AN INVESTIGATION BY THE BEP-TR METHOD OF THE EFFECT OF OBSTRUCTION ANGLE PARAMETER ON LIGHTING ENERGY PERFORMANCE AND DAYLIGHT SUPPLY

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ABSTRACT

Following the EN 15193, 2008 Energy Performance in Buildings Regulation in the European Union Member States, a comprehensive calculation can be made on lighting energy performance and daylight effect. This improved model accounts for Turkey's "BEP-TR" ("Regulation on Energy Performance in Buildings"). In the present study, the effect of the obstruction angle parameter of buildings on lighting energy consumption and daylight provided is examined through a sample hotel project by the BEP-TR calculation method. This study investigates the effect of daylight on lighting energy performance alternatives that were produced according to the height, building distance variations (causing obstruction angle), and the correlation between annual lighting consumption values, daylight supply factor, and obstruction parameters. Accordingly, the current study aims to develop a method to assist zoning regulations, building intervals, and height decisions by determining specific ratios between obstruction parameters, daylight supply factor and lighting energy consumption values. Results of this study clearly show that obstruction parameter variables affect both the daylight supply factor and annual lighting energy significantly.

KEYWORDS

building energy performance, EN 15193, BEP-TR, daylight, site plan

1. INTRODUCTION

In Turkey, where most of the imported and fossil resources are used in electrical energy production, studies on the efficient use of electrical energy have gained importance worldwide in the recent years. EU countries have performed various studies to determine the energy performance of buildings and published the Energy Performance Regulation in Buildings (2002/91 / EC) in 2002 [1]. In continuation with this, EN 15193: 2008 Energy Performance in Buildings, Lighting Energy Requirements standards have been published for the calculation of lighting energy.

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In this standard, the lighting energy requirement of a building can be calculated by using various variables such as the amount of daylight used by the volume, the lighting systems including lamps, devices, control systems, and the geographic location where the volume is located [2].

The building energy performance national calculation method "BEP–TR," prepared based on the directive of building energy performance in Turkey and EN 15193:2008 standard, offers a calculation model that has been developed for the conditions of Turkey. The calculation of lighting energy performance in buildings can be achieved by this method [3]. In this study, the BEP-TR lighting calculation method developed by the Ministry of Public Works and Settlement in Turkey is implemented for a case hotel building situated in Kayseri, Turkey.

2. PROBLEM AND RESEARCH

Although the effect of daylight on energy performance has been the main subject of studies for many years, it has been evaluated by different methods. While some of the studies deal with the parameters affecting the daylight only, other studies show a holistic approach.

In their study, Fang and Cho (2019) propose a building performance optimization process that can assist in simultaneously evaluating daylight and energy performance of design options for a building and producing an optimized design. To test and verify the effectiveness of the optimization process, the study is performed in a small office building with a single-store pitched roof. Nine design variables such as building depth, roof ridge location, span width, span length and location, south window width, louver length, north window width, and opening direction in building geometry, which play a role in the building's daylight supply, are discussed. In this study, after the optimization process, daylight performance is found to be increased, and it is proposed that this process should be applied to more complex design projects for future studies [4].

Acosta et al. (2016) emphasized the importance of window design that will create an excellent visual comfort effect for the users and is the determining factor in saving energy in lighting energy. The research aims to measure these variables in a residential area for different window typology and to analyze the results obtained. For different locations and directions of the window, daylight supply, and energy-saving analyses were performed in a residential room. As a result of the research, the proportions of the facade openings, and the energy savings made accordingly were shown [5].

A study by Greenup et al. (2001) reveals that thermal models that include simplified daylight calculations of a building and calculation of the annual energy performance should be associated with sky conditions. However, it has been found that thermal and lighting modeling or energy modeling programs for a house are insufficient to properly examine buildings in terms of both thermal and visual comfort [6].

As a result of interactions between lighting and HVAC, in their study, Alhagla et al. (2019) wanted to provide guidance on reducing energy consumption and to increase sustainable building designs in Egypt by balancing beneficial natural light and extreme solar heat. They dominated the thermal heat gain and reduced the cooling load as energy consumption and aimed to determine the optimal glazing by researching six glazing types that can lead to energy saving by using simulation techniques to determine the most efficient glass type with a good WWR and a functional daylight autonomy [7].

