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Energy Efficiency Analysis of Car Park Lighting in LED Technology

Abstract. *The article presents the findings of energy efficiency research performed for car par lighting provided in the form of luminaires with LED light sources according to the PN-EN 15193 standard. It characterizes the basic factors on which the energy efficiency analysis research was conducted and presents specific calculations; it also compares the results of those calculations with the ones obtained for a car park design where metal-halide lamp fittings were used.*

Streszczenie. *W artykule przedstawiono wyniki badań efektywności energetycznej oświetlenia parkingu wykonanego na oprawach ze źródłami LED w oparciu o normę PN-EN 15193. Scharakteryzowano podstawowe współczynniki na podstawie których przeprowadzono analizę wydajności energetycznej oświetlenia oraz przedstawiono konkretne obliczenia a także porównano je z projektem parkingu wykonanym na oprawach ze źródłami metalohalogenkowymi. (**Analiza efektywności energetycznej oświetlenia parkingowego ze źródłami LED**)*

Keywords:. Lighting energy efficiency, luminaires with LED light sources, luminaires with metal-halide sources
Słowa kluczowe: wydajność energetyczna oświetlenia, oprawy ze źródłami typu LED, oprawy ze źródłami metalohalogenkowymi

Introduction

The purpose of the present article is to present the basic characteristic properties and to assess the energy efficiency of car park lighting in LED technology, as described in the PN-EN 15193 standard and to compare the results obtained with the results obtained for car park lighting provided in the form of metal-halide fittings.

Performing the energy account

Calculating the energy consumption of a lighting system is performed by means of calculating the LENI indicator. LENI stands for *Lighting Energy Numeric Indicator*. It is determined on the basis of annual energy consumption of a lighting system in proportion to the total area of the lighted surface [3]:

$$LENI = \frac{W}{A}\left[\frac{\text{kWh}}{\text{m}^2 \cdot \text{year}}\right] \quad (1)$$

where: W – power consumption, A – total lighted area.

The indicator is determined on the basis of total annual energy consumption. The basis for its determination is determining the installed wattage of the luminaires. The installed wattage is determined on the basis of the wattage of the luminaires when connected to the mains power and thus it results from the power consumption of the light sources and their regulated power and ignition systems and control systems (including their parasitic capacitance when the luminaires are switched off). Installed wattage is based on the catalog data for the luminaires [1].

Initially, unit power was assumed as a measure of energy efficiency [W/m^2] at a given illuminance level; later, the corrected unit measure of unit power per the illuminance level of 100 lx was used [6].

Project assumptions and measurements

The examined object has a rectangular surface area of 52x21 m, which gives 1092 m^2. The luminaires used are Alfa SL 1M 36W luminaires produced by Alfa. The catalog data and the luminosity curve are provided below [4].

Table 1. Technical data of luminaire

Technical data	
Power consumption	36 W
Luminous efficacy	78 lm/W
Weight	2,5 kg
Size	11x3x31 cm

LED luminaires are characterized with very low wattage levels without compromising the quantitative and qualitative lighting parameters.

Fig.1 A picture of the LED luminaires [4]

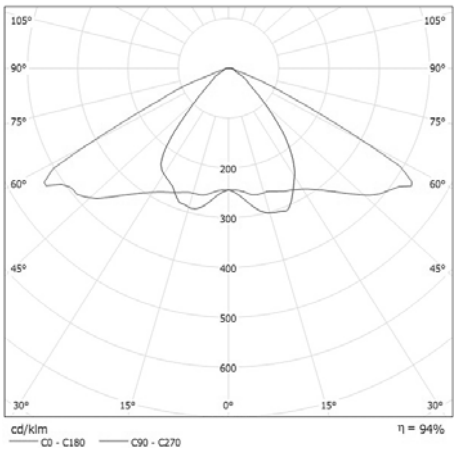

Fig. 2 The luminous curve for the Alfa SL 1M luminaires [4]

The design of the lighting was prepared in the Relux program in accordance with the PN-EN 12464-2 standard: Lighting of work places. Outdoor work places.

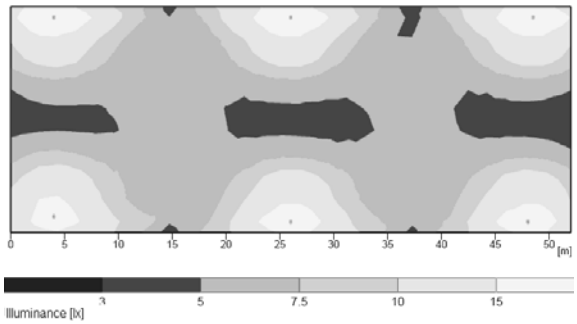

Fig 3. Illuminance measurement results for the examined area

The total luminous flux of the LED sources is 17916 lumens and the total wattage is 216 W, which means that the wattage level per unit area is 0,2 W/m^2 (equivalent to 2,39 W/m^2/100lx). The illuminance and uniformity results are presented in table 2.

