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POWER SYSTEMS AND POWER ELECTRONICS

Analysis of residential lighting in Poland: results from a winter term survey

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Abstract. In 2020, an international project on residential lighting started and was implemented in four countries (Poland, Sweden, UK and Turkey). This article presents the results of a survey carried out in Poland, in the winter term between November 2020 and January 2021. A total of 125 Polish residents (59 women, 65 men, one person did not wish to specify gender) participated in the survey. A variety of data was collected on the respondents and their assessments as well as on their satisfaction with day- and artificial lighting in residential living spaces. The results from questionnaires were analyzed with STATISTICA 13.3. Descriptive statistics and Spearman rank order correlations were adopted to identify the light-related aspects, lighting patterns, and respondents' perception of day- and artificial lighting conditions in living areas. The results revealed that satisfaction with daylighting in the living area, both in summer and winter, was significantly correlated with daylighting level, daylighting uniformity, sunlight exposure and view-out. The results also revealed that satisfaction with artificial lighting was significantly correlated with artificial lighting level, artificial lighting uniformity and color rendering. The results provide valuable information on lighting and factors that influence the luminous environment in residential living spaces.

Key words: lighting technology, interior lighting, residential lighting, daylighting, artificial lighting, survey.

1. INTRODUCTION

Having a shelter is one of the basic human needs. In many societies, an apartment, which is considered the highest good, is used as housing. Apart from satisfying basic living needs, safety and family development, during the COVID-19 lockdown, the apartment was used as a place of work and study for many people [1]. Residential interiors' design had been neglected for a long time, unlike other interiors, until the COVID-19 outbreak forced millions of people to respect lockdowns, self-isolation and quarantines [2]. A significant extension of the time that people spend in their apartments [3] may change the perception of the living space by the inhabitants and result in the need to adapt the space to the new situation [4].

Environmental quality in interiors affects the health, wellbeing, satisfaction and behavior of users [5–7]. The main factors determining the quality of the environment in interiors are air quality [8] as well as thermal [9], acoustic [10] and luminous comfort [11]. Indoor environmental quality covers many issues such as analysis of indoor conditions and de-termination of the desired conditions [12], methods of their implementation [13], energy efficiency and impact on the natural environment [14] as well as cost of solutions [15]. It also includes the interaction between humans, society and the environment [16].

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Luminous comfort in interiors depends mainly on lighting conditions [17]. The minimum requirements for lighting conditions in interiors are defined by standards and other legal acts, international and national ones, e.g. [18, 19]. Implementation of lighting systems in interiors following the normative requirements should ensure the safety of users and enable them to conduct visual tasks effectively and comfortably. However, creating habitable interiors for people goes beyond the implementation of standards. It requires taking into account the recommendations resulting from good practice, often covering individual needs [20, 21]. In residential spaces, special care should be taken to ensure that the living area meets the individual needs and preferences of the users.

Various issues are taken up in research on residential lighting. Ticleanu [22] discussed the main areas of concern related to residential lighting, and outlined general recommendations to limit detrimental effects and contribute to good health. A systematic review of scientific literature by Osibona *et al.* [23] indicated that residential lighting can negatively affect health, but the current evidence base is limited to a small number of studies. Thus, further research was indicated.

Mitra *et al.* [24] used 12 years of the American Time Use Survey (ATUS) data to develop typical occupancy schedules for a range of US household types and occupant ages. The data were compared to utilize occupancy schedules and in many cases the developed schedules exhibited similar patterns, however, differences were also found for certain periods. The spatial-temporal distribution of occupants in residential buildings varied based

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on temporal and demographic factors such as age and the number of occupants, which indicates a need for further research on residential lighting.

Xue *et al.* [25] investigated the effects of daylighting and human patterns on subjective luminous comfort in Hong Kong housing units. The results based on 340 questionnaires confirmed that the degree of luminous comfort was most affected by satisfaction with daylighting. External obstruction was the major physical factor affecting luminous comfort, while the perception of uniformity was the major factor of residents' feelings toward daylight. The use of artificial lighting was the most relevant behavior factor affecting luminous comfort, as using artificial lighting per day indicates poor daylighting conditions and decreased luminous comfort.

Bournas and Dubois [26] studied the effect of room orientation and function on daytime electric lighting use in Swedish multi-dwelling buildings. The results based on a questionnaire survey conducted in 75 apartments indicated that electric lighting use did not vary significantly among occupants living in west-oriented rooms of similar geometry. West-oriented rooms used electric lighting less frequently as compared to rooms of other orientations. Moreover, it was highlighted that daytime electric lighting usage was more frequent in kitchens and it was associated with specific design features, not with room function by itself.

Gerhardsson *et al.* [27] investigated the prospects of introducing a personalized LED technology to Swedish home lighting. The results were based on 536 questionnaires that showed that the costs of energy-efficient lamps had little effect on consumers' lamp choices, and that the degree of consumer acceptance of LED lamps increased without resulting in increased lighting use. Besides the individual characteristics, situational factors, such as indoor built home environment and the availability of lighting, products influenced residents' home lighting and visual comforts. Not only LED technology but also sensor and control technology [28], wearable technology and IoT [29] have been increasingly used in residential lighting lately to meet the diverse needs of the residents.

