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L'chtLabor**




Energy efficient lighting solutions
Wilfried Pohl – Bartenbach Lichtlabor

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Annex 45 ,E3Light' **Bartenbach
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International Energy Agency (IEA)
Energy Conservation in
Buildings and Community
Systems Programme (ECBCS)

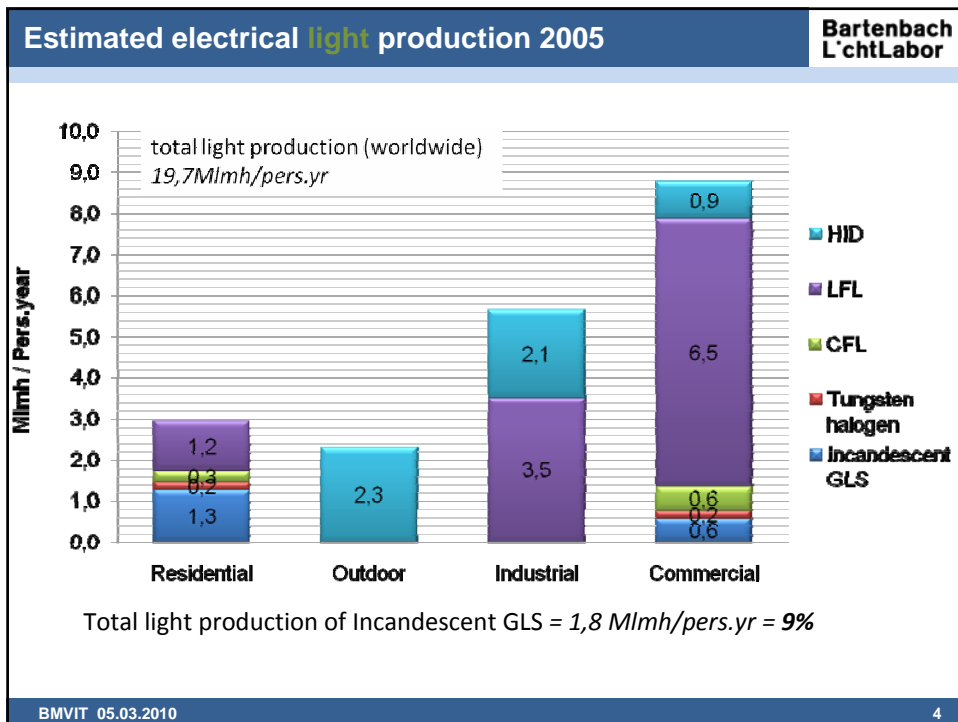
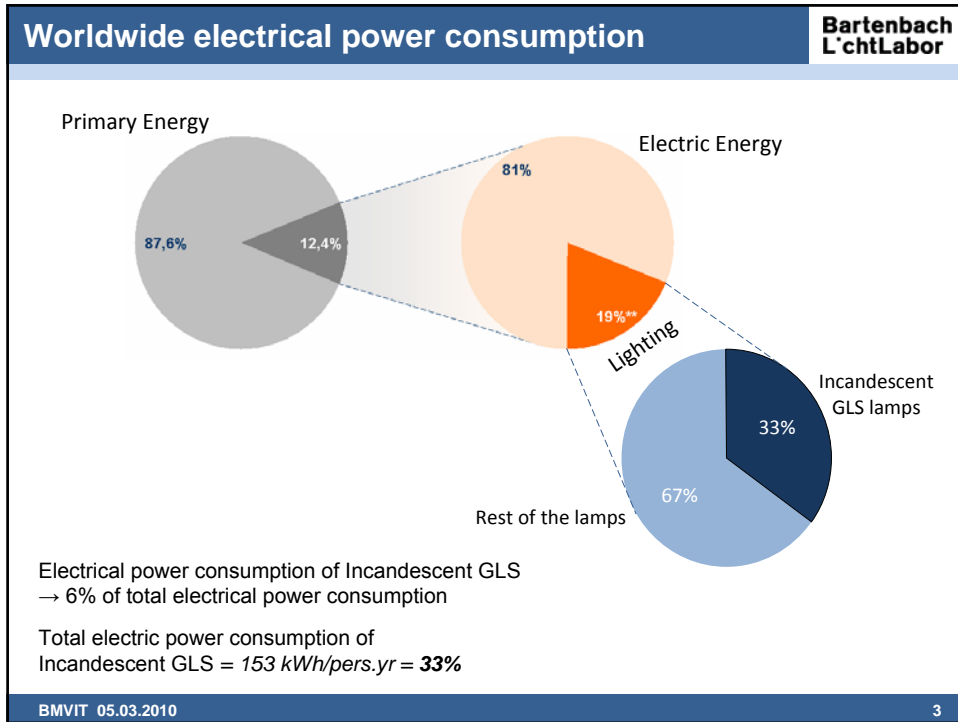
**Annex 45
Energy Efficient Electric
Lighting for Buildings**

