas 2006 [10]

The big news in CFLs - a new standard base for CFL fixtures that **allows bulbs and fixtures to be interchanged freely**.

This overcomes a major obstacle for widespread use of CFLs (if you buy a 26 W fixture, you must use a 26 W CFL).

Consumers who purchase fixtures that use new standard components will be able to change out lamps/ballasts of varying wattage and lumen output to meet their specific lighting needs, ranging from **9 to 27 W.**

The switch is just as easy as it's been to screw different wattage incandescent light bulbs in the same fixture.

Incandescent lamps shift-out

- Energy Independence and Security Act of 2007 – USA
  - no incandescent bulbs manufactured and imported
    - 2012 (100 W), 2013 (75 W), 2014 (40 and 60 W)
- 2008 EU directive to change light bulbs in residential sector
  - with the effect on the production of new bulbs
  - actions specified by each country
- New CFL quality charter - 2008
  - comparison CFL/GLS - previous 1:5 ratio, a new **1:4** is indicated
- 2020 EU Vision
  - a target of **20% energy efficiency savings**, requiring homes, offices and streets to switch to energy saving lighting

Luminaires

Information for a residential luminaire

- **Price**
- **Style** - shape and color - to match users taste or home décor
- **Type, power and number of lamps**
- **Performance**

Owner selection

- **Decorative aspect or style criteria**

The lack of performance information is a major barrier in promoting **energy-efficient residential luminaires**

Luminaires with CFLs for residential use








Controls

- **Aims of a lighting control system**
  - to choose the desired lighting level
  - to improve the lighting energy efficiency
- **Basic strategies for control lighting**
  - time based control – common spaces
  - daylight linked control – photocell – too expensive
  - occupancy linked control – sensors
  - localized switching – on/off switching or dimming

Design of energy efficient lighting

A few basic requirements:

- more light is not necessarily a positive element; visual performances of an individual depend both on the light quantity and quality;
- selection of a lighting system appropriate to the room destination;
- use of localized lighting wherever possible and reduction of the general illumination level;
- use of modern lighting technologies and of adequate control means;
- use of natural light.

Some of the methods to obtain energy efficient interior lighting:

- installation of luminaires with fluorescent lamps for all relevant positions (ceiling or wall mounted) where a use of more than two hours daily is assumed - kitchen or living room, bathrooms, halls or bedrooms;
- use of CFL in dedicated luminaires instead of mounting them in GLS dedicated luminaires; this would encourage the use of CFL throughout the duration of existence of the building;
- use of CFL for portable luminaires with a use of more than two hours per day;
- use of luminaires with the energy label of type A - ENERGY STAR;
- use of presence sensors to open and close the light as needed;
- use of light colors for the interior walls, with the purpose of reducing the electric lighting.