It seems reasonable to conduct a large-scale study on residential lighting, taking into account many aspects related to this issue. A good starting point for such a study is to collect a large amount of data on residents and their activities, architectural and lighting solutions in apartments, and their perception of lighting. Analysis of such data should allow to capture the prevailing trends and look at the problems from the COVID-19 perspective as it was then that the use of residential living spaces has significantly increased.

This article presents the results of research conducted as part of an international project carried out in four countries: Poland (Central Europe), Sweden (Northern Europe), UK (Western Europe), and Turkey (Western Asia). During the first, pilot stage of the research, carried out in July–August 2020, the results of surveys were collected from 60 people, preliminary analyzes of lighting in residential living areas were made, and the consistency of the survey was assessed [30]. The second stage of the research, in which 500 people took part, concerned the identification and comparison of lighting solutions and conditions in residential living areas in the four countries and was carried out in the winter period, i.e. November 2020 – January 2021 (shortest days in the year) [31].

This article presents the results of the second stage of our research, detailing the results for Poland. The three goals of this study were:

- to assess systems used for day- and artificial lighting in residential living areas in Poland where inhabitants spent the most time during the day,
- to assess the subjective perception of day- and artificial lighting quality of residential living areas in Poland,
- to assess correlations between satisfaction with day- and artificial lighting quality and lighting features of residential living areas in Poland.

This knowledge can prove useful in:

- identifying typical day- and artificial lighting systems and how they can be used in residential living areas in Poland,
- determining preferences regarding day- and artificial lighting quality in residential living areas in Poland,
- developing recommendations for day- and artificial lighting in residential living areas in Poland.

2. METHOD

The completion of the research objectives required developing a questionnaire and procedure for conducting a survey, as well as collecting and analyzing the results.

2.1. Survey

The research questionnaire, developed and verified by our team, contained 47 items related to various aspects considering the respondents and their residential living spaces. The items can be grouped as follows:

- Personal data;
- Basic house data;
- Basic apartment data;
- Characteristics of the living area;
- Activities in the living area;
- Daylighting and satisfaction with its quality in the living area;
- Artificial lighting and satisfaction with its quality in the living area;
- Light-related adjustments and changes;
- Smart/sustainable solutions and awareness of national policies about lighting;
- Comments and information on survey completion and content.

The survey in Poland was distributed online via e-mail invitations and/or cross-platform messages, through a web-based survey tool offered by Google. The questionnaire was in the Polish language and available for participants between November 2020 and January 2021. Detailed information on questions included in the questionnaire and procedure of conducting the survey can be found in articles [30, 31].

2.2. Participants

The respondents were users of residential buildings who resided in Poland and who could provide comprehensive insight into lighting conditions. The survey conducted in Poland reached 125 people, including 59 women, 65 men and one person preferred not to state their gender. Among the respondents, there were people from the following age groups: 18–24 years: 22.4% of cases, 25–34 years: 25.6% of cases, 35–44 years: 28.8% of cases, 45–54 years: 12.8% of cases, 55–64 years: 1.6% of cases and over 65 years of age: 8.8% of cases. The respondents were mainly people with higher education in 85.6% of cases, and the monthly income of the respondents' families exceeded the national average in 57.6% of cases. In the survey conducted in Poland, mostly people from cities participated, to a large extent from Lower Silesia and Mazovia regions. The respondents lived mainly in blocks of flats in 63.2% of cases, but also in terraced houses in 25.6% of cases and detached houses in 11.2% of cases. In 51.2% of cases, the inhabited buildings were built after 1990. The area of almost 2/3 of the respondents' apartments/houses did not exceed 100 m^2 (the average floor area of the apartment/house was 97 m^2; MIN = 26 m^2, MAX = 320 m^2, SD = 59.5 m^2).

2.3. Statistical analysis

Data on quantitative and qualitative characteristics were collected in the survey research. Analysis of the results covered:

- determination of basic descriptive statistics, including presentation of the results in the form of histograms,
- determination of correlation coefficients using Spearman rank order correlation (1) between day- and artificial light related aspects and satisfaction with day- and artificial lighting quality in the interiors,
- presentation of selected light-related adjustments that had been done, and potential changes.

Statistical analysis was performed using STATISTICA 13.3.

$$\rho = 1 - \frac{6\sum d_i^2}{N\,(N^2-1)}\,, \tag{1}$$

where d_i is the difference between paired ranks, and N is the number of row instances.

3. RESULTS

The results refer to the living areas where the respondents spent the most time during the day. The results are presented in 4 subsections named as per the living area characteristics and main activities conducted by the respondents (Subsection 3.1), daylighting aspects (Subsection 3.2), artificial lighting aspects (Subsection 3.3) and other aspects (Subsection 3.4).

