Hochschule für Technik
und Wirtschaft Berlin
University of Applied Sciences

Display Technology

Project: LED Lighting

Lutz Gerhold
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Department: Electronics

Prof. Yiannis Kaliakatsos

TEI of Crete

Erasmus+

Contents

1 Introduction to LED's in lighting

There are several different fields in engineering and all of them are dedicated to continuously improvement. The transition from classic light bulbs to LED's as lighting devices is one of those necessary steps to improve overall electrical efficiency. This report focuses on the prospect of using LED`s in lighting engineering.

1.1 The basic physics of LED's

The LED , light emitting diode, is a light source which is based on a semiconductor. It follows the physics of a diode with a p-n junction. Meaning that if a certain amount of voltage is applied to its contacts, the threshold is being exceeded and the electrons are moving through the diode. In case of the LED, the energy is being released with photons, thereby causing the emitting of light.

1.2 Advantages of LED`s in lighting

Since the year 2009, LED's are being used for commercial devices in lighting. In the meantime they have shown great prospects in comparison to the old standard light bulb applications. As we can see in the following table 1, the LED lamps are showing a several times higher life span and electrical efficiency than lamps on incandescent, halogen or CFL bases.

Cost Comparison for 60 watt incandescent equivalent lightbulb (U.S. residential electricity prices)							
	Incandescent[20]	Halogen[21]	CFL[22]	LED (Cree)[23]	LED (Philips)[24]	LED (LEDNovation)[25]	LED (Nanoleaf NL02-1200)[26]
Purchase price	$0.41	$1.50	$0.99	$9.97	$4.35	$31.50	$24.99
PF	1	1	0.5	0.75 [need citation]	0.5	0.5	0.5
Real power used (watts)	60	35	14	9.5	8.5	9.4	10
lumens (mean)	860	860	775[27]	800	800	810	1200
lumens/watt	14.3	24.6	55.4	84	94.1	86.2	120
Color Temperature kelvin	2700	2900	2700	2700	2700	2700	3000
CRI	100	100	82	80	80	94	80
Lifespan (hours)	1,000	4,000	10,000	25,000	10,000	50,000	30,000
Bulb lifetime in years @ 6 hours/day	0.46	1.83	4.6	11.4	4.6	22.8	13.7
Energy cost over 20 years @ 13 cents/kWh	$342	$199	$159	$72	$97	$107	$114
Total cost over 20 years	$360	$216	$164	$90	$116	$135	$150
Total cost per 860 lumens	$360	$216	$182	$96	$125	$143	$108
Comparison based on 6 hours use per day (43,800 hours over 20 yrs)							

Table 1 comparison LED's with other lamp types (taken from Wikipedia)

2 Concept of Lighting Design

In this section we take a closer on the concept of calculating basic problems in lighting. As engineers we might encounter the challenge of calculating the illuminance of light on a certain point and angle. This task is being covered in a basic example in section 2.3 and in section 2.4 we are going to focus on the problem of determining the necessary number of lights in a room, regarding the work related atmosphere. These examples work of course for LED's and all the other lighting applications.

2.1 Terminology of Lighting

Here are the basic physical terms.

Symbol	Name	Unit	"Common meaning"
I	intensity	cd (candela)	brightness
F	flux	lm (lumen)	amount of light emitted
E_x	Illuminance	lx (lux = lm/m²)	amount of light at area x
K	efficacy	lm/W	ratio of flux and power input
MF	maintenance factor	0.....1	influence of dirt and ageing
R	Room index	0.....∞	Indicates the rooms geometry
θ	angle	°	angle of the emitted light
Cu	Coefficient of utilization	0.....1	Indicates the useable amount of light in accordance with R

2.2 formulas and figures

Here we are looking at some of the standard formulas and values

$$R = \frac{L * W}{Hm * (L + W)}$$ L = length, W= width, Hm = mounting height

$$E_x = \frac{I * cos^3\theta}{d^2}$$

$$total\ number\ of\ LED`s\ or\ Lamps\ needed\ n = \frac{E_x * L * W}{F * MF * Cu}$$

Standard Table of R and Cu

K	0.75	1	1.25	1.5	2.0	2.5	3.0	4.0	5.0
Cu	0.3	0.37	0.42	0.46	0.52	0.56	0.59	0.63	0.66

