Intelligent Energy Europe

Bartenbach LichtLabor

Workshop Porto Nov. 2009

Commoncense
Comfort in Lighting

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What is LIGHT ?

Light is visible radiation !

Light is together with air and **water** a basic and unreplacable ***nourishment*** of mankind and nature !

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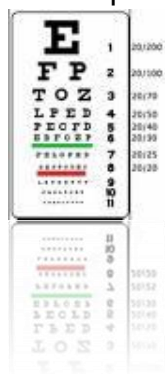
visual response

non-visual response



visual comfort

non-visual/biological comfort

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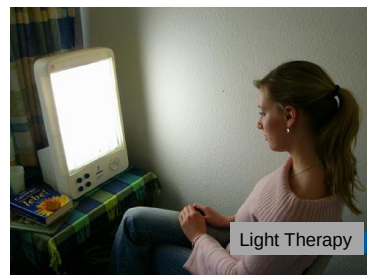

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LIGHT influences Health by ...

- **optimized visual conditions** 25 %

- **by changing mood**
- **mental performances**
- **physical processes**

} 75%

(J.Liberman)

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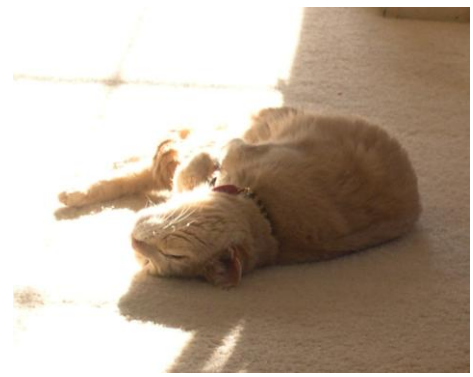
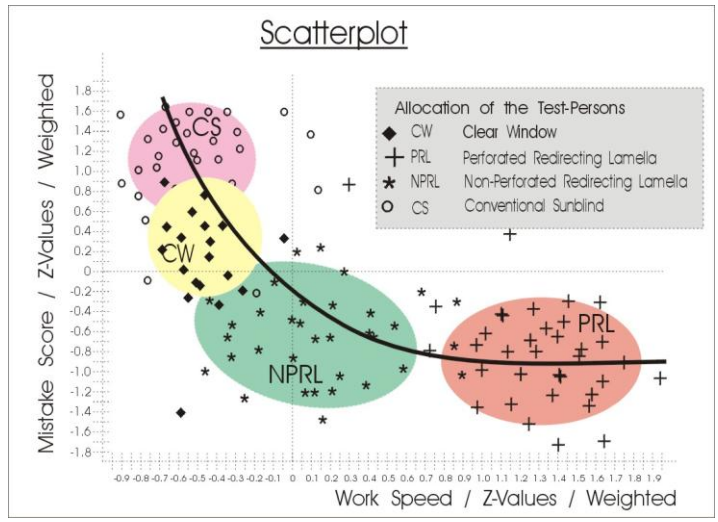
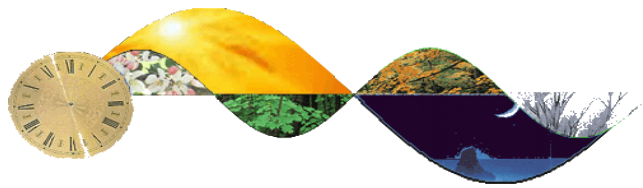


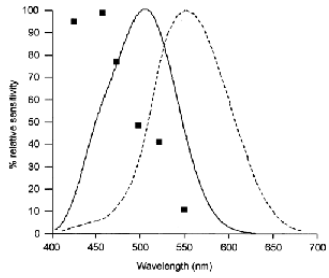
… by changing moods

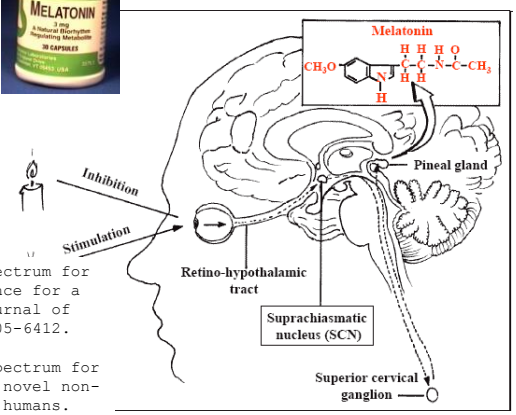
… by changing performance





LIGHT is the most important timer !





Brainard, G. et al. (2001): Action spectrum for melatonin regulation in humans: evidence for a novel circadian photoreceptor. The Journal of Neuroscience, Vol. 21, Nr. 16, pp. 6405-6412.