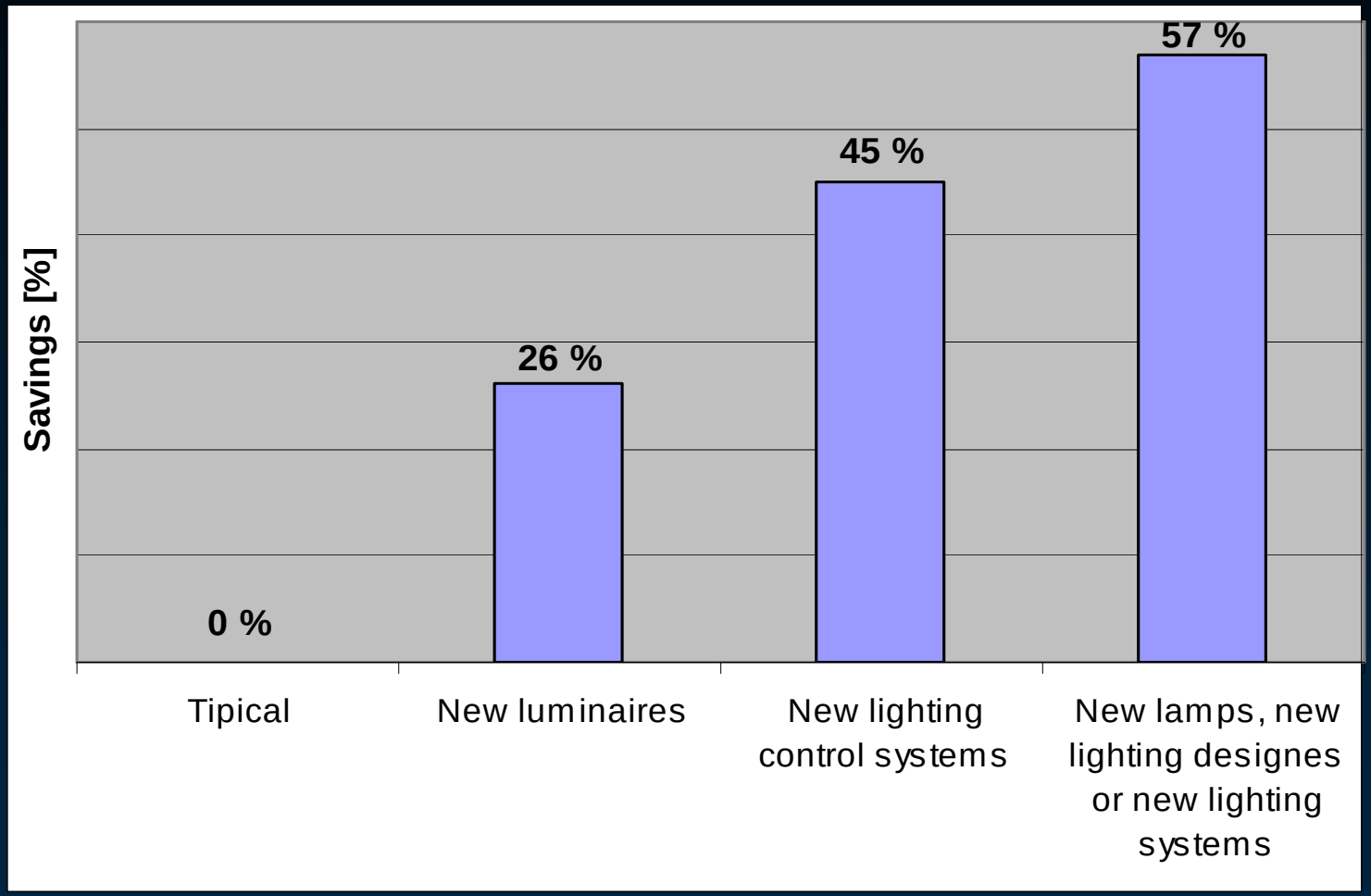
Electric lighting design based on minimal installed power

- The homes design norms NP057-02 recommend the *specific installed electric power* for homes lighting at a value of minimum **20 W/m²** of floor surface. This value is valid for the use of incandescent lamps in rooms lighting.
- When realizing an energy efficient lighting system that uses CFLs for rooms lighting, the light flow emitted by these lamps is about four times larger than that from incandescent lamps. Thus, the specific installed electric power for homes lighting has to be reduced about four times, at a value of minimum **5 W/m²** of floor surface.
- With these values the average illumination level on the working plane for the general illumination of the room of about 100 lx is obtained.

Normed values of average illumination in particular home rooms [Romanian norm]

Room	Type of lighting	Illumination, lx
Sleeping room	general	50
Living room	general	50-100
	local-reading	300
	local-knitting	500
Bathroom	general	75
	local	100-200
Kitchen	general	100
	local	300
Hall	general	75-100
Staircase	general	50-75
Garage	general	50
Garbage collector	general	50
Underground room	general	50-75

Alternative lighting systems [5]



Savings using alternative lighting systems versus the old conventional ones [?]