Ihm.et al. (2009) use a simplified analytical method to evaluate the potential of daylight to save energy use associated with artificial lighting. Notably, the effects of various building geometry, window size, and glass type combinations on the daylight performance are investigated for the US and other locations. To estimate the reduction in total lighting energy use from daylight with dimming controls for office buildings, Ihm and colleagues developed and validated a simplified calculation method. It has been discovered that using a dimming control strategy can achieve up to 60% energy savings per year. It is observed that significant savings can be made, especially when using daylight saving control for an environment where natural light is fully supplied [8].

Krarti et al. (2005) present an analytical method in their study to save energy associated with using artificial lighting and to evaluate the potential of daylight. They investigate the effects of various building geometry, window size, and glass type combinations on daylight performance for four geographic locations in the United States. Four building geometries and different glazing types with different transparent/opaque surface areas were analyzed. As regards the reduction of annual lighting energy consumption, a direct relationship has been established between the glass transmittance and the window area. It has been demonstrated that the apparent permeability of the window and the brightness of daylight, which is defined as the product of the transparent/opaque surface ratio of the window, have a significant effect on energy savings from daylight [9].

Mavromatidis et al. (2013) discuss daylight problems in housing and other buildings and respond to providing the increasing needs of employees regarding welfare and visual comfort and natural light in volumes. In the early design phase, many simulation scenarios were used for daylight factor estimation, regarding the size of the glass area, materials, and opacities [10].

In the research of Zinzia et al. (2015), the energy requirements are tested for the lighting of a standard office building with a comprehensive method that considers the EN 15193:2007 Building Energy Performance Standard Calculation method. In this study, the variability of the EN standard daylight factor parameter is investigated by comparing the energy performance of the office building based on daylight intake in three different cities. [11].

In a survey-based study by Xue et al., external obstruction is considered as a key physical factor affecting luminous comfort conditions [12]. A previous study by Sabry et al. investigates the daylighting performance of a residential unit facing diverse external obstruction scenarios as well as the diverse reflectance of the external surface of the neighboring buildings are also considered. Obtained results of this study show that daylighting performance is directly related with external obstruction parameters [13]. In another study, the geometrical changes in the obstructions and their impact on the conditions of daylighting and views are investigated, and it is determined that obstruction distances are found effective at improving the conditions for views and daylighting in the perimeter blocks as well as solar radiation [14].

Lu and Du (2019) investigated the daylighting availability within buildings of a highly dense residential urban area under a cold climate in north-east China and obtained findings based on innovative simulations by using climate-based daylight modelling, three typical urban layouts are assessed according to vertical daylight illuminance at the building facade. Due to the comprehensive analysis of daylighting potential results, a direct relationship is observed between daylighting potential, urban forms, and climate conditions [15]. A similar study by Abidi and Rajagopalan (2020) investigates the daylighting conditions in apartment buildings for a dense environment in Melbourne's central business district and obtained simulation and field measurement results that show daylighting levels are insufficient in one third the investigated apartments due to the presence of deep floor plates and external obstructions.

As a result of the research and articles examined, it is seen that many studies have been carried out to reduce energy performance while benefitting from daylight. Notably, the effects of the volume of the obstructions affecting the daylight of a volume for EN 15193: 2008 standard, the geographical conditions, the dimensions of the windows, the location, the type of glass used in the windows and the transparency of these windows have been tested by many methods. It has been demonstrated that these parameters significantly affect lighting energy performance.

In the literature, no studies have been found on the effect of distance and height variables of obstruction parameters on lighting energy performance, and the impact of existing buildings in the urban environment or the building intervals and heights planned in the zoning plan on daylighting. In the present study, the effect of the variability of the obstruction parameter on daylighting and the lighting energy consumption is examined through a sample building to establish a correlation between the obstruction parameter, annual lighting energy consumption and daylight supply availability.