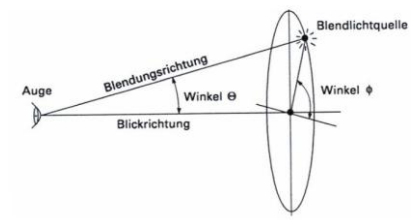
Thapan, K. et al. (2001): An action spectrum for melatonin suppression: evidence for a novel non-rod, non-cone photoreceptor system in humans. Journal of Physiology, Vol. 535, Nr. 1, pp. 261-267.

Glare

$$UGR = 8 \log \frac{0{,}25}{L_b} \sum \frac{L_S^2 \omega}{p^2}$$

Ls luminiance of glare source (cd/m²)
ω the size of glare source (solid angle sr)
p position in the field of view (positionsindex)
Lb average luminiance of surroundings (in cd/m²).

not applicable for large (solid angle Ω >0,1SR or >1,5m²) or very small light sources



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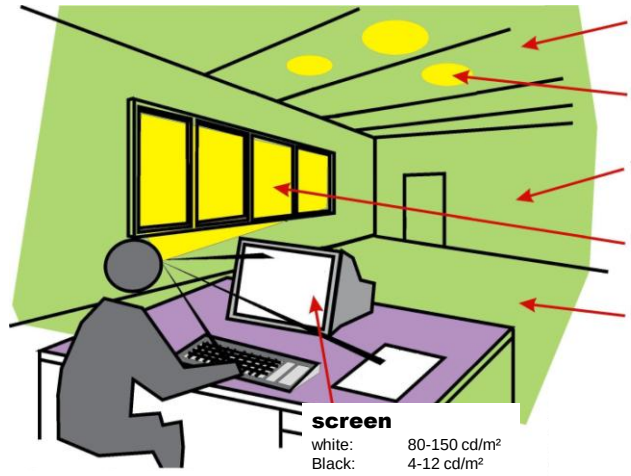

ceiling:
EU: <400 cd/m2 (p>0.7)
actual: up to 2000 cd/m²
target: **80-140 cd/m²**

luminaires:
EU: <200 cd/m²
actual: up to 10000 cd/m²
target: **<200 cd/m²**

wall:
EU: <200-400 cd/m2 (p>0.5)
actual: up to 1000 cd/m²
target: **40-100 cd/m²**

window:
EU: 200-400 cd/m²
actual: 8000 cd/m² and higher
target: **150-350 cd/m²**

floor:
EU: p>0.2)
actual: up to 1000 cd/m²
target: **20-60 cd/m²**

screen
white: 80-150 cd/m²
Black: 4-12 cd/m²

Luminance-Levels
(EU-standards, actual and targets)

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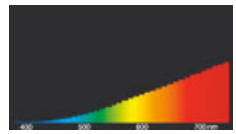
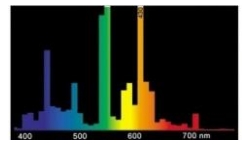
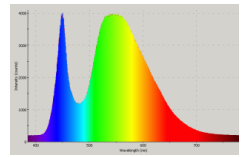
Spectrum







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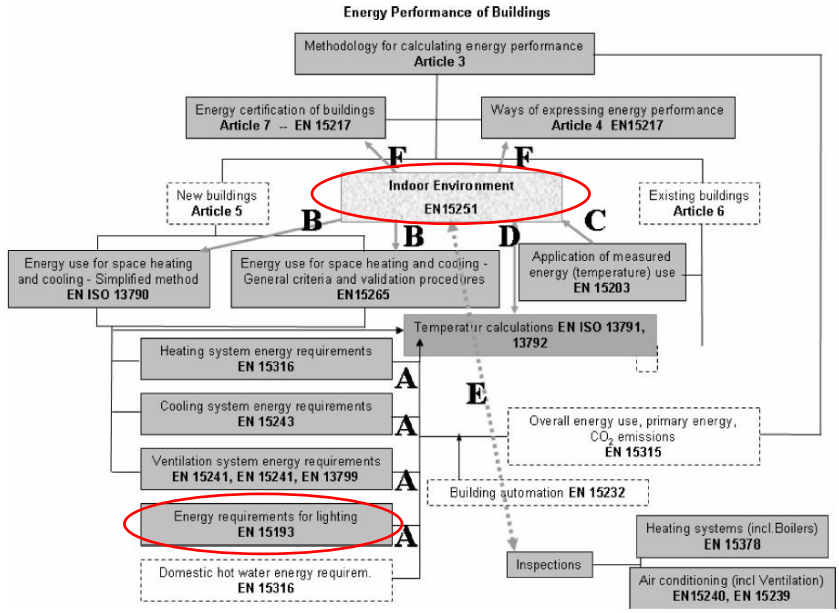
Examples of requirements for different room types and tasks according to EN12464