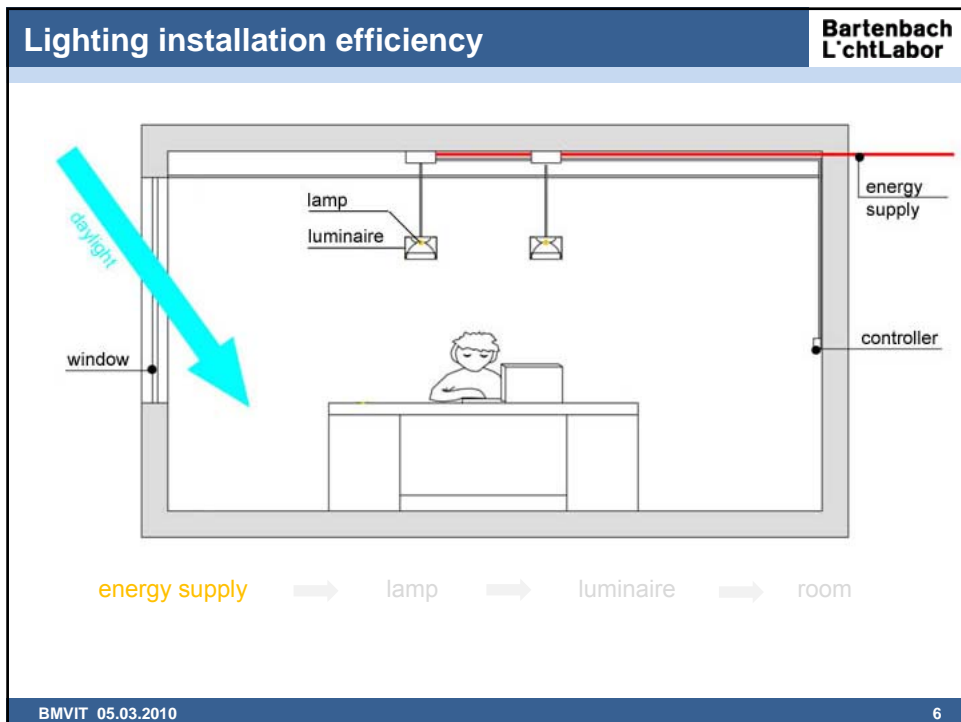
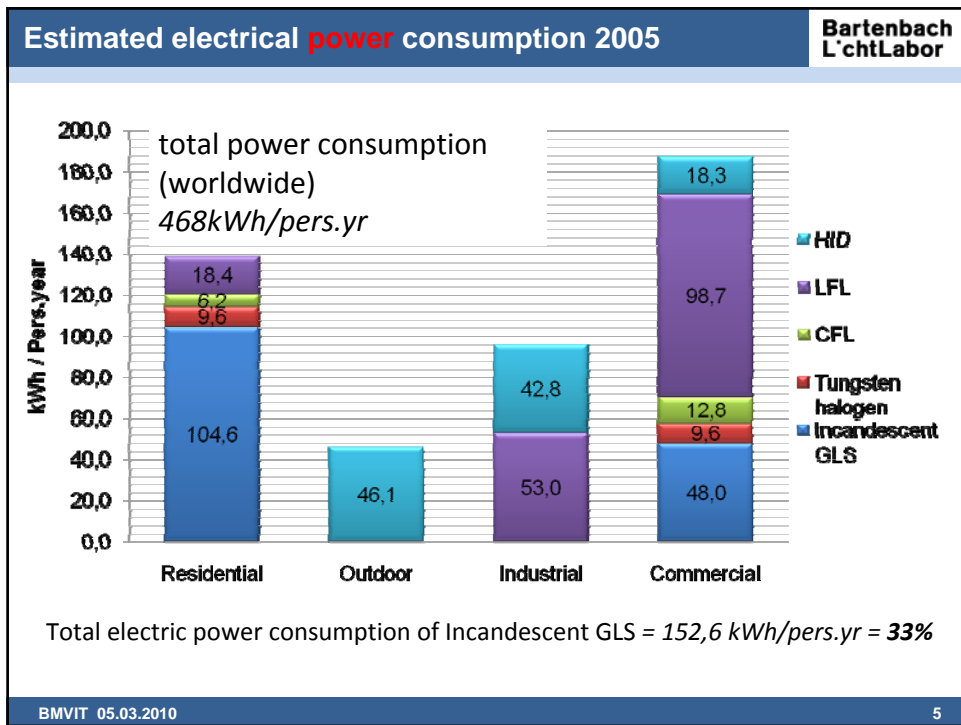
**Guidebook on Energy Efficient Electric Lighting for
Buildings**

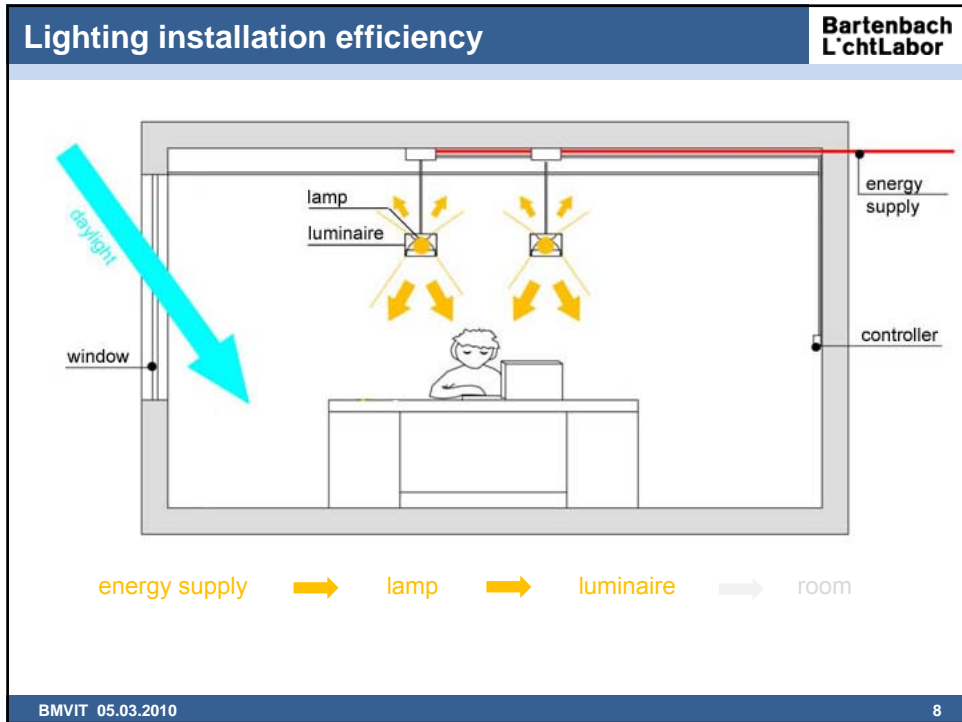
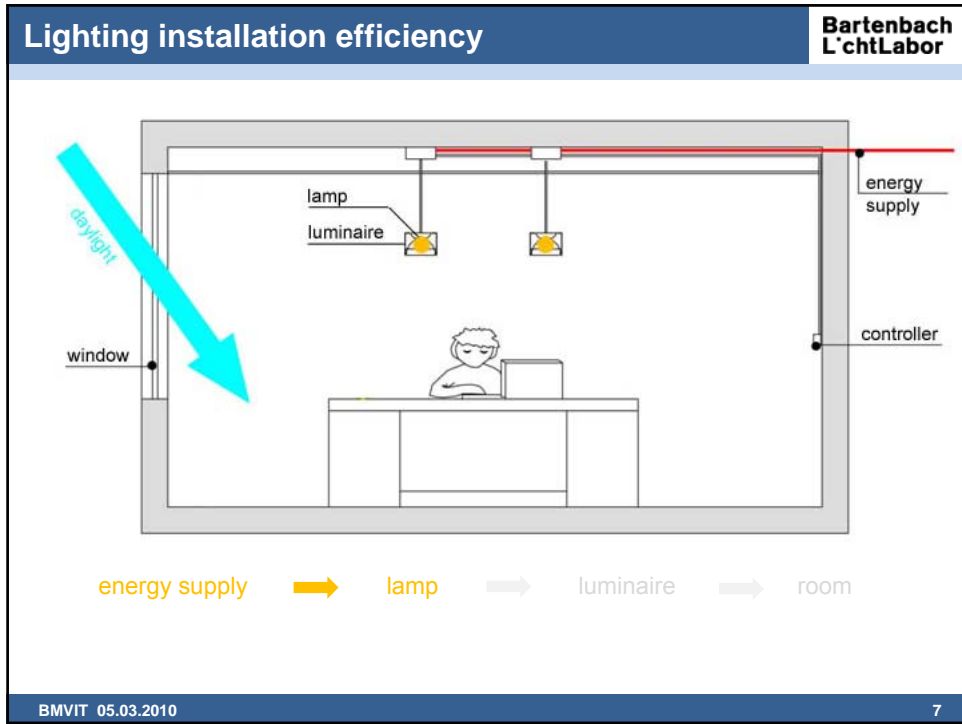
**Edited by Liisa Halonen & Eino Tetri
Helsinki University of Technology
Lighting Laboratory**

