Influence of the Light Distribution of LED Luminaires on the Energy Consumption for Lighting in Public Premises

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Abstract: *Most of the existing on the market LED luminaires are characterized by lambertian light distribution. The use of such luminaires in public premises can increase brightness (and glare) to an uncomfortable degree as compared to linear fluorescent lamps. Using proper luminaire optical system can lead to achievement of "batwing" fluorescent distribution pattern and improve uniformity. LED luminaires characterized by batwing distribution are investigated and compared to LED luminaires with lambertian light distribution in order to estimate their economic efficiency in terms of installed lighting load. The current paper represents such an investigation and gives economical appraisal of a lighting installation accomplished with LED luminaires with batwing or lambertian light distribution.*

1. Introduction

The term energy efficient lighting installation refers to lighting installation that meets the necessary lighting requirement for a particular application and at the same time consumes minimum energy and needs minimum maintenance [1]. The efficiency of a lighting system is preliminary decided through the design stage. First of all the efficiency of the light source to be used and its drive should be considered and the most efficient that can meet the desired requirements for the specific application should be chosen. The color appearance and color rendering should be considered. Choosing the most appropriate pattern of white can lead to enhancement of the objects in the room, that are lit or ambience of the space. Also the color rendering requirements for the specific application should be met. When light source is chosen its life expectancy should be taken in consideration. The high efficiency of the light source itself does not always lead to efficiency of the luminaire in which it is fitted, so also the LOR (Light Output Ratio) of the luminaires should be considered for maximum efficiency of a lighting system. The luminaires at a given space should be arranged in such a way that they provide effective illumination and are accessible at the same time to ensure easy maintenance. Another consideration that should be taken into account is the light distribution pattern of the luminaires. For most of the LED luminaires on the market lambertian light distribution is typical, while in office environment usually wide and even light distribution with good uniformity is aimed [2].

2. Approach and considerations

For investigation of the influence of the light distribution of LED luminaires on the efficiency of the lighting system in an office environment a typical premises has been used. The requirements for office spaces are given in the European standard for indoor lighting EN 464-1/2011 [3]. This document specifies the requirements for lighting solutions for indoor work places and their associated areas in terms of quantity and quality of illumination.

According to this standard the task illuminance (quantitative value) in the office considered is set to 300lx, the illuminance of the immediate surroundings is 200lx and the illuminance of the background is set to 50lx. The quality of the lighting system is estimated through discomfort glare (UGR) – set to a value below 19, the requirement for color rendering index (R_a) should be above 80, and the uniformity of lighting (U_0) should be at least 0.4. For evaluation of the efficiency of the luminaires considered, the Lighting Energy Numerical Indicator (LENI) is used [4].

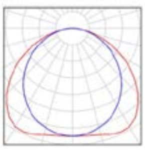
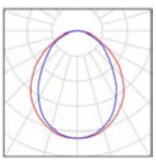
3. Results from the investigation

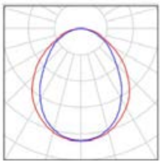
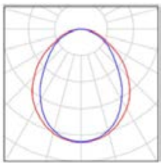
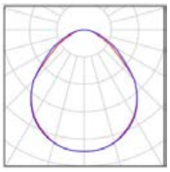
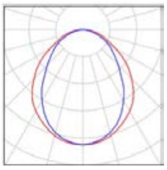
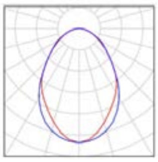
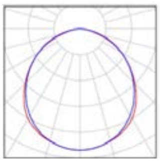
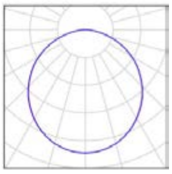
The office taken in consideration has the following dimensions: length – 19.2m; width – 14.2m; height – 2.8m, area – 273.55m^2, height of the work plane – 0.8m, the maintenance factor is considered MF – 0.8. The simulation of the premises is shown on fig. 1