Room type resp. visual task	E_{mean}	UGR	Min. R_a
Office			
floors	100	28	40
writing, reading	500	19	80
technical drawing	750	16	80
Restaurants	-	-	80
Parking garage, way in and out	300	25	20
Health Care			
Surgery Rooms	1000	19	90
Autopsy	5000	-	90



pure Lighting:

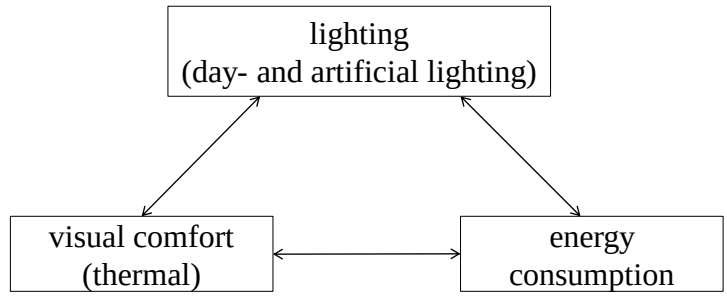
EN 12464-1	Light and lighting – Lighting of Workplaces – Part 1: Indoor Workplaces
EN 15193	Energy performance of buildings – Energy requirements for lighting
CIE 69	Methodes for characterizing illuminance meters and luminance meters; performance, characteristics and specifications

overlapping with Lighting:

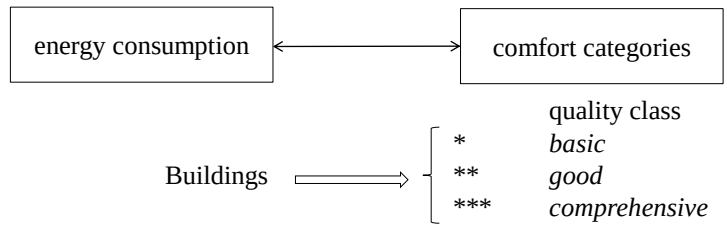
prEN 15255	Thermal performance of buildings – *room cooling…*
prEN 15265	Thermal performance of buildings – *energy for cooling…*

EN ISO….	Ergonomics of the thermal environment - …..

(see also EN15251 page 12 diagram 'interaction with other standards')



'Energy performance of buildings – Energy requirements for lighting'



Controls (daylight and artificial light) is described by 'dependency factors':

- Daylight dependency factor $F_{D,n}$
- Occupancy dependency factor F_O
- Constant illuminance factor F_C

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Table F.2 — Lighting design criteria class

	Lighting design criteria class		
	*	**	***
Maintained illuminance on horizontal visual tasks ($\bar{E}_{m\ horizontal}$)	☑	☑	☑
Appropriate control of discomfort glare (UGR)	☑	☑	☑
Avoidance of flicker and stroboscopic effects	✓	✓	✓
Appropriate control of veiling reflections and reflected glare		✓	✓
Improved colour rendering ?		☑	☑
Avoidance of harsh shadows or too diffuse light in order to provide good modelling		✓	✓
Proper luminance distribution in the room ($E_{vertical}$)		✓	✓
Special attention of visual communication in lighting faces ($E_{cylindrical}$)			✓
Special attention to health issues (Note)			✓

☑: has to comply with required values from Tables 5.3 in EN 12464-1:2002.

✓: has to conform to verbally described requirements from EN 12464-1.

NOTE Health issues may even require much higher illuminances and therefore higher W/m^2.

The maximum power density load (*PN*) connected to the lighting design class is given in the benchmark Table F.1.

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Resume:

- Very poor contents regarding lighting !
- Only ½ + ¼ + ¼ pages = ca. 1 page in the whole standard !?
- Annex D (informative) table extracted from EN12464
- References to EN12464 (lighting standard) and **EN15193 (Energy)**

Citation:

‘Lighting quality of building is evaluated by measurement of illuminance.’ ?