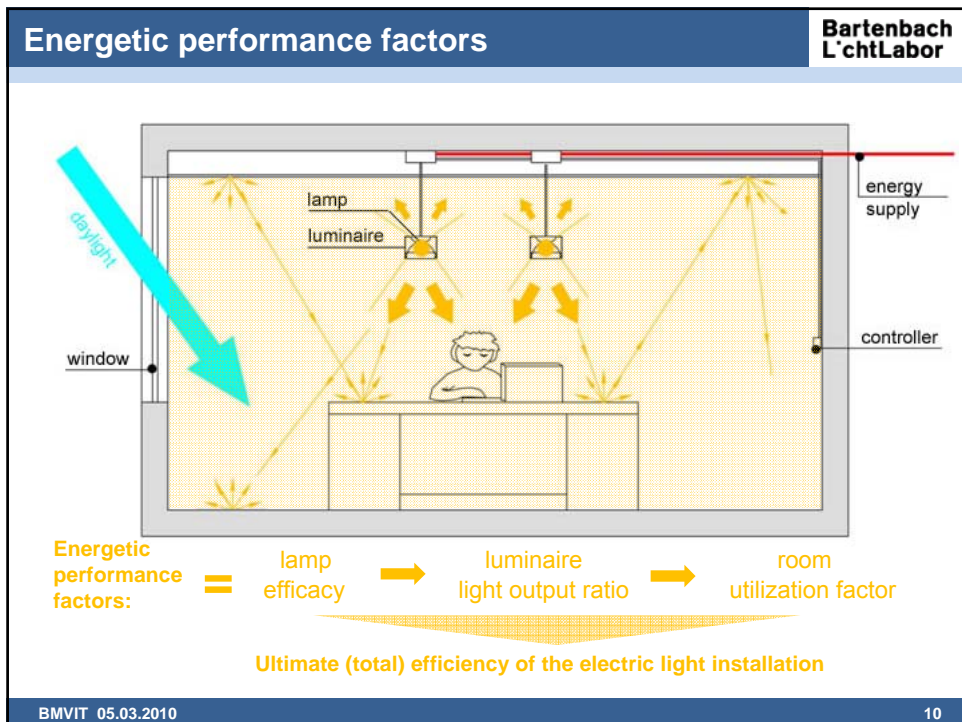
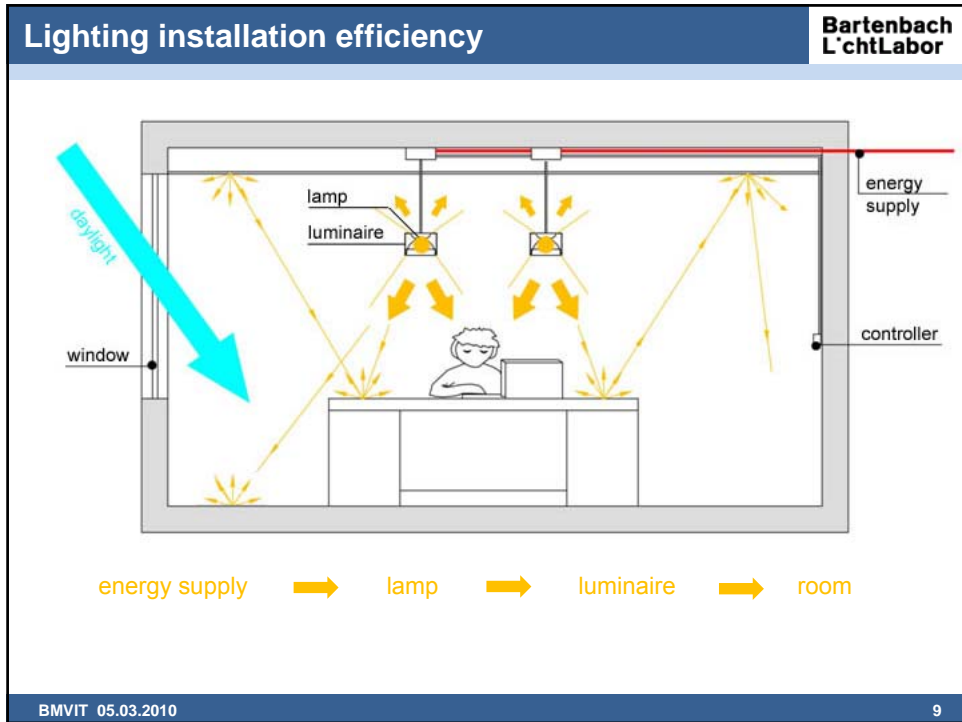
Available spring 2010 !