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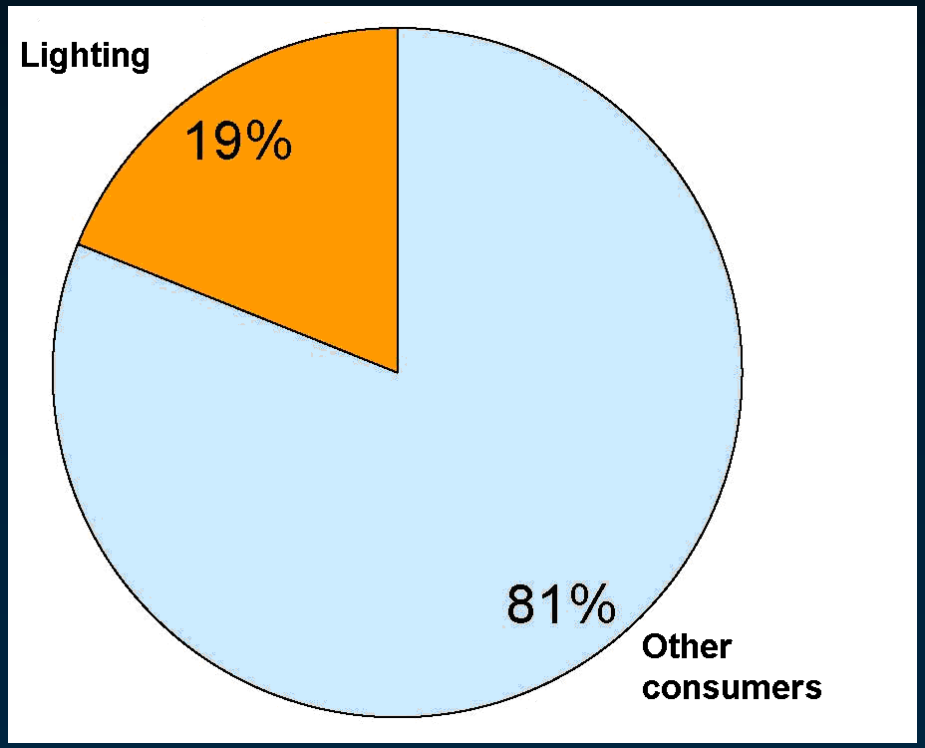
Lighting

An important quota from the world consumption of energy

- Lighting represents 19% of the world energy consumption
- The price of electricity is higher and higher
- The new technologists assures a high-quality lighting and the reduction of the CO_2 emissions



Source: Elektrbel

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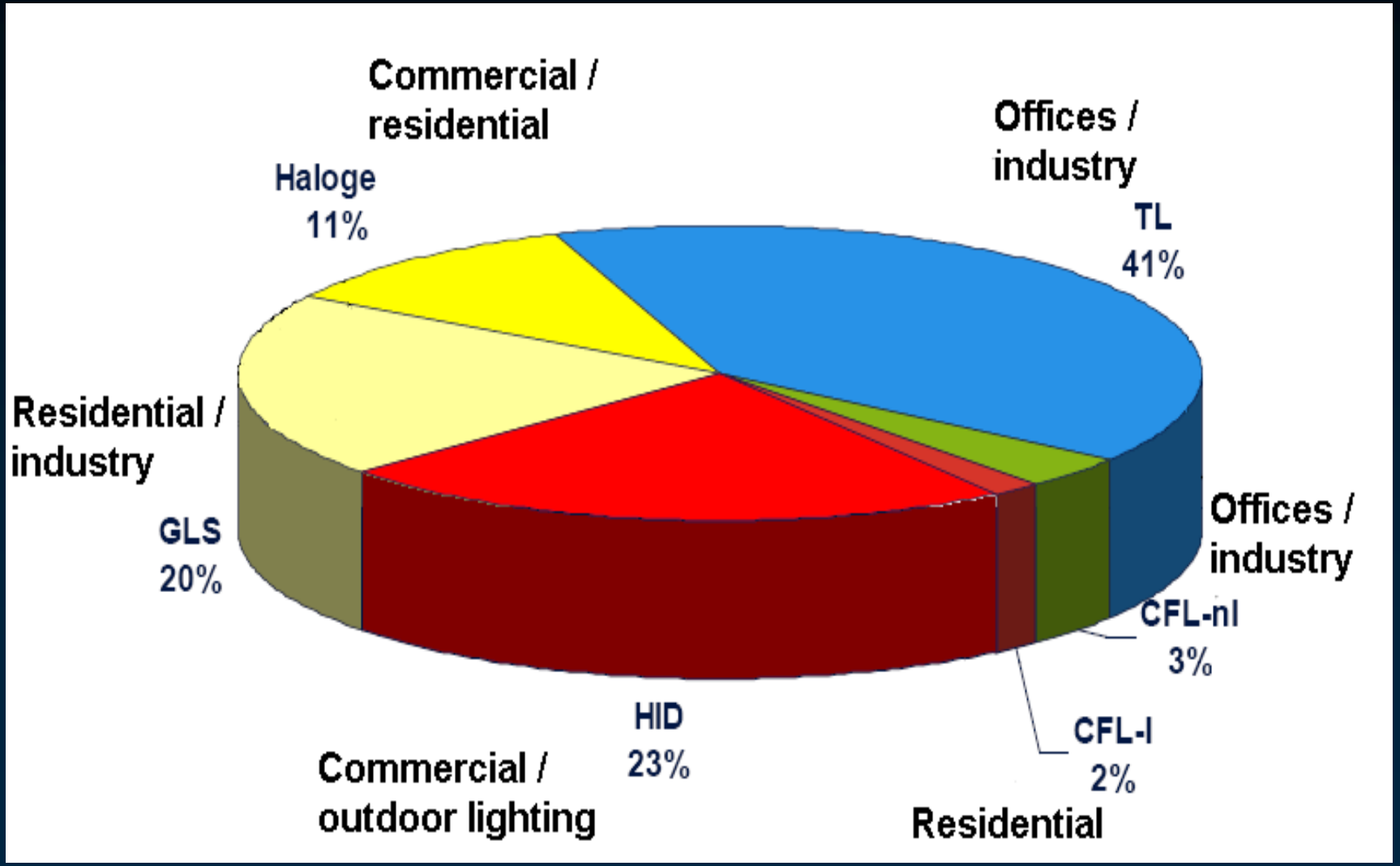
CO_2 emissions