EN15251 → **EN15193**

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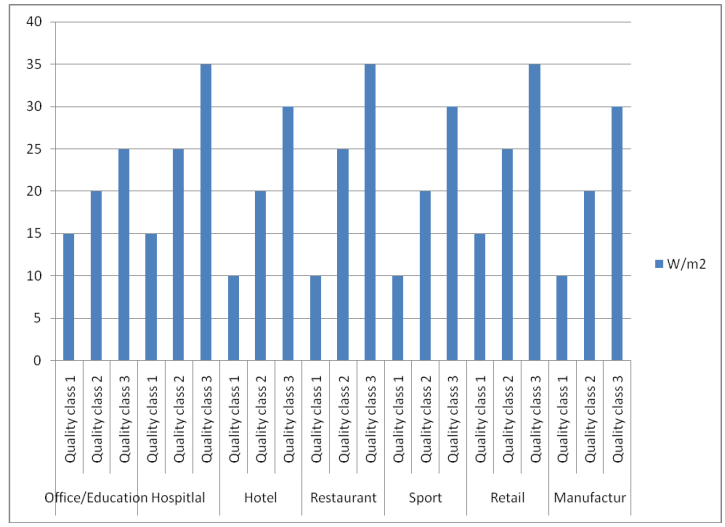
Limits for connected lighting power (in W/m^2) according to EN15193 for different building types and quality levels.



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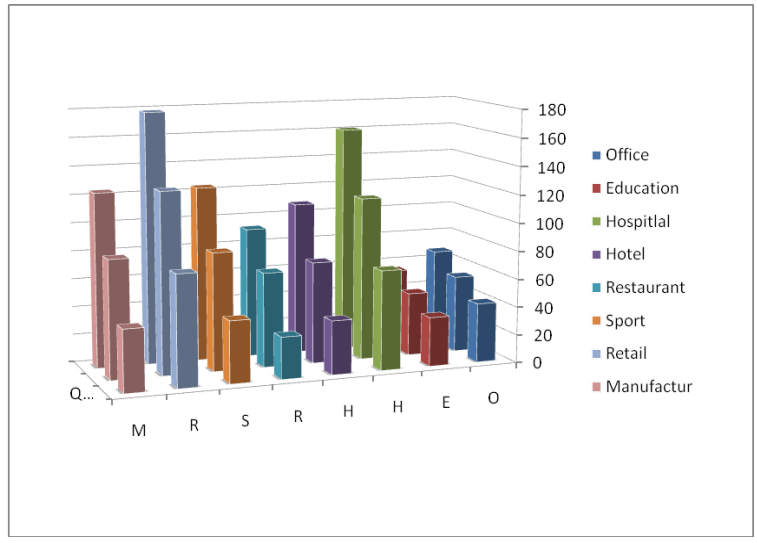
Limits for energy consumption (in kWh/m^{2}year) according to EN15193 for different building types and quality levels



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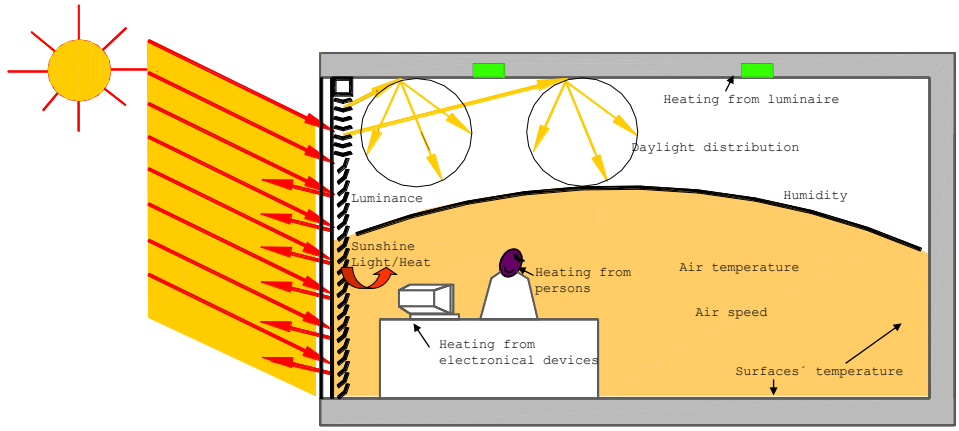
Daylight:
Luminance
Distribution
View to outside
Sunshine