Table 2. The illuminance and uniformity results

Illuminance and uniformity results			
E_{min} [lx]	E_{max} [lx]	E_{avg} [lx]	Uniformity
3,8	20,5	8,3	0,46

Illuminance measurements in the car park were performed with relation to the project assumptions. The results are presented in table 3.

Table 3. Measurement results

Measurement results illuminometer LX 101 no L274059								
			Illuminance Lx				Require-ments	
No	Place of measurement	Light source type	Mea-sured	max	aver age	Uniformity	Eav g.	Uniformity
1	Car park 1	LED	23	24	15	0,63	5	0,25
2	Car park 2	LED	11	24	15	0,63	5	0,25
3	Car park 3	LED	24	24	15	0,63	5	0,25
4	Car park 4	LED	15	24	15	0,63	5	0,25
5	Car park 5	LED	8	24	15	0,63	5	0,25
6	Car park 6	LED	16	24	15	0,63	5	0,25
7	Car park 7	LED	12	24	15	0,63	5	0,25
8	Car park 8	LED	7	24	15	0,63	5	0,25
9	Car park 9	LED	13	24	15	0,63	5	0,25
10	Car park 10	LED	22	24	15	0,63	5	0,25
11	Car park 11	LED	10	24	15	0,63	5	0,25
12	Car park 12	LED	21	24	15	0,63	5	0,25

Assessment of the energy efficiency of the lighting

On the basis of the measurements conducted, it was determined that the lighting used conforms to the standard with regard to the illumination and uniformity levels. Additionally, energy efficiency calculations of the lighting examined with the use of equation 1 are presented below:

(2) $$LENI = \frac{216 \cdot 3500}{1092} = 0,07[\frac{\text{kWh}}{\text{m}^2 \cdot \text{year}}]$$

where: luminaires lighting time = 3500 h/year.

For comparison purposes, a design of the same car park with metal-halide Philips MVP504 GC 1xCDM-T70W luminaires was prepared. The catalog data and the luminous curve are presented below [5].

Fig 4. A photo of the Philips MVP504 luminaires [5]

Table 4, Technical data

Technical data	
Power consumtion	70 W
Luminous efficacy	64 lm/W
Size	38,5x30x11 cm

Luminaires using metal-halide light sources consume much more power with lower luminous efficacy rates than diodes in order to preserve the same quantitative and qualitative parameters.

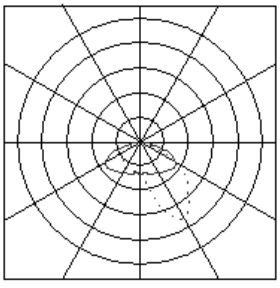

Fig. 5 The luminous curve for the Philips MVP504 luminaires [5]

The design of the lighting was, similarly to the design using diode sources, prepared in the Relux program.

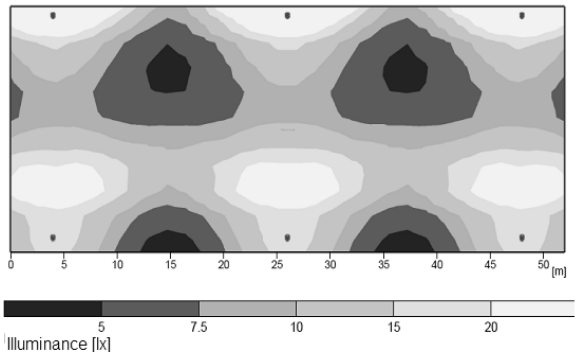

Fig 6. Illuminance measurement results for the examined area

The total luminous flux of the metal-halide light sources is 39600 lumens and the total wattage is 510 W, which means that wattage level per unit area is 0,47 W/m^2 (equivalent to 3,75 W/m^2/100lx). The illuminance and uniformity results are presented in table 5:

Table 5. The illuminance and uniformity results

Illuminance and uniformity results			
E_{min} [lx]	E_{max} [lx]	E_{avg} [lx]	Uniformity
4,3	32,8	12,5	0,35

The results of energy efficiency calculations for the designed car park are presented below:

(3) $$LENI = \frac{420 \cdot 3500}{1092} = 0,16[\frac{\text{kWh}}{\text{m}^2 \cdot \text{year}}]$$

where: luminaires lighting time = 3500 h/year.

The value of the energy efficiency indicator LENI for metal-halide luminaires is 0,16 kWh/(m^2 year), which means that it is twice as high as in the case of LED luminaires.

Conclusion

The analysis of the indicators specified in the standard [2] makes it possible to provide specific lighting energy consumption values. In order to perform correct calculations, every parameter must be included. It was confirmed that the object using LED luminaires has higher energy efficiency than the same object with lighting provided in the form of metal-halide luminaires if the illuminance and uniformity values specified in the standard are to be preserved; what is more, it has higher color rendering index characteristics.

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