3. PURPOSE AND METHOD

The BEP-TR lighting calculation method, EN 15193: 2008 standard has been developed in accordance with the conditions in Turkey. This calculation method introduces the calculation steps for determining the energy consumed for lighting purposes in buildings and the numerical indicator that can be used for certification purposes for the lighting energy requirement [2]. The formula in BEP-TR is used to find the total amount of energy consumed for lighting purposes of a space (WL, t). Explanations of the variables related to the formula are given below:

$$W_{L,t} = \left\{ \left(P_n \times F_c\right) \times \left[\left(t_D \times F_o \times F_D\right) + \left(t_N \times F_o\right) \right] \right\} / 1000 \, (\mathrm{kWh}) \tag{1}$$

P_n: Total Installed Lighting Power in The Zone (W)

F_c: Constant Illuminance Factor

t_D: Daylight Time Usage (h)

F_o: Occupancy Dependency Factor

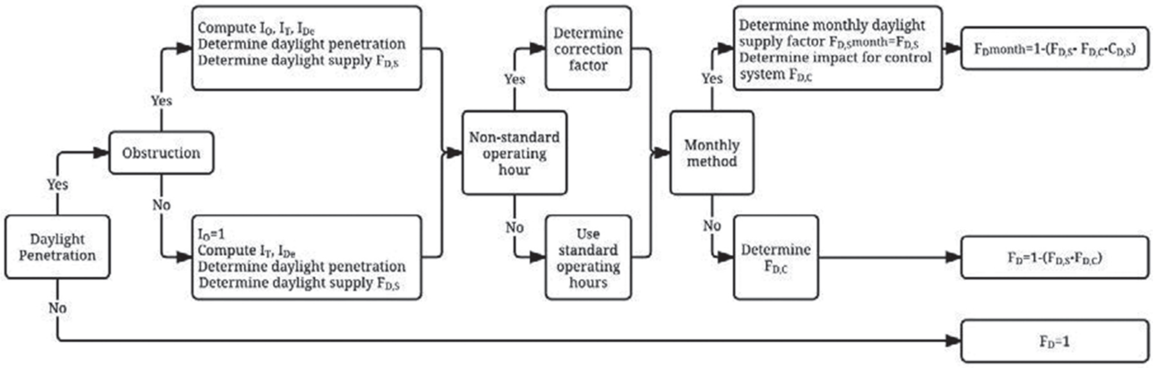
F_D: Daylight Dependency Factor

t_N: Non-Daylight Time Usage (h)

To classify the building's lighting energy performance, it is necessary to calculate the annual AESG value (AESG = W/A (kWh /m2 x year) EN 15193: 2008 standard volume for obstructions affecting the daylight (F_D) affects daylight dependency factor and affects annual AESG value. The utilization of space from daylight, the dimensions of space and windows, geographical conditions, the type of glass used in the windows, and the obstructions by which these windows are affected affect daylight intake [17]. The effect of daylight is estimated by (F_D). The parameters affecting (F_D) are determined in the flow chart in Figure 1 [11].

In this study, the change in lighting energy due to daylight in buildings is calculated according to the mentioned method by considering the obstruction parameters. In the calculations, providing visual comfort was also taken as a priority, using the "*Dialux-Evo*" simulation program to determine the lighting levels and the installed lighting power (P_n) accordingly.

FIGURE 1. Parameters Affecting Daylight According to EN 15193 Standard [11].



The study aims to determine the effect of the obstruction parameter on daylight penetration and energy performances of the hotel building chosen as the study area, by considering "distance and height variables related to the obstructions" among the parameters affecting daylight.

4. CALCULATION OF LIGHTING ENERGY CONSUMPTION ACCORDING TO THE BEP-TR METHOD—A CASE STUDY

In this section, lighting energy consumption is calculated according to the BEP-TR method by considering a hotel, accepted to be in Kayseri Province. In the calculations, the results obtained by evaluating the daylight dependency factor F_D as an alternative to the "obstruction situation" were evaluated. Other variables related to the calculation have been kept constant.

4.1 Introduction to the Building

The building is a Hotel project that is considered to be located in Kayseri Province (35:30 E 38:43 N), and it is accepted that the building's active room occupancy hours are between 08:00 and 24:00, and the circulation areas and the lobby are occupied for 24 hours. The room height is 4.00 meters, and the project consists of a hotel ground floor as well as first and second floors providing daylight penetration through a single facade. The lobby consists of 8 Standard Rooms,

FIGURE 2. Hotel Ground Floor Plan.