Indoor gains:
Tools
Persons
Artificial light

Climate:
Air temperature indoor
Surface temperature
Humidity
Air speed



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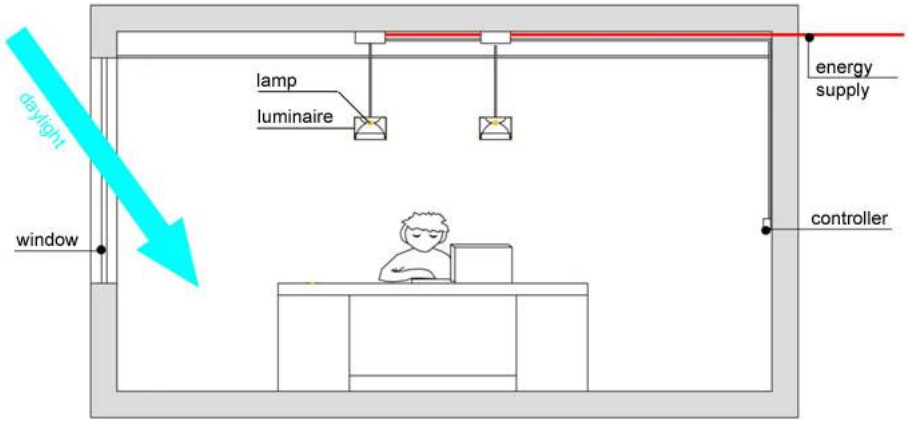
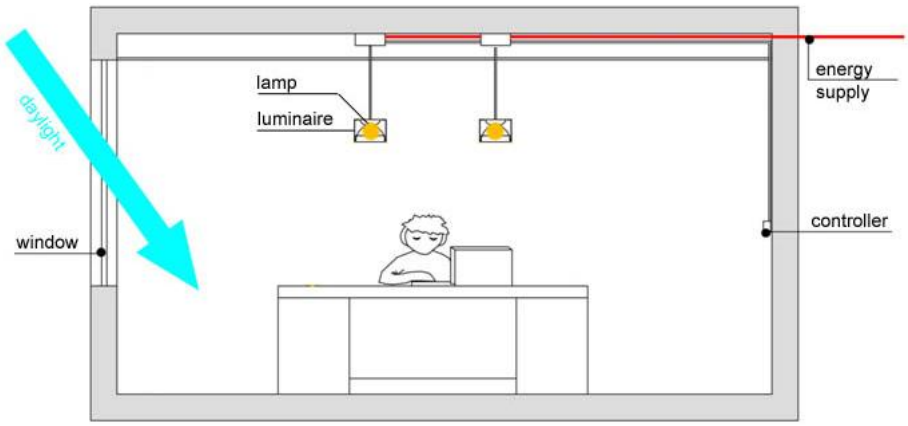


energy supply → lamp → luminaire → room



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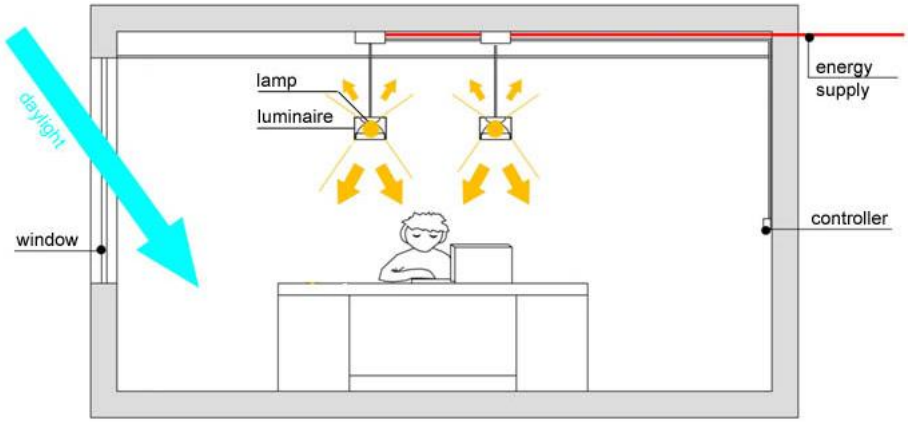
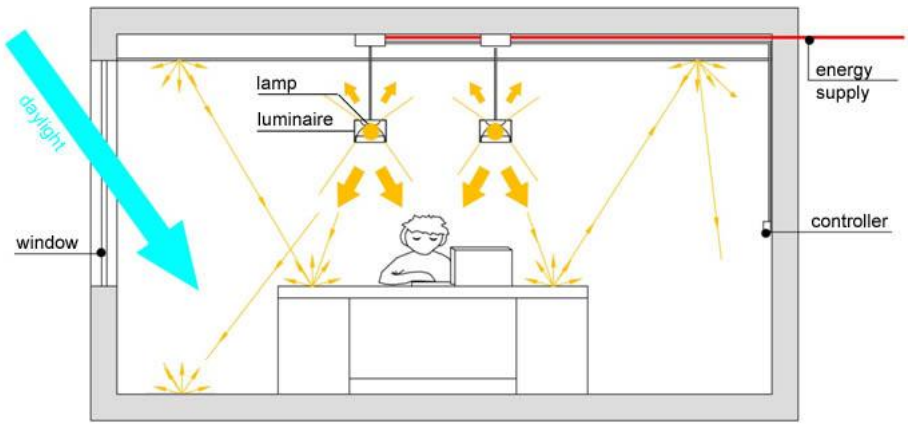
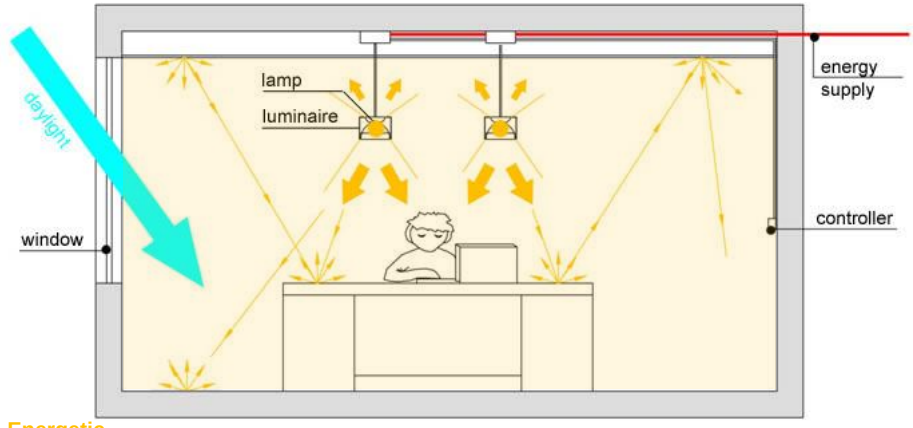