3.1. Living area and activity

The respondents provided information on their living area sizes, ceiling, walls, floor and furniture colors, occupation time per day, and main activities. The average floor area of the living area was 21.5 m^2 (MIN = 6 m^2, MAX = 60 m^2, SD = 9.5 m^2) and in 97.6% of cases, the floor area was not larger than 40 m^2 (Fig. 1a). In 95.2% of cases, height of the living area did not exceed 4 m (Fig. 1b).

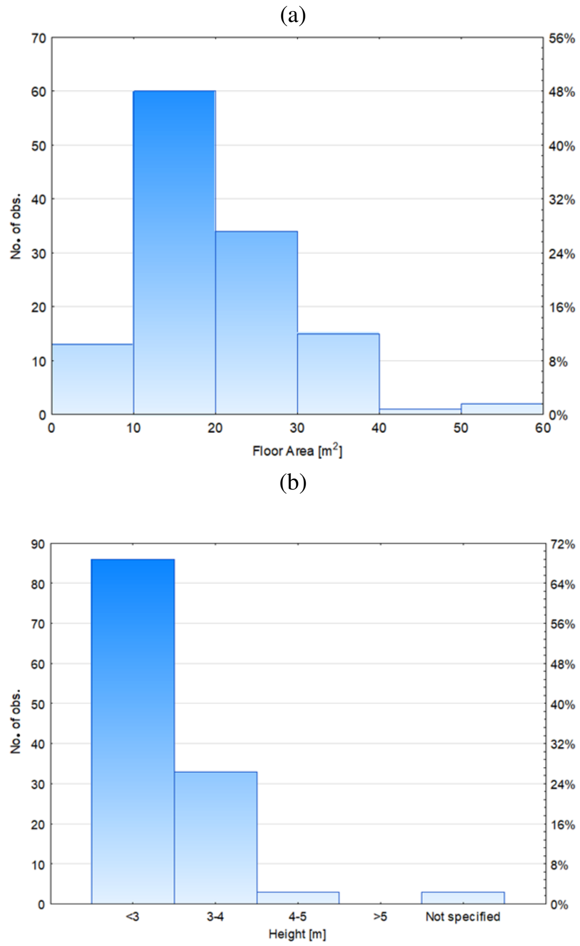

Fig. 1. Histograms presenting (a) floor area and (b) height of the living area

Dominant colors in the living area were:

- for ceiling: white in 95.2% of cases (also gray and brown – a few instances of each);
- for walls: white in 48.8% of cases and gray in 23.2% of cases (also yellow, green, orange and brown – a few instances of each; also red, blue and purple – one case of each);
- for the floor: brown in 64% of cases, gray in 12.8% (also yellow, orange and willow-green – a few instances of each; also, white and blue – one case of each);
- for furniture vertical surfaces: brown in 44% of cases, white in 22.4% of cases, and gray in 10.4% of cases (also orange, yellow, black and red – a few instances of each). In more than 40% of cases, the interiors were occupied for more than 8 h per day (Fig. 2a). Main activities performed in the living areas were working with computers in 60% of cases, and mostly resting and watching TV in 28.8% of cases (Fig. 2b).

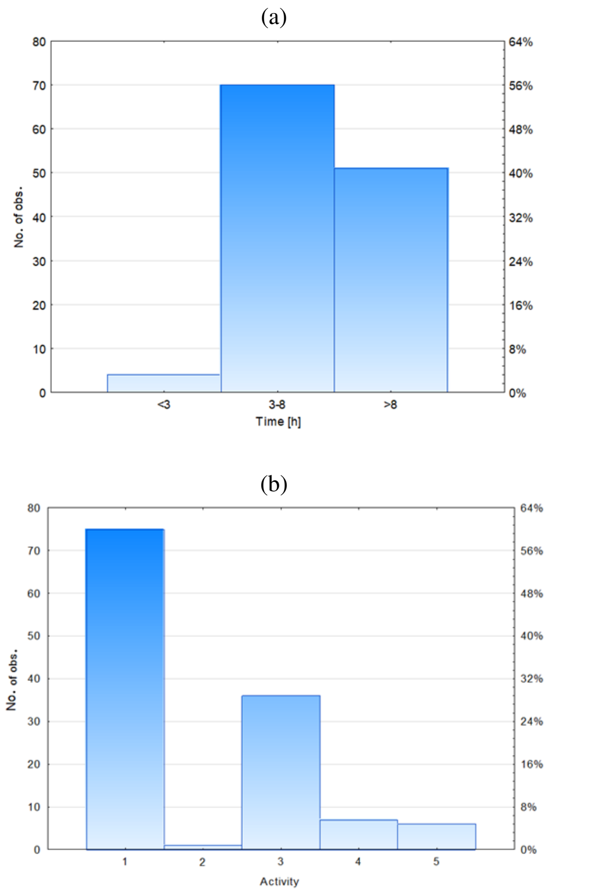

Fig. 2. Histograms presenting (a) occupation time and (b) main activities in a day in the living area. (Main activities: 1 – working with computer, 2 – reading or writing but without a computer, 3 – mostly resting and watching TV, 4 – mostly resting but without TV, 5 – other)