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Europe

The unused potential of the new lighting technologies

- About 2/3 of the lighting systems installed in the European Union are using old technologies

ESTIMATED SAVINGS

- 14 milliards Euro – the annually electricity costs
- 59 million tones – the annually CO_2 emissions
- 196 million barrels – petroleum annually
- The equivalent of 67 electricity power plants

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Opportunities

Energy savings gained by replacing the old lighting systems

Application	Energy savings	Reduction of CO^2 emissions
Outdoor	HPL  57%  Cosmopolis	109kg CO_2
Commercial	Halogen PAR 30  80%  MASTER Colour CDM	115kg CO_2
Offices / industry	TL8  61%  T5 with HF Gear	77kg CO_2
Residential	GLS  85%  CFLi	34kg CO_2

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Opportunities - homes illumination

- About 2 bilion (energy inefficient) incandes-cent sources are sold annually
- High potential to reduce energy consumption

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Opportunities - homes illumination

- **Potential savings**
- 5-8 billion Euro of energy costs
- 20 billion tons CO_2 emissions/year
- 74 billion barils of oil per year
- equivalent of 25 electric energy production units

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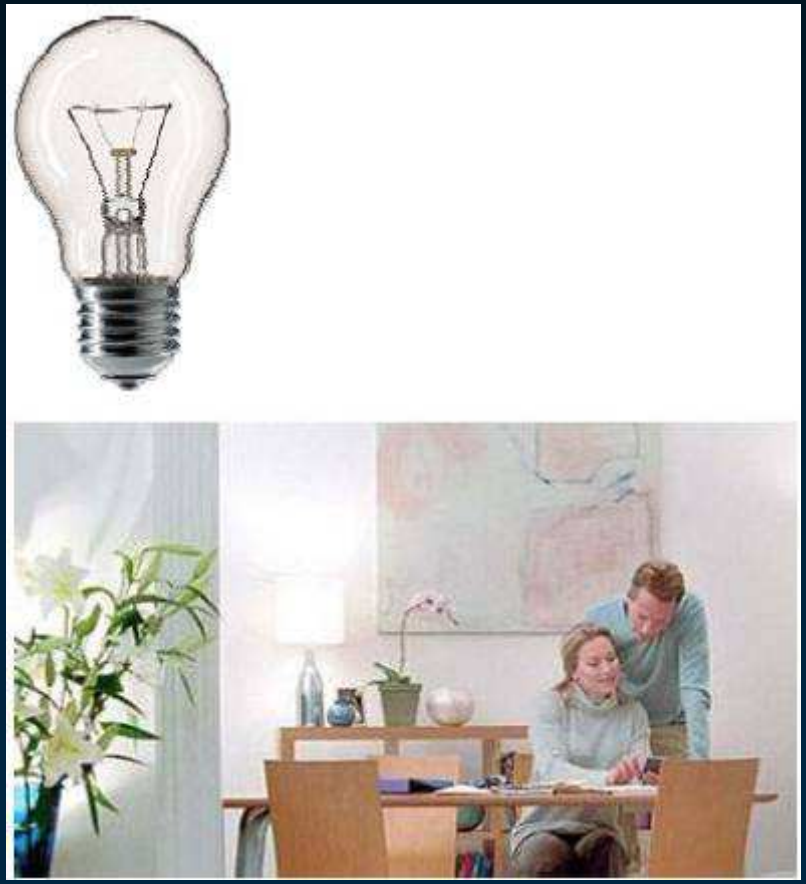
Opportunities - homes illumination