energy supply → lamp → luminaire → room



energy supply → lamp → luminaire → room



Energetic performance factors: = lamp efficacy ➡ luminaire light output ratio ➡ room utilization factor

Ultimate (total) efficiency of the electric light installation

$$E = \frac{\Phi_{Lamps}}{A} \times \eta_{lor} \times \eta_R \times \eta_m$$

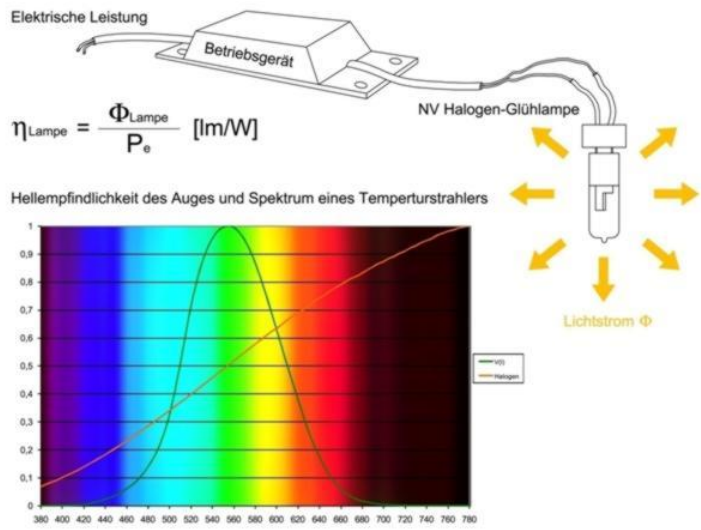
light output ratio luminaire

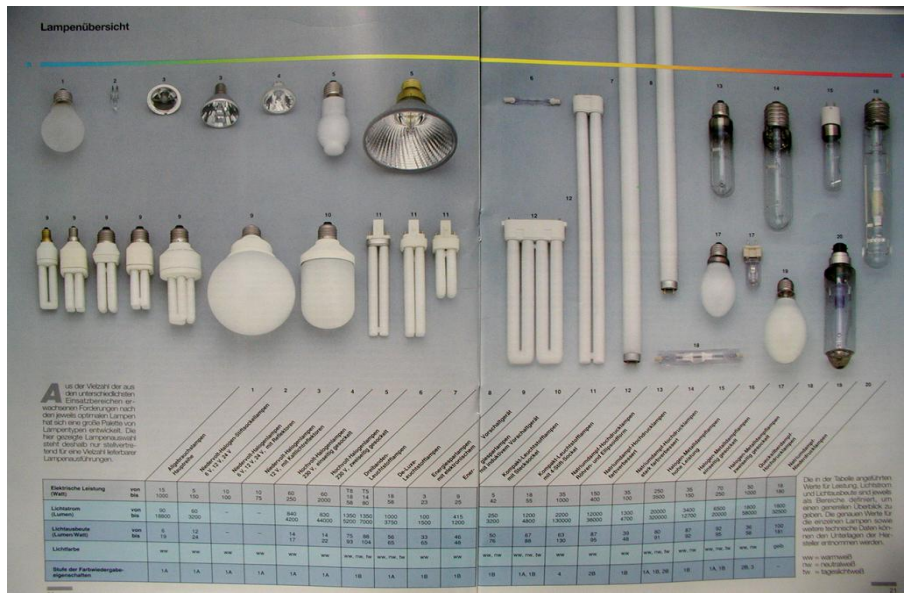
room utilisation factor

maintenance factor

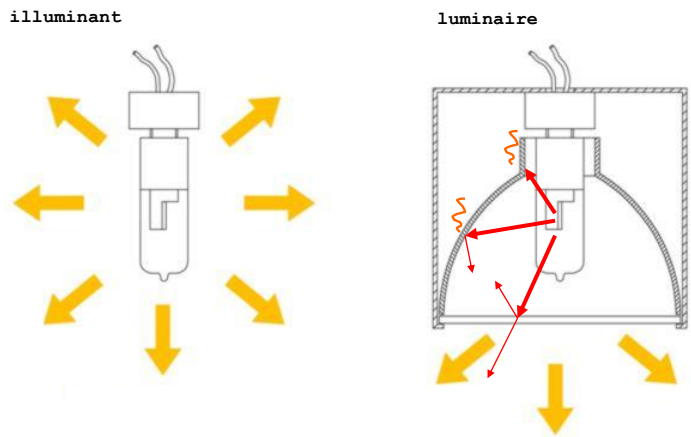
$$\Phi = \frac{E \times A}{\eta_{lor} \times \eta_R \times \eta_m}$$

lamp efficacy (including the ballast):





OLEDs



$$\eta_{lor} = \frac{\Phi_{luminaire}}{\Phi_{illuminant}}$$

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Luminaires

Junior

Nautilus

Linsen-Leuchte

Sekundär-Leuchte

Werfer + Spiegel

Wandstrahler

Indirekt-Leuchte

Spiegelraster -Leuchte

Evolventen-Leuchte

Rund-Leuchte

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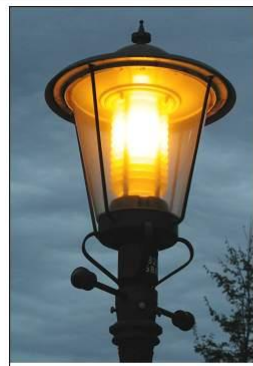
Refurbishment of historic „Ritter Lantern", City of Amsterdam, Netherlands