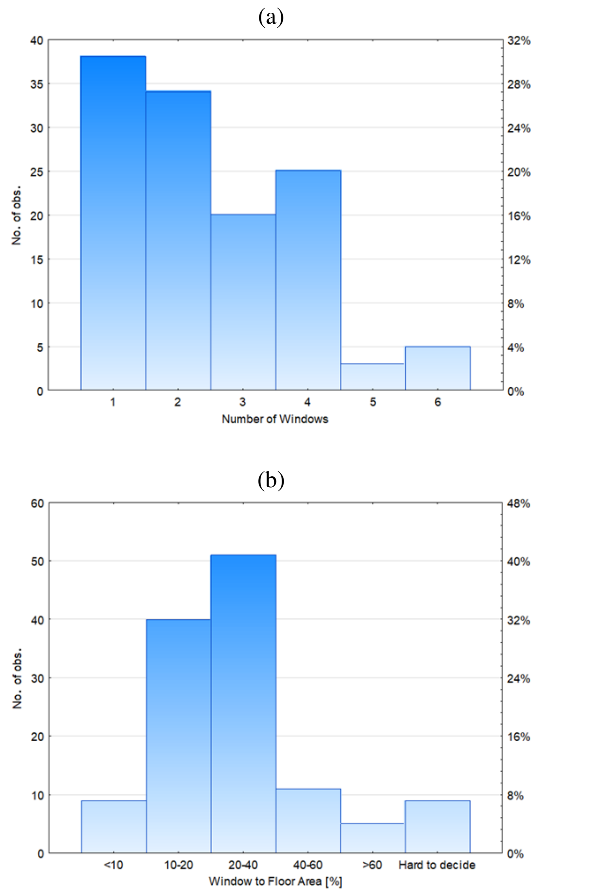

Fig. 3. Histograms presenting (a) the number of windows and (b) window-to-floor area ratio in living area

3.2. Daylighting

All living areas had access to daylight through windows located on the walls or roof. Interiors with windows on the walls predominated. They were located: on one wall in 64% of cases, on two walls in 24% of cases, and on more than two walls in 7.2% of cases. Only in two cases interiors had roof windows and in four cases they had both roof and wall windows. Windows' orientation varied. In about 30% of cases, the windows were south directed and in a similar percentage of cases, the windows were west directed. In about 20% of cases, the windows were east directed, and the smallest share (about 15% of cases) was obtained for the windows facing north.

The respondents provided information on the number of windows in their living areas (Fig. 3a) and estimated the percentage of window area to the overall floor area of the living area – the window to floor area ratio (Fig. 3b). In about 40% of cases, the window to floor area ratio in the living area was lower than 20%. Also, in about 40% of cases, the window to floor area ratio was 20–40%.

The respondents also assessed the overall view-out through the windows in their living areas. There was no situation in which the respondents could not see the skylight at all through their windows. In 28.8% of cases, the view of the skylight through the windows was not obstructed at all, in 40% of cases, there were some obstructions, but mostly skylight was seen through the windows, and in 31.2% of cases, the buildings and other objects obstructed view-out heavily.

The respondents estimated the time of direct sunlight penetration in the living area in winter and summer (for summer, they provided answers based on their previous experience) (Figure 4a). In the living areas, the use of shading devices was common (not used in seven cases only). The most popular shading devices used were as follows: curtains in 40.7% of cases, blinds in 40% of cases and louvres in 13.3% of cases. The degree and purpose of shading devices usage showed variance. Despite the widespread use of shading devices, they were usually not drawn at all in 40% of cases in summer and 69.6% of cases in winter (Figure 4b).

The main reasons for using the shading devices in summer were according to the pilot study [30]: to prevent direct sunlight penetration in 36.3% of cases, to obtain privacy in 24.2% of cases, to prevent heat in 15.9% of cases and to decorate in 15.4% of cases. However, the main reasons for using the shading devices in winter were: to obtain privacy in 46.5% of cases, to decorate in 30.3% of cases and to prevent direct sunlight penetration in 12% of cases.

The respondents also rated two characteristics considering daylighting conditions in their living areas: level and unifor-