- **European initiative**
- **Homes illumination**
- Dominated by incandescent sources
- Uses 4-5 times more energy than energy efficient sources
- 95% loses as heat



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Opportunities - homes illumination

Replacing the incandescent lamps

- Energy cost ~0,12 Euro/KWh

	Incandescent lamp GLS 100W	Philips Ambiance 20W Energy saving CFL
Price	€ 0.50	€ 9.00
Working hours	1000	8000

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Opportunities - homes illumination

Replacing the incandescent lamps

	GLS 100W	Ambiance 20W
Energy cost € / an	€ 0.12 x 100 kWh = **€ 12.00**	€ 0.12 x 20 kWh = **€ 2.40**
Energy consumption for 8000h	(8000h x 100W) / 1000 = **800 kWh**	(8000h x 20W) / 1000 = **160 kWh**
Energy cost for 8000h	800 kWh x € 0.12 = **€ 96.00**	160 kWh x € 0.12 = **€ 19.20**
Total costs (lamp + energy)	8 x € 0.50 + € 96.00 = **€ 100**	1 x € 9.00 + € 19.20 = **€ 28.20**
Payback time		€ 9.00 – (8 x € 0.50) / (€ 12.00 – €2.40) = **0.52**
CO_2 emissions for 8000h	**344**	**69**

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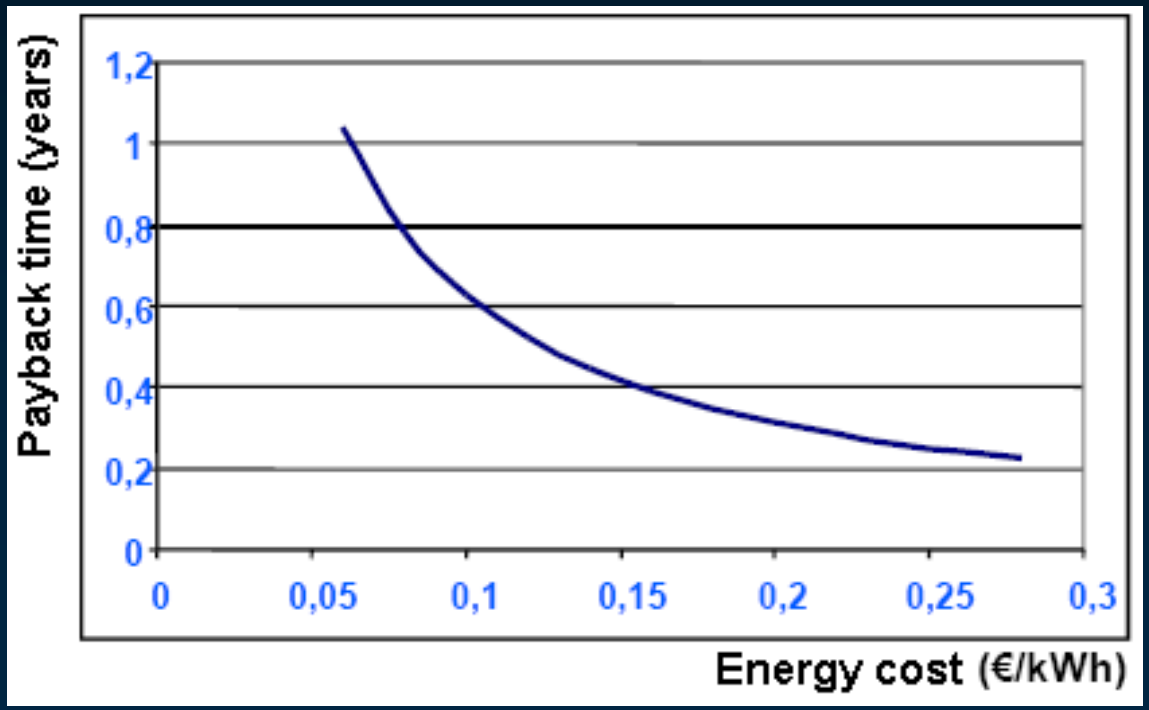
Opportunities - homes illumination

