Evaluation of the energy efficiency of LED lighting arrangement in the lobby

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Abstract— The article presents the results of energy efficiency tests performed in the lobby of the JET OFFICE office building located in Poznań on the basis of the PN-EN 15193 standard. It characterizes the most important factors on the basis of which the analysis of the energy efficiency of the lighting was performed, and presents specific calculations.

Keywords —lighting energy efficiency, LED technology, LENI factor

I. INTRODUCTION

The concept of energy efficient lighting did not appear until the 80's of the 20th century. Back then, it was the reaction to the first global energy crisis. It was then that the Illuminating Engineering Society of North America recommended minimizing the energy consumption on lighting [3]. The term "energy efficient lighting" means lighting with lower energy consumption without compromising the quantitative and qualitative features of the lighting.

The goal of the present article is to present the basic characteristic values and to evaluate the energy efficiency of the lighting fitted in the lobby of the JET OFFICE office building. The lighting was based on the LED technology in such a way so as to, first of all, fulfill the esthetic requirements for the representational purposes of the building.

II. BASIC ENERGY REQUIREMENTS FOR INDOOR LIGHTING

Multiple parameters that must be considered in order to determine the energy efficiency factor for the lighting were assumed in the standard. They include, among others, the installed lighting power of the luminaires fitted, as well as the constant illuminance factor and the daylight dependency factor [2].

The analysis of basic values should start with the energy consumption for lighting factor. This parameter consists of the energy consumed by the luminaires fitted and of the so-called parasitic load consumed when the light source is shut off.

The value of the energy consumed is minimized by means of three techniques, that is:

- Controlling the constant illuminance of the lighting,
- Controlling and adjusting the luminaires,
- Using daylight.

The essence of any consideration of the energy efficiency of indoor lighting is the LENI factor. The abbreviation means the Lighting Energy Numeric Indicator which is determined on the basis of annual energy consumption for lighting in relation to the total area of the lighted surface [2]:

$$LENI=\{F_c \times (P_N/1000) \times [(t_d \times F_d \times F_o) + (t_N \times F_o)]\} + 1 + \{(5/t_y) \times [t_y - (t_d + t_N)]\} \quad [kWh/(m^2 \times year)] \quad (1)$$

Where:

F_{c-} - constant illuminance factor,
P_N- installed power density of the lighting in the building $[W/m^2]$
F_d – daylight dependency factor,
F_o – occupancy dependency factor,
t_d – daylight time usage,
t_y- standard year time, 8760 h,
t_N- non-daylight time usage.

The cut score values of the LENI factor and particular times are specified in the standard [2].

III. ENERGY EFFICIENCY EVALUATION OF THE LIGHTING IN THE LOBBY

The room examined is of rectangular shape with the dimensions of 6,5 x 5 m and the height of 2,8 m. In order to light the area, LED strips with the illuminance of 4,8 W/m covered with a semi-transparent material were used and four fluorescent light fixtures 1x 58W were fitted in order to provide the appropriate vegetation conditions to the plants. The diagram of the lighting installation is presented on figure 1 [5], and figures 2 and 3 present the luminaires fitted.

Table 1 presents a summary of the results of the average illuminance calculations as well as the calculations of the minimum and maximum illuminance values for the lighting in the room.

TABLE I. ILLUMINANCE CALCULATION RESULTS

Area	**E_m**	**E_{min}**	**E_{max}**
Work surface	512 lx	290 lx	686 lx
Workplace vicinity	367 lx	215 lx	524 lx

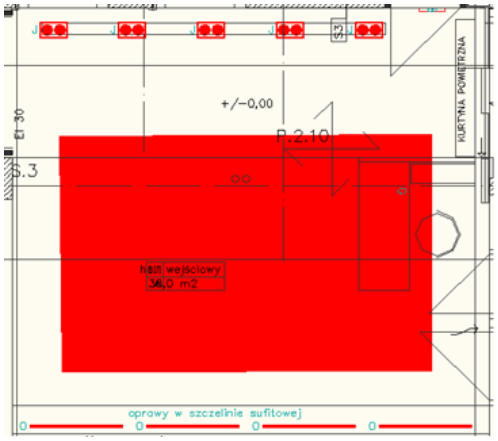

Fig.1. A plan view of the room with indication of the positioning of luminaires [5]