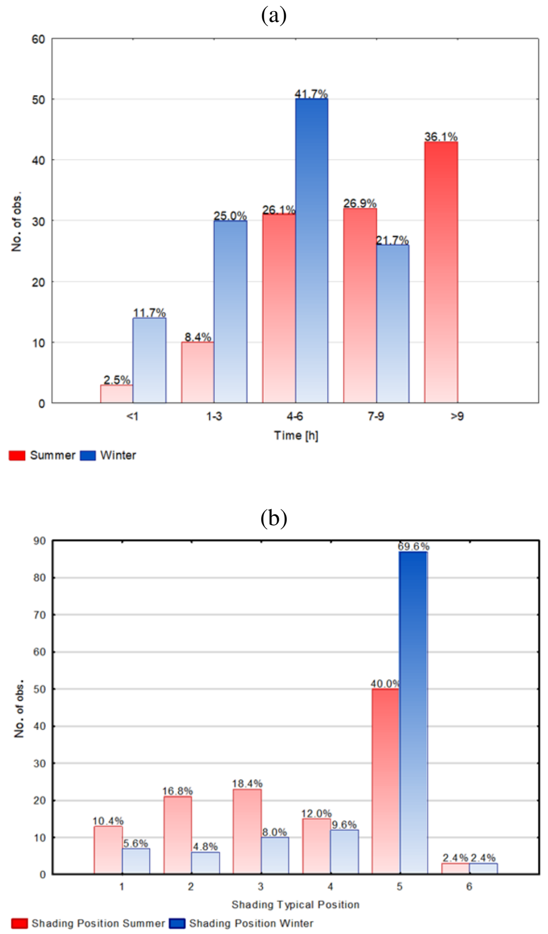

Fig. 4. Histograms presenting (a) the pattern of direct sunlight penetration time and (b) shading device's typical position in living areas for winter and summer. (Typical shading device's position: 1 – all drawn, 2 – usually drawn by more than a half, 3 – usually drawn by a half, 4 – usually drawn by less than a half, 5 – usually not drawn, 6 – not applicable, no shading devices)

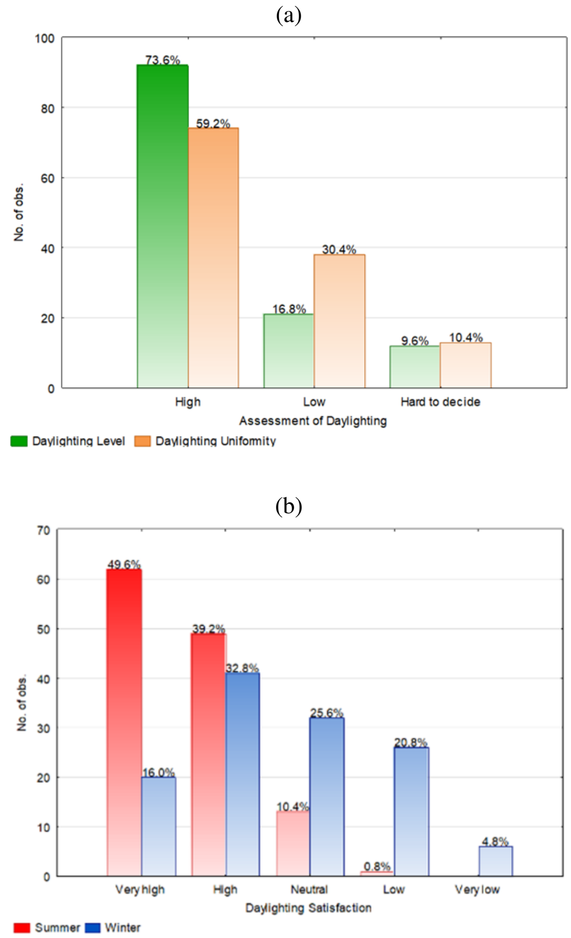

Fig. 5. Histograms presenting (a) assessment of daylighting level and uniformity and (b) satisfaction with daylighting quality in living areas in summer and winter

mity of daylighting (Figure 5a), as well as satisfaction with daylighting quality in their living areas in summer and winter (Figure 5b). In general, the respondents rated both the daylighting level (73.6% of cases) and also day-lighting uniformity (59.2% of cases) as high. It can clearly be seen that satisfaction with daylighting is much higher in summer based on their previous experience. In 88.8% of cases in summer and 48.8% of cases in winter, satisfaction with daylighting was rated at least high. In about 25% of cases in winter, satisfaction with daylighting was rated low or very low.

Spearman rank order correlations were adopted to find the most important factors influencing satisfaction with daylighting. Correlations between the dependent variables (satisfaction with daylighting in summer and satisfaction with daylighting in winter) and independent variables (daylighting level, daylighting uniformity, sunlight exposure and view-out) are presented in Table 1. Moderate and positive correlations were found for daylighting quality satisfaction in winter with daylighting level ($r = 0.595453$; $p < 0.01$) and with daylighting uniformity ($r = 0.607844$; $p < 0.01$). Also, positive correlations were noted for daylighting quality satisfaction in summer with daylighting level – moderate ($r = 0.506694$; $p < 0.01$), and with daylighting uniformity – low ($r = 0.466681$; $p < 0.01$). There were low and negative correlations between day-lighting quality satisfaction in both summer and winter with sunlight exposure ($r = -0.309996$; $p < 0.01$ for summer, and $r = -0.262434$; $p < 0.01$ for winter). Finally, there were also low but positive correlations between daylighting quality satisfaction in both summer and winter with view-out ($r = 0.215588$; $p < 0.05$ for summer, and $r = 0.290867$; $p < 0.01$ for winter).