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Candle > (O)LED **Bartenbach
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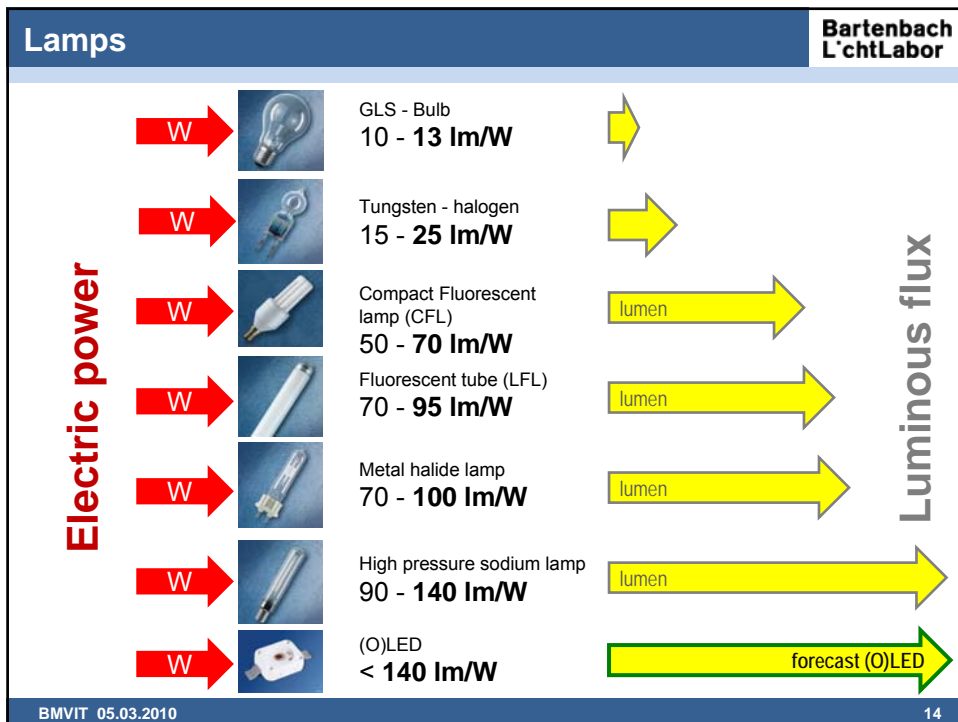
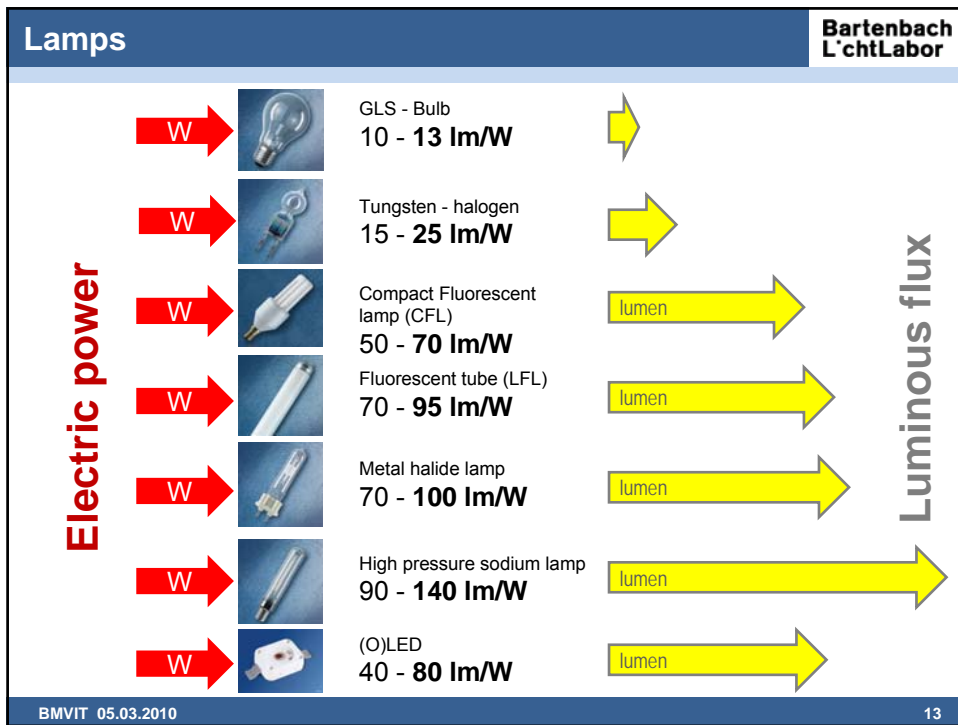
1. Generation	2. Generation	3. Generation	4. Generation
			

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GLS - bulb **Bartenbach
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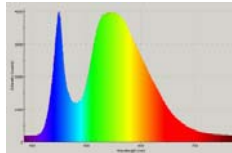


LED benefits

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LED benefits:

- Lifespan < 100.000h
- colour mixing possibility (flexible colour temperature CCT)
- 'cold' spectrum (no infrared)
- design flexibility
- brilliant light due to its small size
- easy control and dimming
- safety due to low voltage operation
- high efficacy compared to incandescent lamps



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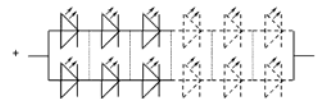
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Change in lighting industry