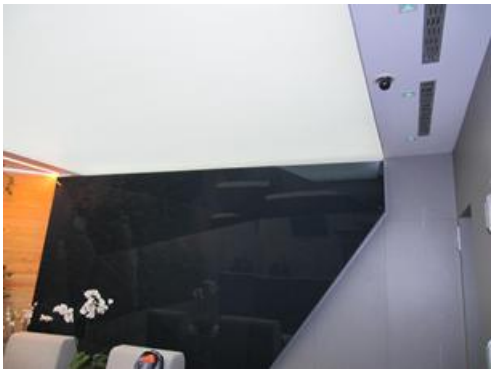

Fig. 2. A view of the room from the entrance door

Fig. 3. A view of the reception desk in the room

The measurements were performed on the work surface with the height of 0,75, 1,15 m (two-level receptionist's desk) as well as in the vicinity of the workplace at floor level.

The installed lighting power per unit area is 42,75 W/m^2.

IV. CONCLUSION

The evaluation of the energy efficiency of lighting is suitable most of all to calculate the value of the LENI factor. A summary of all the parameters necessary to calculate this value is presented below in the form of table 2 [1]**:**

TABLE II THE SET OF PARAMETERS NECESSARY TO CALCULATE THE VALUE OF THE LENI FACTOR

F_o	F_c	F_d	t_y	t_d	t_N	P_N
-	-	-	[h]	[h]	[h]	[W/m^2]
0,7	0,9	1	8760	3000	2000	42,75

$$LENI = \{0,9\times (42,75/1000) \times [(3000 \times 1 \times 0,7) + (2000 \times 0,7)]\} + 1 + \{(5/8760) \times [8760 - (3000 + 2000)]\} = 137,92 \text{ kWh } /(\text{m}^2 \times \text{year})] \quad (2)$$

The boundary value for the room examined is about 147 [kWh /(m^2 × year)], which is presented on figure 4. Then, the energy efficiency factor calculated (2) falls within normal limits [2].

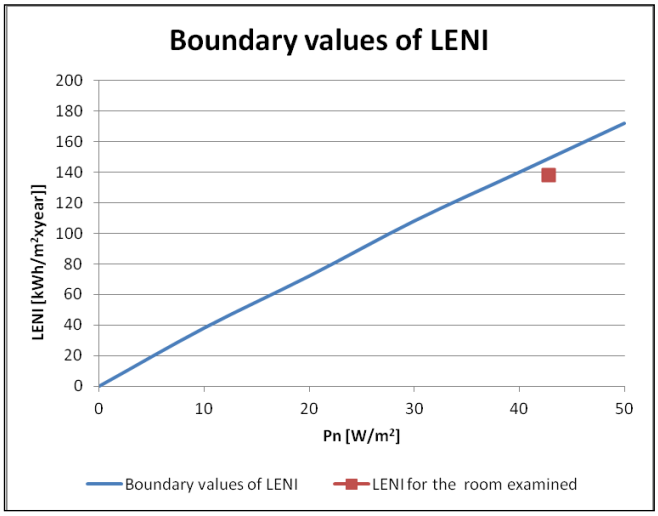

Fig 4. Boundary values of LENI

The tests performed show that the object tested was designed and constructed in accordance with the existing lighting standards both with respect to the appropriate illuminance values as well as the energy efficiency. This was possible only thanks to the use of electroluminescent lighting. Mounting the ceiling as a uniform illuminated surface with the use of a different type of luminaires would result in much higher energy consumption.

REFERENCES

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