Table 1
Correlations between daylight related aspects and satisfaction with daylighting quality in the interiors in Poland

	Daylighting level	Daylighting uniformity	Sunlight exposure	View-out
Satisfaction in summer	0.506694^{1}	0.466681^{1}	-0.309996^{1}	0.215588^{2}
Satisfaction in winter	0.595453^{1}	0.607844^{1}	-0.262434^{1}	0.290867^{1}

$N = 125$; $^{1}p < 0.01$; $^{2}p < 0.05$.

3.3. Artificial lighting

Ceiling luminaires were used mostly for artificial lighting of the living areas (about 45% of the luminaires used), and with about 20% of cases it was the only source of illumination. Desk or floor portable luminaires also had a large share, almost 40% of the luminaires used, in living area illumination. About 10% of the luminaires used were the wall mounted ones and in the remaining cases, cove lighting systems were used. About 25% of respondents used at least 3 types of luminaires in the living area.

The respondents used different light sources for artificial lighting in the living areas (Fig. 6a). Almost 80% of respondents had at least one LED lamp in their rooms, and in about 50% of cases it was the only type of light source. The time of using artificial lighting in the rooms was significantly different in summer and winter (Fig. 6b). In 70.8% of cases, in summer the artificial lighting was used for no more than 3 hours per day. In winter, artificial lighting was used for more than 7 hours per day in 62.3% of cases.

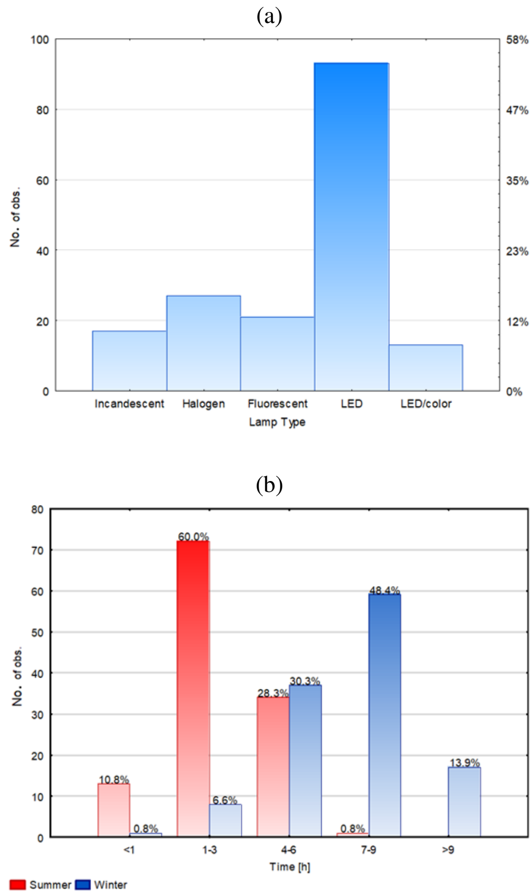

Fig. 6. Histograms presenting (a) types of artificial light sources used and (b) time of using artificial lighting in the interiors in summer and winter

In artificial lighting of the interiors, the use of warm-white light was predominant and was used in 71.2% of cases, although the use of neutral white light had also a significant share and was used in 22.4% of cases (Fig. 7a). Almost 70% of the respondents considered that the colors of furniture, paintings, etc. were rendered properly when the rooms were lit with artificial lighting, and only 3.2% assessed this feature as low (Fig. 7b). Almost 70% of respondents rated that lamps in the interiors were too bright, causing discomfort.

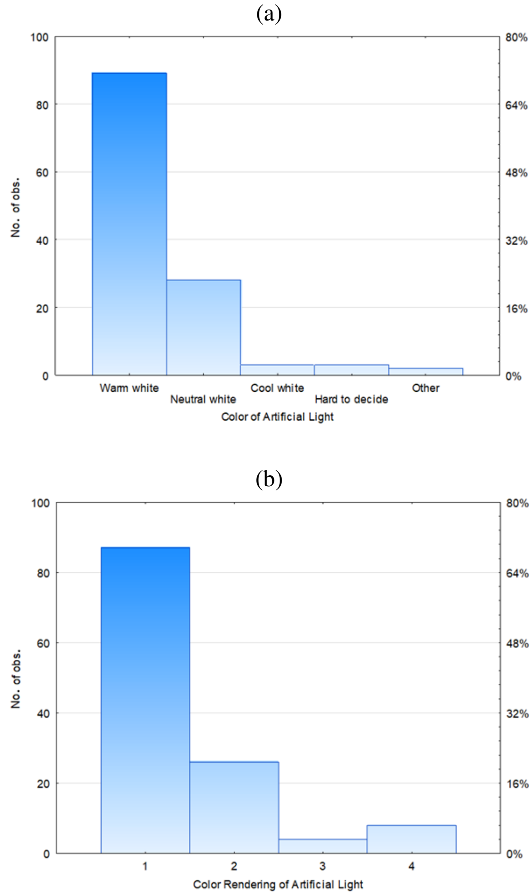

Fig. 7. Histograms presenting (a) color and (b) color rendering of artificial light. (Color rendering: 1 – colors are rendered properly; 2 – some colors do not seem natural; 3 – colors are not rendered properly; 4 – hard to decide)

The respondents also rated the level and uniformity of artificial lighting (Fig. 8a), as well as satisfaction with artificial lighting quality in their living areas (Fig. 8b). In general, the respondents rated both the artificial lighting level (82.4% of cases) and artificial lighting uniformity (55.2% of cases) as high. Considering satisfaction with artificial lighting quality in the living area, more than 75% of respondents rated it at least as high.