EXISTING LANTERN
SON-T 50W
$E_{mean/street}$ = 2.6 lx

15 W Energy-Saving

20 € Savings/Lantern
(operation cost a year)

3.400 Lanterns

68.000 € Total Savings
(operation cost a year)

Power: x 2/3

Illuminance: x 3

NEW RITTER LANTERN
CDM-T 35W
$E_{mean/street}$ = 7.5 lx

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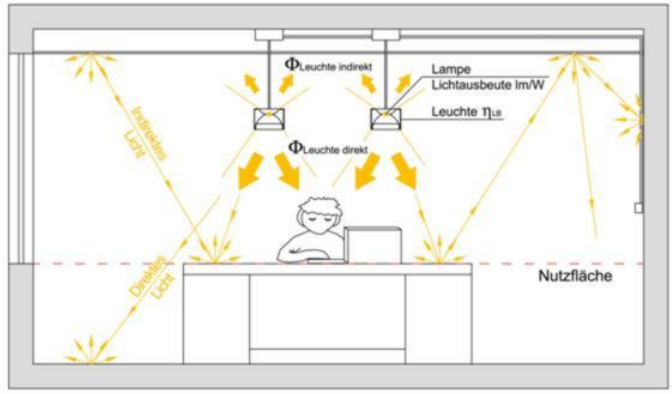
Room Utilization Factor



$$\eta_{Raum} = \frac{\Phi_{Nutzfläche}}{\Sigma \Phi_{Leuchten}}$$

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The factor depends on:

- the room geometry
- the reflectance coefficients of the surfaces
- the luminaires (LID, positioning)

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Depends on:

- the room geometry
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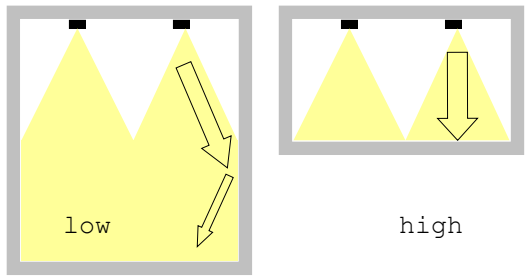

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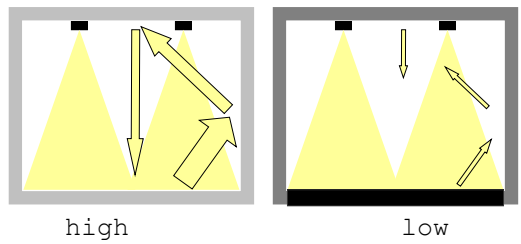
Depends from:

- the room geometry
- the reflectance coefficients of the surfaces
- on the luminaires (LID, positioning)

where is η_R higher ?