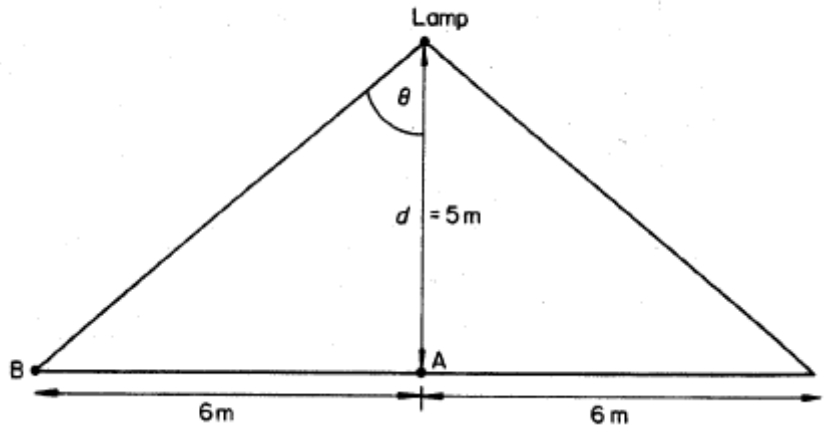
Standard illuminance in certain areas

Area	**Illuminance**
Car Park	20
Corridor	50
Sitting Room	75
Shopping Centre	200
Factory area	250
Engineering Workshop	300
Brightly lit office	400
Precision work	500
Operating theatre	1200

2.3 Calculation example - illuminance in a certain point

A 250 W Street Lamp emits a light of 22500 cd and is situated 5m above the road

Calculation of illuminance at difference points.



Illuminance in Point A E_A

$$E_A = \frac{I * cos^3\theta}{d^2} = \frac{22500\ cd * \cos(0°)^3}{25\ m^2} = 900\ lux$$

here θ is given with 0° because Point A is right underneath the Lamp

Illuminance in Point B E_B

we need angle θ

lets follow the rules of trigonometry which are stated by "SOH CAH TOA"

$$Tan\,\theta = \frac{AB}{d} = \frac{6\ m}{5m} = 1.2 \qquad \theta = Tan^{-1}(1.2) = 50.2°$$

$$E_B = \frac{I * cos^3\theta}{d^2} = \frac{22500\ cd * \cos(50.2°)^3}{25\ m^2} = 236\ lux$$

Logic consequence: Point A which is right underneath the lamp is (about 4 times) brighter than point B which is a few meters away.

2.4 Calculation example - lighting design in a room

Lets plan the lighting design in an office 8 m x 14 m x 3 m to a level of 400 lux at bench level. The working plane is 0.850 m. We plan to use 42 W LED Ceiling luminaries with an output when new of 4000 lm. Therefore we assume a maintenance factor of 0.8 .

1.) How many lamps do we need?

$$n = \frac{E_x * L * W}{F * MF * Cu}$$

but we got to find R and Cu first

1.1.) Lets find R

$$R = \frac{L * W}{Hm * (L + W)} = \frac{14\ m * 8\ m}{(3\ m - 0.85\ m) * (14\ m + 8\ m)} = 2.36 \approx 2.0$$

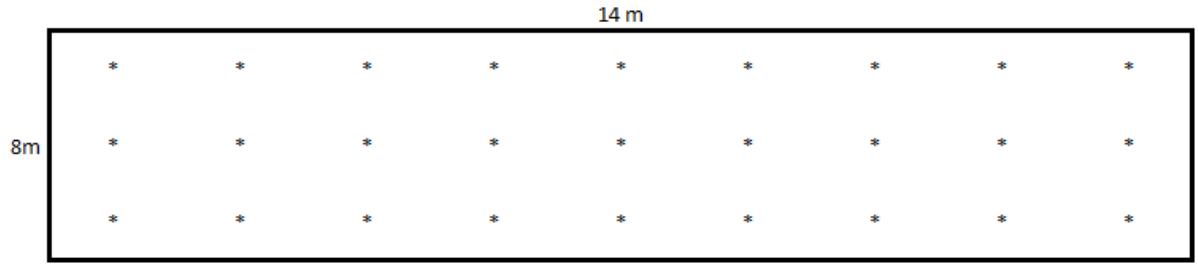
From the table we get Cu = 0.52

R	2.0
Cu	0.52

Total number n of lamps/ LED's

$$n = \frac{400\ lux * 14\ m * 18\ m}{4000\ lm * 0.8 * 0.52} = 26.9 \approx 27$$

2.) How can the LED be positioned ?



This is just a simple suggestion, which is not concerning separated sections in the office.