Spearman rank order correlations were adopted to find the most important factors influencing satisfaction with artificial lighting. Correlations between the dependent variable (satisfaction with artificial lighting) and independent variables (artificial lighting level, artificial lighting uniformity and color rendering) are presented in Table 2. Artificial lighting quality satisfaction had the moderate and positive correlation with artificial lighting level ($r = 0.528499$; $p < 0.01$). There were also positive but low correlations between satisfaction and both artificial lighting uniformity ($r = 0.315704$; $p < 0.01$) and color rendering ($r = 0.309413$; $p < 0.01$).

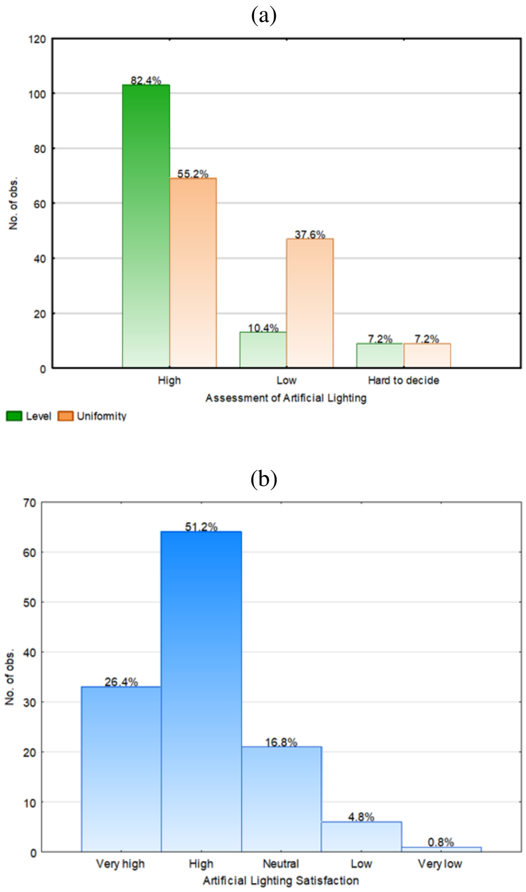

Fig. 8. Histograms presenting (a) assessment of artificial lighting level and uniformity and (b) satisfaction with artificial lighting quality in living areas

Table 2
Correlations between artificial light related aspects and satisfaction with artificial lighting quality in the interiors in Poland

	Artificial lighting level	Artificial lighting uniformity	Color rendering
Satisfaction	0.528499	0.315704	0.309413

$N = 125$; $p < 0.01$.

Finally, the respondents indicated their methods of selecting artificial lighting for their rooms. Most often, the selection of artificial lighting was intuitive (33.8% of cases), but also based on having knowledge in the field of lighting (26.5% of cases) or on information from catalogs and the internet (9.9% of cases). In 20.5% of cases, the respondents had no chance to decide on an artificial lighting system because it was pre-installed. The most often indicated priorities when choosing artificial lighting were: light color (19.1% of cases), power and amount of light (18.9% of cases), lighting energy efficiency (16.3% of cases), aesthetics (14% of cases) and function (13.6% of cases). To a lesser extent, the choice of artificial lighting was caused by cost (7.6% of cases), color rendering (6.7% of cases) and brand (3.4% of cases).

3.4. Other results

The survey results also showed that:

- 13% of respondents had smart lighting control systems,
- 75.2% of respondents considered sustainable solutions while selecting lighting,
- 20% of respondents were aware of national policies about lighting.

In open-ended questions, the respondents reported day- and artificial lighting adjustments they had introduced and effectively used. They also indicated day- and artificial lighting changes they would do if they could design lighting from the beginning. Selected adjustments and changes are presented in Table 3.

4. DISCUSSION

Respondents of diverse ages and gender, but mainly people with higher education and living in cities, participated in the survey conducted in Poland. Many participants had knowledge in the field of lighting, as evidenced by the fact that 26.5% of respondents used their knowledge to select artificial lighting for their interiors. When analyzing the results for Poland, the demographic characteristics of people participating in the survey should be kept in mind.

As many as 96.8% of respondents stayed in the considered living areas for at least 3 hours a day and 40.8% of respondents occupied them for more than 8 hours a day, which is a very high rate and indicates a good understanding of the physical conditions in the interiors. A strong trend can be noticed in the colors used in the living areas. In fact, 3 colors dominated: white, brown, and gray, with white dominating for the ceiling and walls and brown for the floor and furniture. The use of gray color for walls, but also for floors and furniture, was also common.