Replacing the incandescent lamps

- Payback time less than 1 year
- 80% energy savings



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Barriers

of installing a new and efficient lighting system

- Information
  - The users don`t know the latest technologies
  - The low interest of the users for the lighting
  - The people who can take decisions are not lighting experts

- Costs
  - Higher implementation costs are leading to major energy and running cost savings

Examples

Examples

Examples

Examples

Examples

Examples

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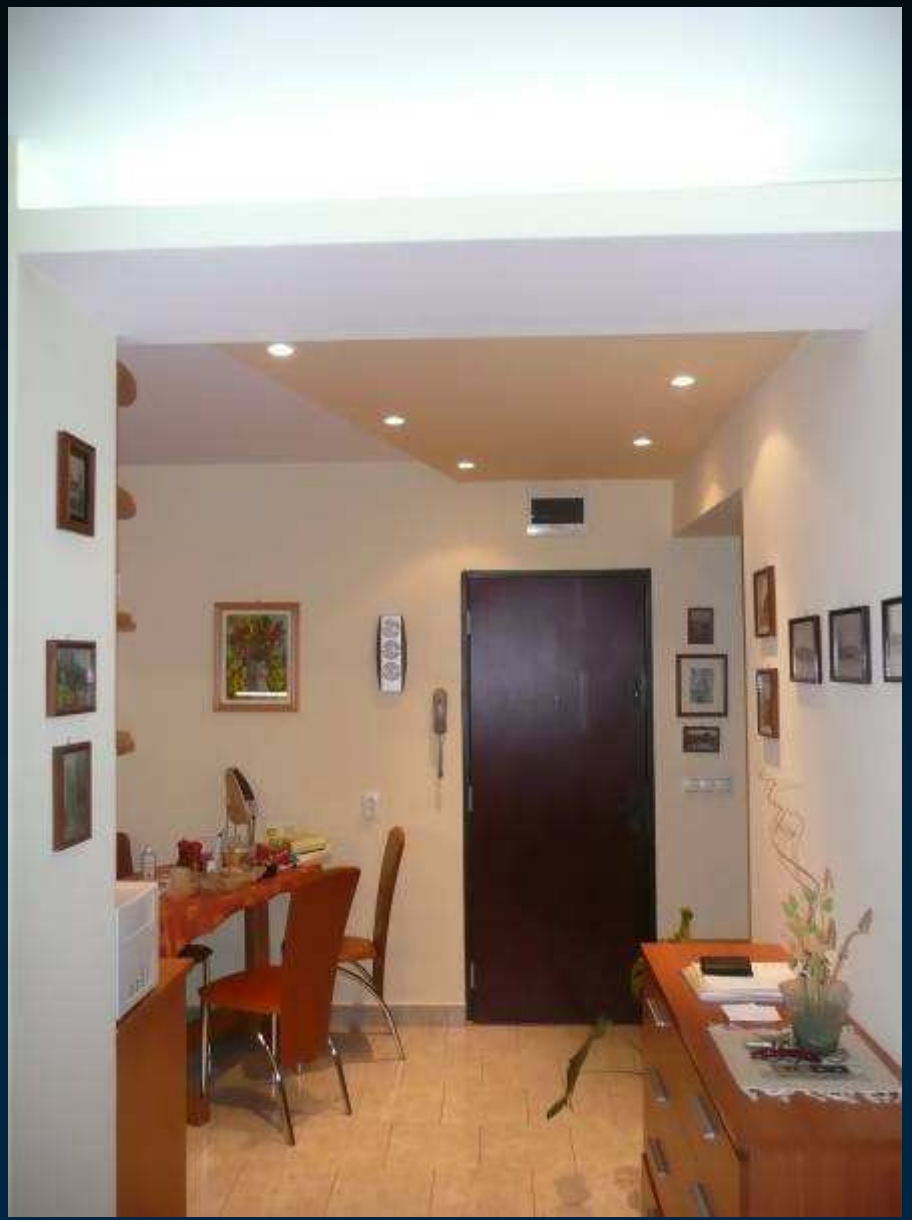
Examples



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