3 Types of LED's in lighting

According to their purpose there are different LED applications. For the standard household it means for example to replace the old existing light bulbs. That means the new LED system has to be compatible to the old system, to make the transition as easy as possible. Basically all types of LED devices have a small circuit included to transform and rectify the AC voltage to a convenient DC voltage

3.1 LED Bulbs

These lights were made with standard light bulb connections such as bi-pins, bayonets and thread- fittings, as we can see in picture

Picture 1 Types of LED Bulbs

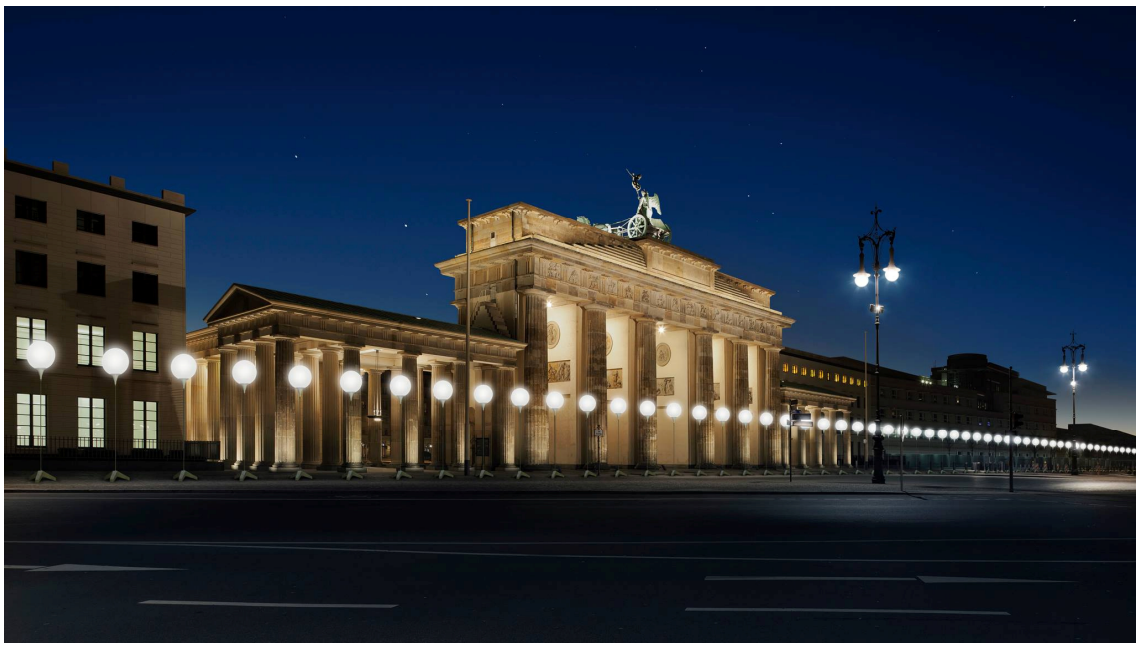
3.2 LED Tubes

These lights are designed to be physically compatible, as we can see in picture 2, with the standard fitting which are being used for fluorescent tubes.

Picture 2 Types of LED Tubes

4 LED's in art: "Lichtgrenze"

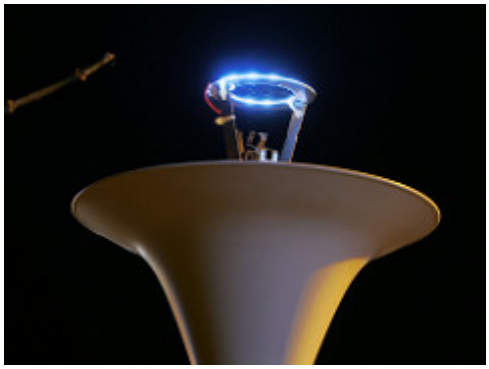
To celebrate the 25th anniversary of the opening of the German wall on the 9th November 2014 the artists and brothers Christopher Bauder und Marc Bauder designed a special temporary installation using LED's. They called this project "Lichtgrenze", which translates as Border of Light, to hint the historical breakthrough in German and European history. They rebuild the 15km long, structure of the Berlin wall with 6880 white highlighted balloon posts. In picture 3 we can see the Brandenburg Gate with the decoration of the Lichtgrenze and picture 4 shows the visual dimension all over the city.



Picture 2 Brandenburg Gate with the Lichtgrenze decoration

Picture 3 Visualization of the Lichtgrenze

In each and every balloon post, as you can see in picture 5, were several SMD LED's installed with a battery in the base of the post. To provide stability the base had also a container filled with water.



Picture 4 SMS LED's in the balloon post

The LED's were highlighting the white balloon from the evening of the 7th November until the 9th November. During the evening festivities they were all released in a domino like effect which we can see in picture 6.

Picture 5 Releasing of the balloons

Sources

[1] Wikipedia, LED Lighting

[2] Lecture material, LED, Prof. Yiannis Kaliakatsos

[3] Lecture Material DkIT, Electrical Services Design

[4] Wikipedia, Lichtgrenze