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The Analysis and Assessment of Lighting System in Mass Residence Building on the Example of Dormitory in Warsaw

Piotr Pracki[a]*, Urszula Blaszczak[b]

[a]*Warsaw University of Technology,Faculty of Electrical Engineering, 75 Koszykowa street, 00-662 Warsaw, Poland*
[b]*Bialystok University of Technology, Faculty of Electrical Engineering, 45a Wiejska street, 15-351 Bialystok, Poland*

Abstract

In this paper the analysis and assessment of the existing lighting system in one of the students' dormitories in Warsaw is presented. It is one of the first steps of the project "Thermo-modernization of two chosen public buildings according to nZEB standards". We characterized the analyzed building focusing on the characteristics of the interiors and lighting equipment used. The study covered a detailed inventory of the lighting system as well as the measurements of illuminance distributions on task areas in the interiors. On the ground of the results the levels of the average illuminance and illuminance uniformity on task areas in the interiors were calculated, analyzed and compared with the required values for this type of facility. The levels of the lighting installed power density and normalized power density in the interiors were calculated and analyzed either. Moreover, the installed power density and total annual energy density for the lighting system in the building were calculated. On the ground of the results the lighting energy efficiency for the analyzed building was stated. The results of the lighting conditions and its energy efficiency assessment are a reference to the planned in the further studies lighting proposals to improve the quality of the luminous environment in the interiors and energy standard in the dormitory.

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Keywords: Lighting technology; energy efficiency; visual comfort

Nomenclature

E	average maintained illuminance on the reference surface for the interior [lx]
U	illuminance uniformity on the reference surface for the interior [-]

* Corresponding author. Tel.: +48-22-234-75-05; fax: +48-22-234-73-53.
E-mail address: piotr.pracki@ien.pw.edu.pl

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A	floor area [m^2]
P	installed power for the lighting system [W]
P_D	installed power density for the lighting system [W/m^2]
P_N	normalized power density for the lighting system [W/m^2 per 100 lx]
E_{BUD}	weighted average maintained illuminance for the building [lx]
W_D	total energy density for the lighting system per year [kWh/m^2 per year]
W_{DB}	lighting energy density per year [kWh/m^2 per year]
W_{DT}	parasitic energy density per year [kWh/m^2 per year]
F_C	constant illuminance factor [-]
F_D	daylight dependency factor [-]
F_O	occupancy dependency factor [-]
t_D	daylight operation time for the lighting system [h per year]
t_N	non-daylight operation time for the lighting system [h per year]
t_Y	one standard year, taken as 8760 h
LEEC	Lighting Energy Efficiency Class for the building

1. Introduction

Mass residence buildings are designed for temporal residence of people living outside their homes. Students' dormitories are included in this group. There are about 500 dormitories in Poland and each year they become the "second home" for almost 140 000 young people. The decision to live in a dormitory used to be considered as an economical choice, however nowadays economy is not the main and only aspect of such decision. It means for young people that they have to accept the presence of non-relatives in their private lives, communicate with them and solve everyday problems. Variety of personalities is the bigger the more international the dormitory is. This experience helps the inhabitants to develop their social skills and has significant influence on their future as strong relationships originate from this period of life.

Dormitory plays an important role in life of their inhabitants – it is a place where they rest after long hours spent at the university, but also study and work on their projects etc. It means that the function of the interior is very complex as it has to obey different, sometimes opposite requirements. Comfort of life and work is determined by the environmental circumstances. The most important factors affecting comfort in interiors are temperature, humidity, quality of ventilation, air-conditioning, lighting and noise level[1].

Lighting is one of the environmental factors causing that people can perform their tasks effectively in comfort conditions. The main objective of the interior lighting, still reflected in the lighting standards[2], is to ensure people the visibility of tasks, objects and their surroundings, while providing visual comfort, which should also ensure safety to work conducted and stay in buildings. As for many years it was the primary goal, the research in interior lighting field was aimed at exploring the opportunities to fulfil these three human needs. At present, the reference in the design and assessment of interior lighting to these three human needs only is not sufficient. Lighting should be considered broader, to fulfil the human needs that are much more complex[3]. Good lighting promotes not only the expected visual performance[4] and comfort[5]. Lighting integrated with the interior architecture determines spatial perception and aesthetic judgment, the moods, emotions, interpersonal communication and behaviour of people[6]. It has a proven impact on safety, health and well-being of people[5,7].

In 2010 European Union decided that all new buildings ought to have consumption of energy on almost zero level. They will be nearly zero-energy buildings (nZEB) according to the EPBD[8]. This objective is to be accomplished in the beginning of 2021. Even sooner, since 2019, this target should be achieved in case of new buildings occupied and owned by public authorities.

As a response to this demand a research project started in Poland in 2015. Its aim is to develop methodology – including technology and financial aspects – of modernisation of public buildings to the nZEB standard. The applicability of developed universal methodology will be verified on the example of two case studies. Both buildings were constructed in different periods of time and as a result various technologies and installations were used. They were also designed for different purposes. The project will include also extensive educational campaign devoted to