Access to daylight in the analyzed interiors varied, as evidenced by the distribution of the wall to floor area ratios (Fig. 3b) and information about obscuring the sky view from the windows by neighboring objects. Taking into account also the different orientations of the windows, the respondents described very different daylighting conditions in the living areas. The respondents assessed the level of daylighting in the rooms as very high, but also its uniformity was appreciated (Figure 5a). It was also possible to capture the seasonal difference in the assessment of direct solar penetration (Fig. 4a) and the satisfaction with daylighting quality (Fig. 5b), as well as to distinguish factors significantly correlating with the satisfaction with daylighting in the interiors (Table 1). The results on seasonal difference in the degree of shading devices use (Figure 4b) and the reasons for their use (in summer, first to prevent direct sunlight penetration but also to obtain privacy, and in winter, first to obtain privacy but also to decorate) were also interesting. The main adjustments on daylighting in the rooms concerned the installation of shading devices or their replacement with other ones. The reported potential changes indicated that the respondents noticed an insufficient level of daylight in the rooms (Table 3).

Table 3
Selected light-related adjustments that had been introduced and were effectively used and changes that would be done if the respondents could design their living areas from the beginning

Light-related adjustments (introduced)	Light-related changes (potential)
Mounted blinds/louvres Mounted special curtains ensuring privacy and considerable daylight level Blinds changed to louvres Louvres changed to blinds	Enlarging windows Adding windows Changing windows shape Changing building/windows orientation Removing outer objects to let more daylight in
Conventional incandescent lamps changed to halogen lamps, fluorescent lamps or LEDs Halogen lamps changed to LEDs LEDs changed to brighter light sources Lamps changed from warm-white to neutral light Mounting lamps with warm-white light Mounting RGB LED lamps Adding more luminaires Adding desk/floor/night luminaires Adding point luminaires for pictures Changing one ceiling luminaire to few luminaires Changing ceiling lighting to cove lighting Changing luminaire to one providing narrow light Mounting point lighting Mounting line lighting Mounting general wall lighting Mounting electric tracks and halogen lamps Mounting energy-efficient artificial lighting Limited artificial light level Mounting remote control for general lighting Mounting control system to regulate light level Preparing more electric points for luminaires Separating electric circuit into two circuits for luminaires	Installing LED lighting properly arranged Adding LED stripes Adding LED lighting with control Adding more luminaires on ceiling Adding portable luminaires New/changing luminaires layout Increasing light level Changing color of light Improving color rendering More natural lighting Improving wall lighting for aesthetics Increasing ceiling lighting Limiting ceiling lighting Controlling ceiling luminaires Mounting point, wall lighting Improving aesthetics of luminaires Changing luminaires to modern ones Various and controllable lighting Separating luminaires for better control Mounting electric tracks for luminaires Increasing indirect lighting Luminous ceiling with color of light changing Changing local lighting to general one

Ceiling systems, applied in about 45% of cases, were most commonly used for electric lighting of the respondents' rooms, but desk or floor portable luminaires had a similar share. The most frequently used light sources were LEDs, and the share of incandescent, halogen and fluorescent lamps was on the level of 20% for each type (Fig. 6a). Strong preference of the respondents in the use of warm-white light (Fig. 7a) and the use of light sources that correctly render the colors of the illuminated objects were also reported (Fig. 7b). A very clear, seasonal difference in the use of electric light for room illumination was also captured (Fig. 6b). The respondents, as in the case of daylighting, assessed the level of artificial lighting as very high and its uniformity as quite high (Fig. 8a). Satisfaction of the respondents with the quality of artificial lighting in the interiors was high (Fig. 8b), although it did not reach the level of satisfaction with daylighting in summer. As in the case of daylighting, the factors significantly correlating with satisfaction with artificial lighting quality were the level and uniformity of artificial lighting, but also color rendering (Table 2). The main adjustments, but also potential changes in artificial lighting, concerned replacing light sources with LEDs, adding more or other types of luminaires, and using lighting control.

5. CONCLUSIONS

As part of final concluding remarks, it was found out about the significant impact of daylighting level and uniformity, view-out through the windows and direct sunlight exposure on satisfaction with daylighting quality in the living area, both in the summer (results both from the pilot study [30] and self-estimations of the participants of the current survey) and winter. Artificial lighting level and uniformity, and color rendering had a significant impact on satisfaction with artificial lighting quality in the living area. The correlations between satisfaction and light-related aspects in the living area were moderate or low.

The presented results are of high cognitive value, and they can serve as a reference for other research on this topic, but also in continuing our study. Future research directions may be related to:

- observing more diverse population in terms of place of residence and education,
- repeating the same survey in the summer term with 125 people and checking if the obtained results are consistent with the results obtained from the winter term study,
- extending research on satisfaction and studying preferences with day- and artificial lighting in residential living spaces.

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