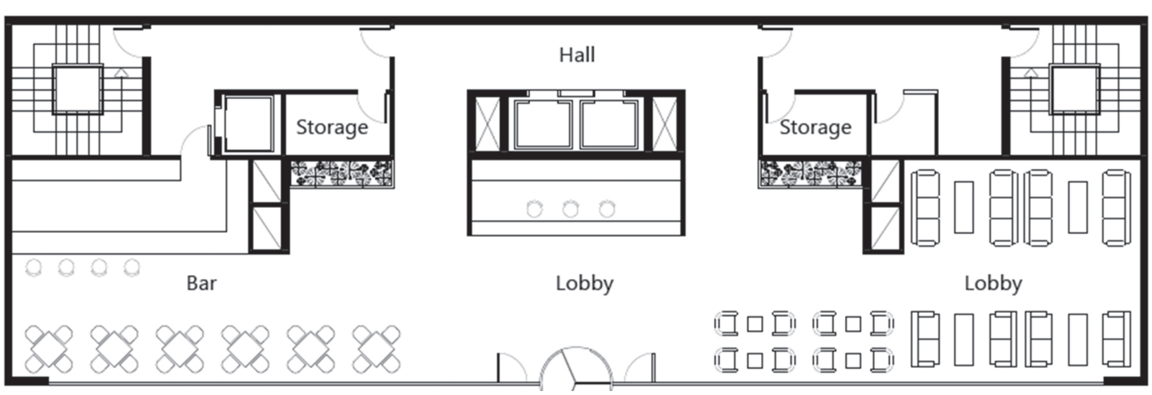


FIGURE 3. Hotel Floor Plan (1st and 2nd Floor).

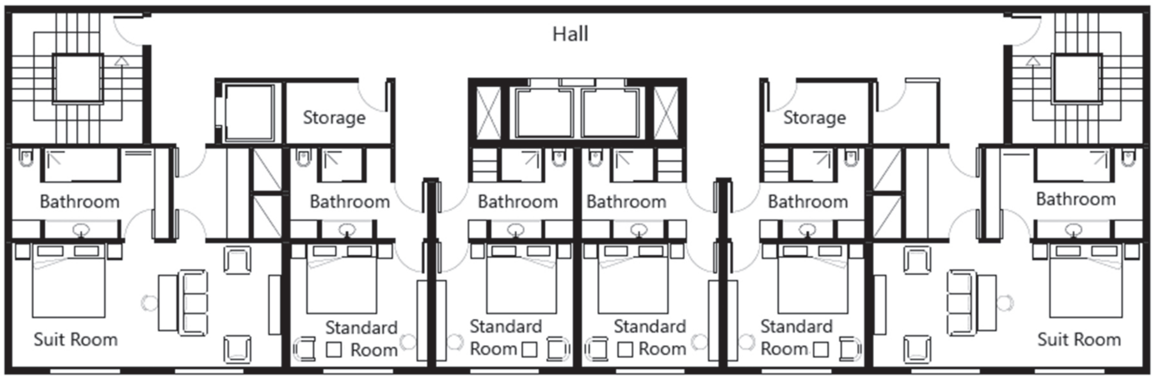


TABLE 1. Features of the Spaces Considered in the Hotel Project.

Volumes	Lobby (×1)	Standard Room (×8)	Suit Room (×4)	Standard Bathroom (×8)	Suit Bathroom (×4)	Hall (×2)	Stairs (×6)	Storage (×6)
Volume Dimension (m)	6m × 31m	3.4m × 3.8m	3.4m × 7.4m	3.8m × 2.5m	4.3m × 2.5m	23.4m × 2m	3.6m × 3.6m	2.9m × 1.7m
Volume Area (m^2)	186 m^2	12.92 m^2	25.16 m^2	8.25 m^2	10.46 m^2	59.97 m^2	12.96 m^2	4.91 m^2
Window Width × Length (m)	29m × 3m	2m × 1.6m	2m × 1.6m (2 window)	None	None	None	None	None

4 Suites, 2 Floor Halls, 6 Floor Storerooms, staircase, and other service areas. The volumes in the building are detailed in Figures 2 and 3.

In the project, 4 + 4 double glazing classical glass type has been chosen as the main glazing, and it is accepted that there are no solar control elements in the windows. Lighting control is provided manually in the building, and linear LED and LED fixtures are used in volumes. Data on the volumes discussed in the project are given in Table 1.