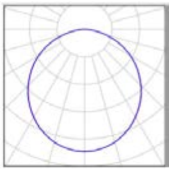
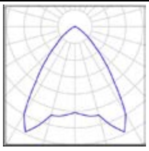
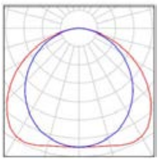
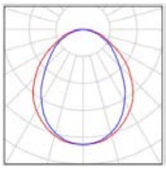
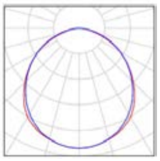
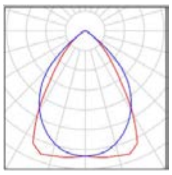
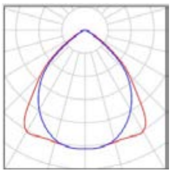
Fig.1 Structure of the office taken in consideration

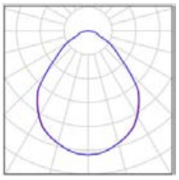
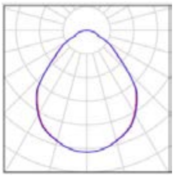
The results and information for the luminaires considered are summarized in table 1 [5].

Table 1 Results [5]

Luminaire type	Model	Light distribution curve	Power, W	Illuminance, E_{av}, lx U0	Number of luminaires	Specific connected load, W/m^2; LENI, W/m^2 per year
Zumtobel 42182944 ML4 EB LED2400-830 M600Q LDO KA [STD]			25	501 0.4	72	6.58 13.86
Zumtobel 42182945 ML4 EM LED2800-830 M600Q LDO KA [STD]			25	512 0.4	64	5.85

Zumtobel 42182845 ML4 EM LED3000-840 M600Q LDO KA [STD]			25	512 0.4	64	5.85 12.28
Zumtobel 42182845 ML4 EM LED3000-840 M600Q LDO KA [STD]			25	553 0.4	63	5.76 12.2
Zumtobel 42182655 ML5 EH LED3000-840 M600Q LDO TBL [STD]			25.5	508 0.4	56	5.22 10.97
Zumtobel 42182947 ML4 EM LED2800-830 M625Q LDO KA [STD]			26	538 0.4	64	6.08 12.77
Zumtobel 42182953 ML4 EM LED3000-830 M600L LDO KA [STD]			27	499 0.43	56	5.53 12.9
Zumtobel 42182952 ML4 EB LED2600-830 M600L LDO KA [STD]			27	546 0.5	72	7.11 14.97
Zumtobel 42925666 MIREL-O NIV LED3800-840 M625Q LDO KA [STD]			27.6	544 0.4	49	4.94 10.29

Zumtobel 42182134 MIREL-O NIV LED3800-840 M625Q EVG KA [STD]			26.7	544 0.4	49	4.78 9.95
Zumtobel 42925630 MIREL-L LAY LED3800-840 M625Q LDO KA [STD]			29	497 0.4	42	4.45 9.23
Zumtobel 42182948 ML4 EB LED3200-830 M600Q LDO KA [STD]			32	524 0.4	56	6.55 13.77
Zumtobel 42182847 ML4 EM LED3800-840 M600Q LDO KA [STD]			32	530 0.6	48	5.62 11.83
Zumtobel 42182956 ML4 EB LED3400-830 M600L LDO KA [STD]			35	559 0.5	56	7.17 14.88
Zumtobel 42182665 ML5 EV LED3600-840 M600L LDO TBL [STD]			35.4	565 0.4	49	6.34 12.73
Zumtobel 42182779 ML5 EV LED3800-830 M600Q LDO TBL [STD]			35	540 0.5	48	6.14 12.94

Zumtobel 42182598 LFE E LED4600-840 M625L12 LDO KA SRE [STD]			34.9	513 0.6	36	4.59 9.45
Zumtobel 42182593 LFE E LED4600-840 M625L15 LDO KA SRE [STD]			35.4	517 0.6	36	4.66 9.59

4. Conclusions

From the results shown in table 1 it is obvious that the batwing light distribution is more effective than the lambertian or cosine. A great influence on the efficiency of the LED luminaires has their optical system. The greatest efficiency is received for luminaires with diffuse light, and again the wider the light distribution, the better the efficiency.

Energy effective lighting design requires an appreciation of the characteristics of low energy light sources, knowledge of the levels of visual amenity required for different applications and close attention to optical systems and luminous intensity distribution curves of the luminaires.

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