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

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

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

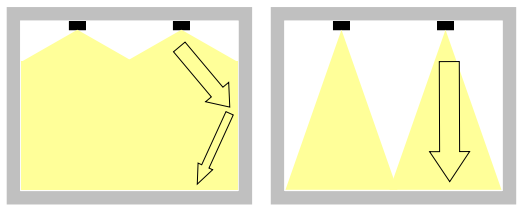
ρ_{mean} = 0,2 > $f_{indirect}$ = **8%**

ρ_{mean} = 0,7 > $f_{indirect}$ = **70% !!**

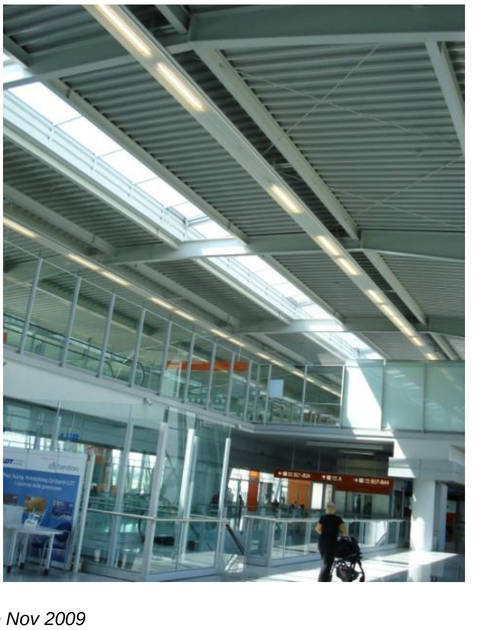
Depends from:

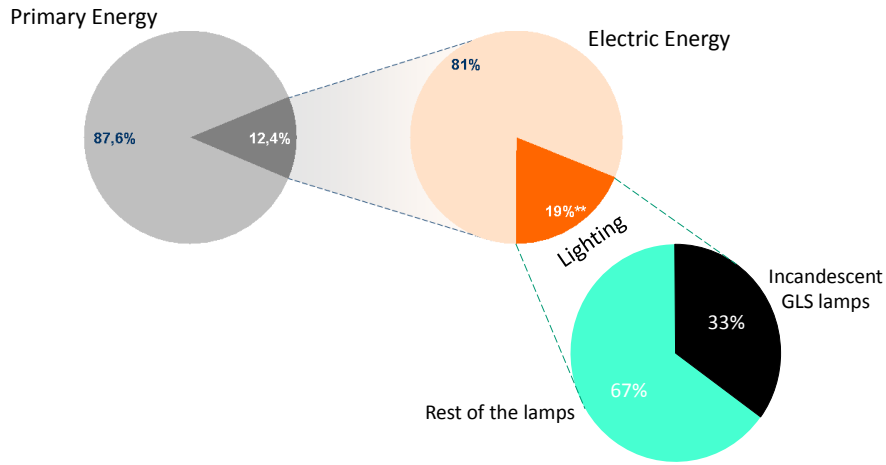
- the room geometry
- the reflectance coefficient of the surfaces
- on the luminaires (LID, positioning)

where is η_R higher ?

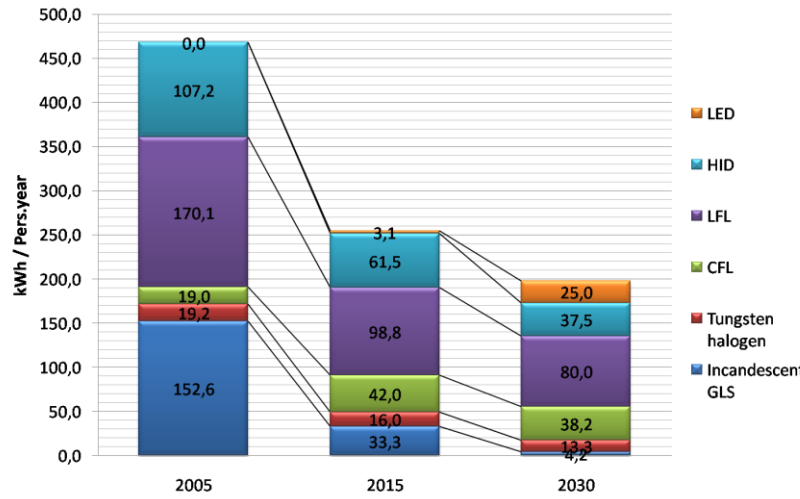


low high





Forecast



(Source: IEA Annex 45)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