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Metal working > electronics



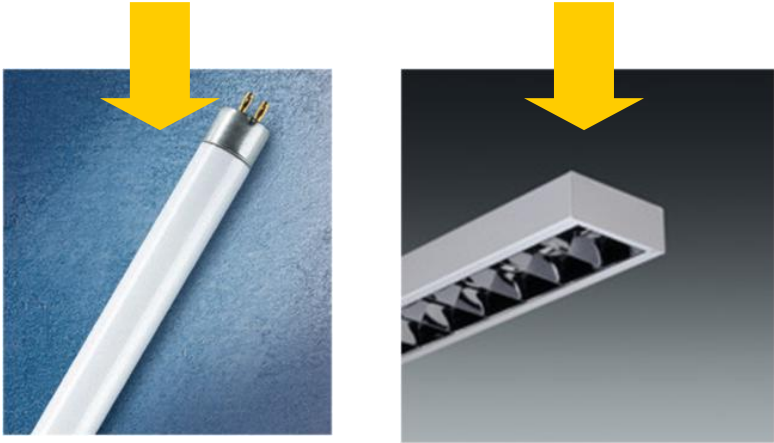
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Lamp - Luminaire

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Lamp and Luminaire

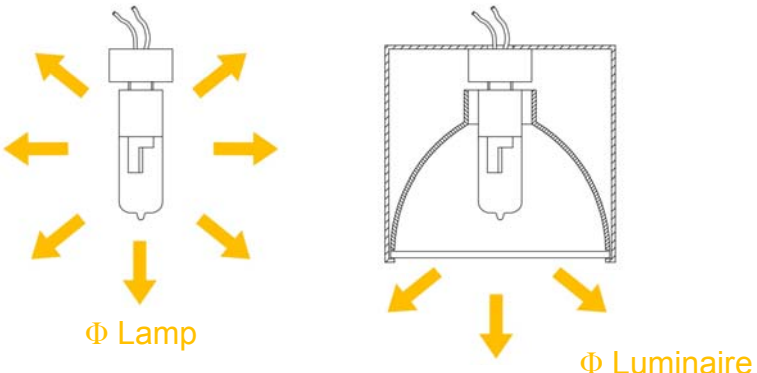


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Luminaire light output ratio

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Luminaire light output ratio


$$\eta_{LB} = \frac{\Phi \text{ Luminaire}}{\Phi \text{ Lamp}}$$

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Radiation principles

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The diagram illustrates ten different lighting radiation principles:

- Junior-Strahler:** A simple spotlight with a narrow beam.
- Nautilus-Strahler:** A spotlight with a beam that curves like a nautilus shell.
- Linsenleuchte:** A light fixture with multiple lenses focusing light.
- Sekundärleuchte:** A light fixture with a secondary reflector to spread light.
- Spiegel/Werfer-System:** A system using a mirror to reflect light onto a table.
- Wandstrahler:** A light fixture mounted on a wall, projecting light horizontally.
- Indirektleuchte:** A light fixture that directs light upwards to reflect off the ceiling.
- Spiegelrasterleuchte:** A light fixture with a grid of mirrors to create a pattern of light.
- Evolventenleuchte:** A light fixture with a spiral-shaped reflector.
- Rundleuchte:** A circular light fixture with a grid of reflectors.

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Luminaire Example


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The photograph shows a rectangular luminaire fixture installed in a ceiling. It features a grid of reflective elements, likely mirrors or polished metal, arranged in a pattern that creates a series of light reflections. The fixture is illuminated from within, and the surrounding ceiling is a light color.

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Luminaire Example

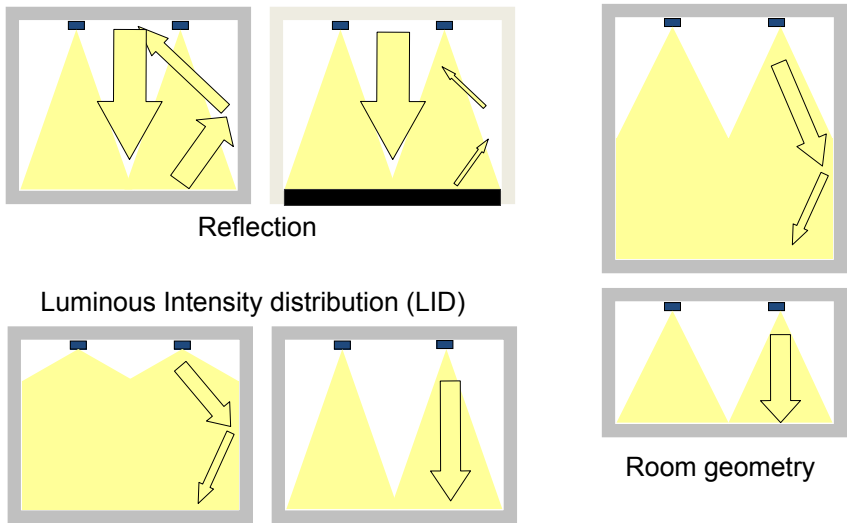
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Room Utilization Factor (RUF)

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Reflection

Luminous Intensity distribution (LID)

Room geometry

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Room surfaces <-> Indirekt - portion

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$$\eta_{utilization} = f_{direct} + f_{indirect} \Rightarrow f_{indirect} = \frac{A_{workplane}}{A_{room}} \cdot \frac{\rho_{mean}}{1 - \rho_{mean}}$$

Example: office-room $A_{workplane}/A_{room} = 30\%$

Additional **indirect-portion** over multiple reflections at the room surfaces ($f_{indirect}$)

$$\rho_{mean} = 0,2 > f_{indirect} = \mathbf{8\%}$$

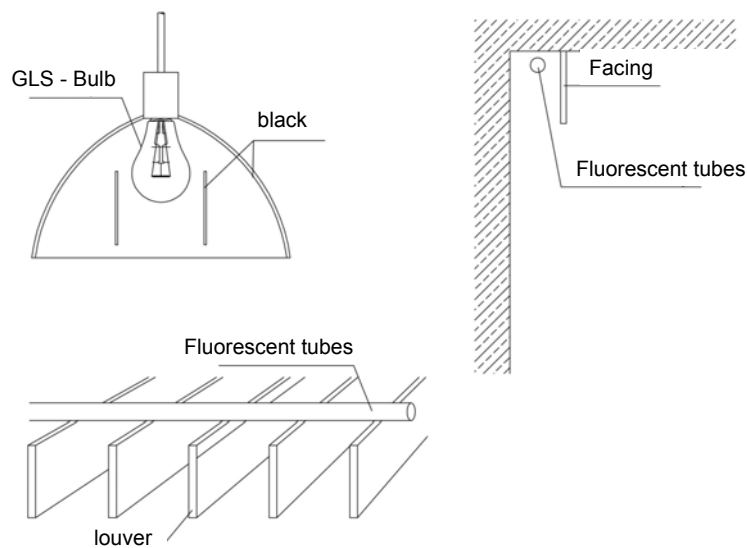
$$\rho_{mean} = 0,7 > f_{indirect} = \mathbf{70\% !!}$$

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Faults

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Bad example **Bartenbach L'chtLabor**



The left image shows a long, narrow path at night, illuminated by a series of streetlights that create a long, narrow beam of light, leaving the rest of the path in deep shadow. The right image is a close-up of a traditional street lamp with a glowing yellow light, mounted on a dark pole.

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Bad example **Bartenbach L'chtLabor**



The main image shows a large, open-plan indoor space, possibly a lobby or waiting area, with a grid ceiling. The ceiling is illuminated by recessed lights, creating a bright, uniform glow. A close-up inset in the bottom right corner shows the grid ceiling in detail, highlighting the pattern of the lights.

Inefficient lighting solution

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Energy costs
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A simple appraisal (Shop):

Installation costs	30,- €/m ²
Installation power density	20 W/m ²
operation time	3000 h/year (non-daylight space)

This results in

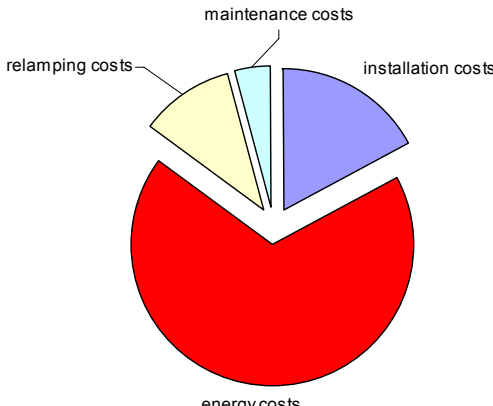
energy consumption	60 kWh/m ² year
costs for electricity (0,15€/kWh prize)	9,- €/m ² year
costs for electricity for 10 years	90,- €/m ²

In such cases the **electricity costs exceed the installation costs by far !**

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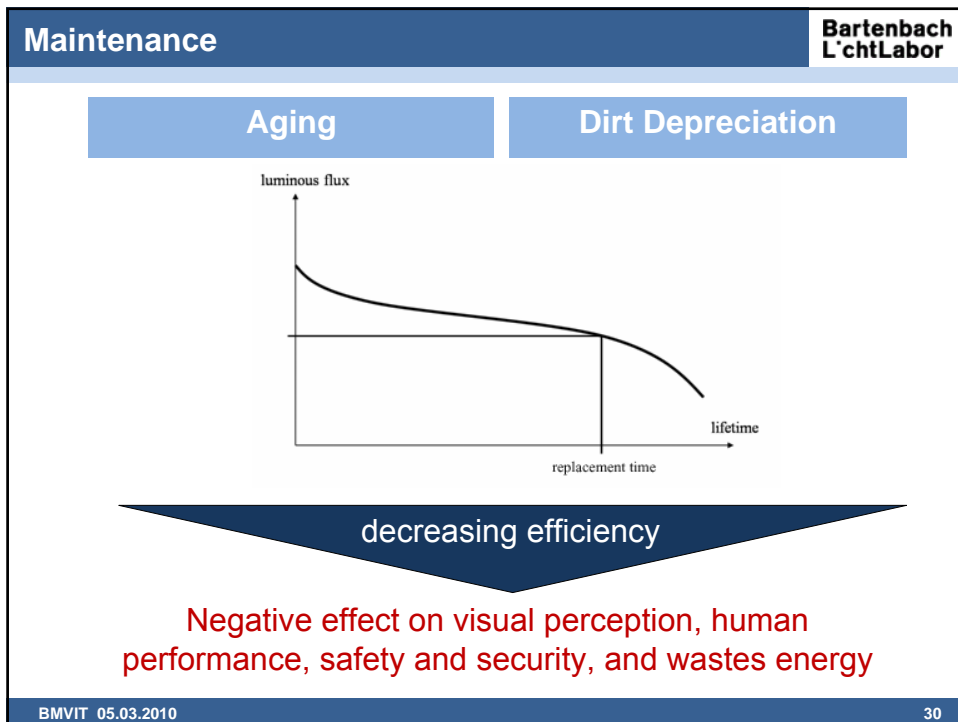
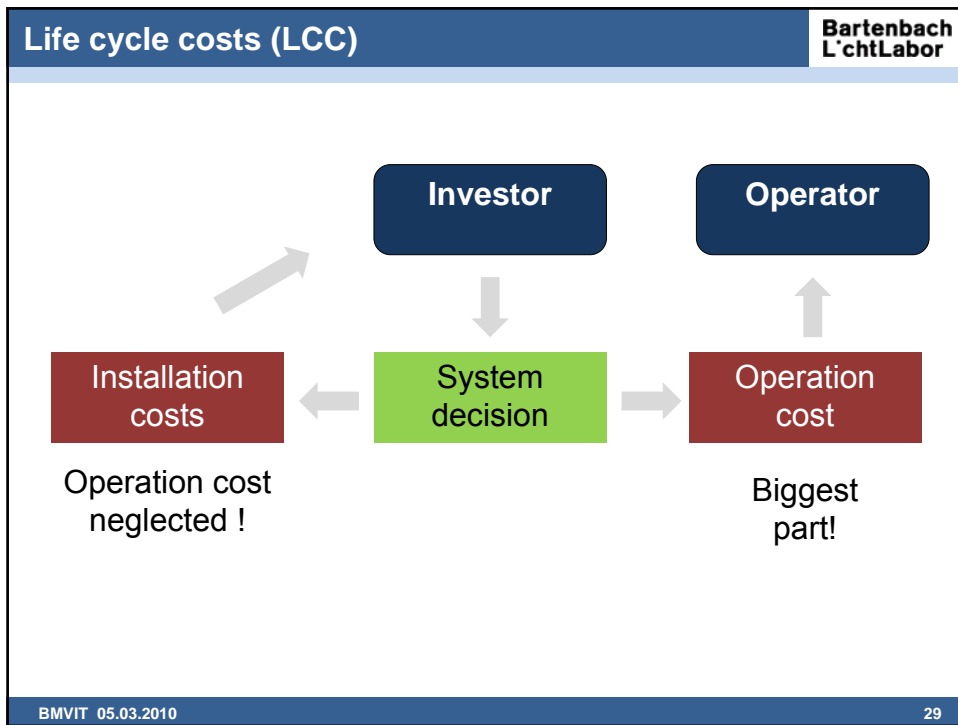
Life cycle costs
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composition of total costs (final values)



Total cost 15,- €/year.m²

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Maintenance

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A regular maintenance schedule:

- cleaning of luminaires, daylighting devices and rooms
- relamping (usually before burn-out)
- replacement of other parts
- renovation resp. retrofitting of antiquated systems and components
- proper control (at least switch off if not needed)

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Bad example

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Lack of control

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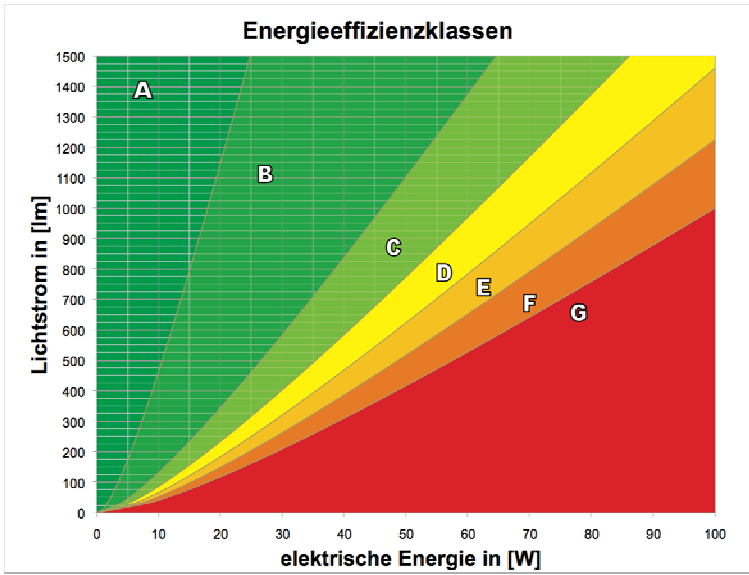
Bad example **Bartenbach
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Lack of control

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Standards – EUP-directive **Bartenbach
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Energieeffizienzklassen

Class	Color	Approx. Light Output Range [lm]	Approx. Electrical Energy Range [W]
A	Dark Green	1000 - 1500	10 - 25
B	Light Green	600 - 1400	20 - 40
C	Yellow-Green	400 - 1200	30 - 50
D	Yellow	300 - 1000	40 - 60
E	Orange	200 - 800	50 - 70
F	Light Orange	150 - 700	60 - 80
G	Red	100 - 600	70 - 100

Lichtstrom in [lm]

elektrische Energie in [W]

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Standards – EPBD-directive
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EN15193 Power limits
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Limits for connected lighting power (in W/m²) according to EN15193 for different building types and quality levels.

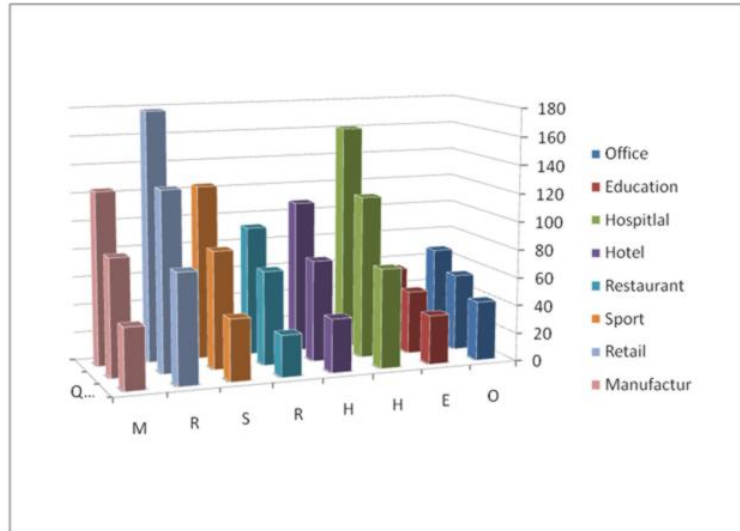
Building Type	Quality Class 1	Quality Class 2	Quality Class 3
Office/Education Hospital	15	20	25
Hotel	10	20	30
Restaurant	10	25	35
Sport	10	20	30
Retail	10	25	35
Manufactur	10	20	30

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EN15193 Energy limits

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Limits for energy consumption (in kWh/m²year) according to EN15193 for different building types and quality levels



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Measures

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What can we do?

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Measures **Bartenbach
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Existing Installations

- 95% > 10 years
- 90% > 20 years

> Extreme energy saving potential

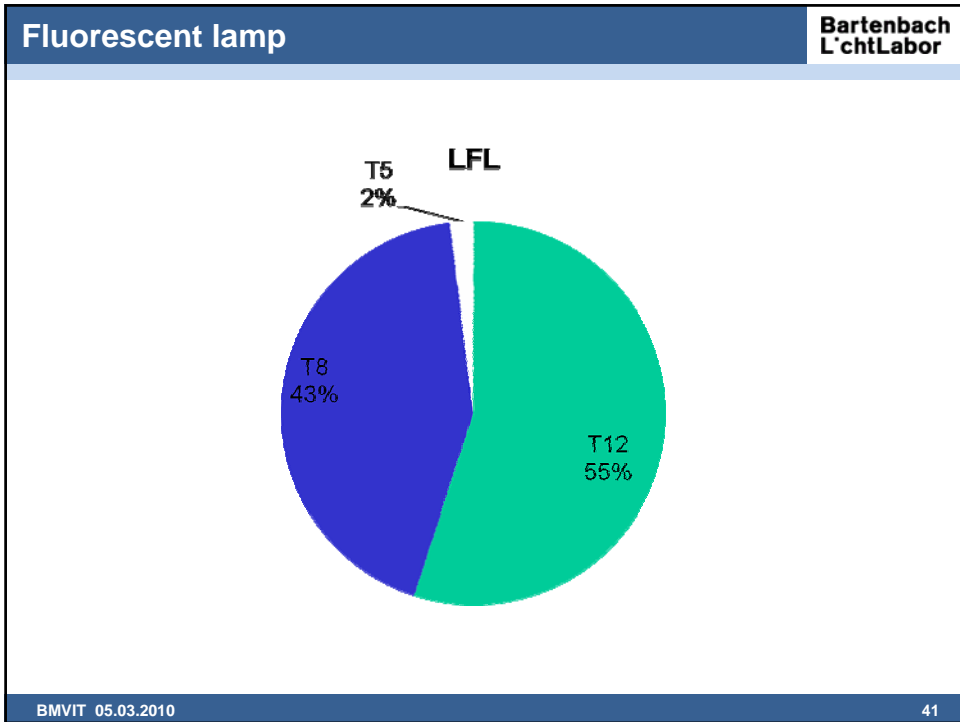
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Example **Bartenbach
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Antiquated (> 20 years old) T12 – Louver - Luminaire

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Upgrade measures

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Office Lighting

55% of the worldwide LFL connected power is for the antiquated T12 (38mm diameter)

Antiquated T12

Magnetic ballast

change

New generation T5


High frequency ballast

16mm 26mm 38mm

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Upgrade measures **Bartenbach
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Domestic Lighting

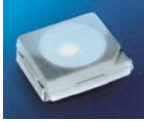




> 80% of the connected power is for the inefficient GLS-Bulb

GLS-Bulb



change



Tungsten Halogen CFL LED

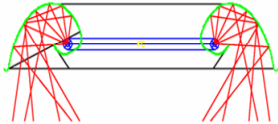


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Upgrade measures **Bartenbach
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Development of

- high reflective surfaces
- new manufacturing technologies

➔ 'efficiency' (LOR) of luminaires reach 80% or more



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Retrofitting: Street lighting Amsterdam **Bartenbach L'chtLabor**

Change of 8.000 luminaires






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Retrofitting: Street lighting Amsterdam **Bartenbach L'chtLabor**


Refurbishment of historic „Ritter Lantern“, City of Amsterdam, Netherlands

 <p>EXISTING LANTERN SON-T 50W $E_{\text{mean/street}} = 2.6 \text{ lx}$</p>	<p>15 W Energy-Saving 20 € Savings/Lantern (operation cost a year) 3.400 Lanterns 68.000 € Total Savings (operation cost a year)</p> <p>Power: $\times \frac{2}{3}$ ➔ Illuminance: $\times 3$</p>	 <p>NEW RITTER LANTERN CDM-T 35W $E_{\text{mean/street}} = 7.5 \text{ lx}$</p>
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Daylight utilization



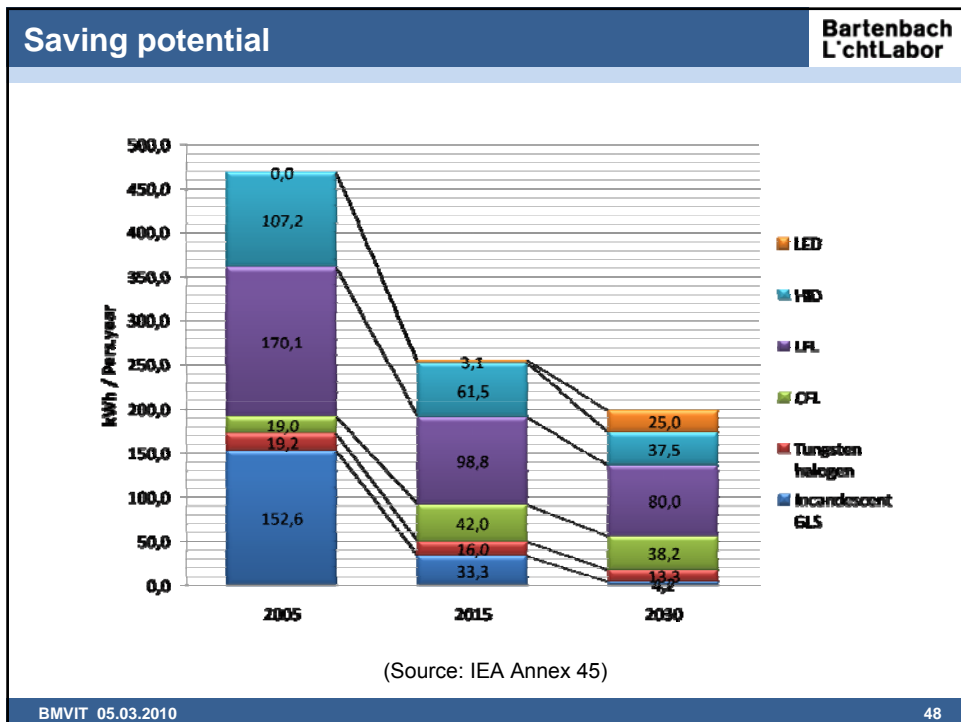


Most effective measure to save electric lighting


- intelligent facade
- daylight construction

E. g. Office building – daylight for more than 70% of the working times

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Design & quality **Bartenbach
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Conclusion **Bartenbach
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Recommendations for energy efficient lighting:

1. Intelligent architecture and facade constructions (use of daylight)
2. Efficient lighting concepts (high room utilization factor, e.g. bright surfaces)
3. Use of high quality luminaires and lamps
4. Proper controls (on/off, daylight, occupancy)
5. Good maintenance

 **Bright Future !**

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Thank you!
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