4.2 Evaluation of Visual Comfort Conditions

The desired values are determined according to the EN 12464-1 standard to provide visual comfort conditions in the examined areas. The color rendering (Ra) values of the lamps should be minimum 80 according to the type of action in the volumes discussed [18]. In the spaces examined in Table 2, the recommended and current lighting levels are included to provide visual comfort conditions.

Accordingly, it is seen that the desired lighting levels are met according to reference standards.

TABLE 2. Suggestion Regarding the Places Handled-Current Lighting Levels (lx) [18].

Volume Type	Lobby (×1)	Standard Room (×8)	Suit Room (×4)	Standard Bathroom (×8)	Suit Bathroom (×4)	Hall (×2)	Stairs (×6)	Storage (×6)
Suggestion Regarding the Places Handled (lux)	300	—	—	200	200	300	300	200
Current Lighting Levels (lux)	317	285	317	189	192	287	290	206

4.3 Calculation of Building Lighting Energy According to the BEP-TR Lighting Calculation Method

The lighting energy requirement of the building discussed in this section is calculated according to the BEP-TR lighting calculation method.

4.3.1 Calculation of Total Installed Lighting Power in The Zone (P_n)

The installed power (Watt) for all devices in the spaces is calculated according to the lighting design by using the "*Dialux-Evo*" simulation program. Table 3 shows the total installed power (Watt) values for volumes.

4.3.2 Constant Illuminance Factor (F_C) Calculation

This value is the factor related to the consumption of the total installed illumination power in a volume due to constant illumination control. It is considered when there is a dimmable lighting control system in volumes. Since there is no lighting control due to dimming in this building, the constant illuminance factor (F_C) value is accepted as 1 (ineffective), as referenced by the standard.

4.3.3 Day Length and Working Hours Relation—Calculation of t_D and t_N Value

According to the BEP-TR lighting calculation method, depending on the use hours of the building, annual t_D and t_N values to determine the length of the day should be calculated for

TABLE 3. Installed Power (Watt) Values for Artificial Lighting in the Spaces.

Volume Type	Lobby (×1)	Standard Room (×8)	Suit Room (×4)	Standard Bathroom (×8)	Suit Bathroom (×4)	Hall (×2)	Stairs (×6)	Storage (×6)
Pn (Watt)	1260W	137W	317W	46.4W	52W	249.3W	44W	54W

TABLE 4. Absence Factor (F_A), Controls Function Factor (F_{OC}) and (F_o) Regarding the Spaces Handled.

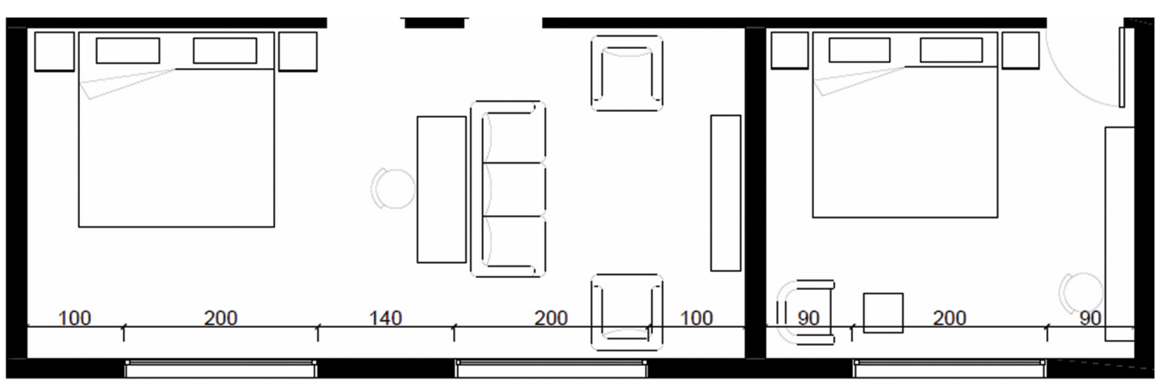
Volume Type	Lobby (×1)	Standard Room (×8)	Suit Room (×4)	Standard Bathroom (×8)	Suit Bathroom (×4)	Hall (×2)	Stairs (×6)	Storage (×6)
Absence Factor (F_A)	0	0.6	0.6	0.6	0.6	0.8	0.2	0.5
Controls Function Factor (F_{OC})	1	1	1	1	1	1	1	1
Occupancy Dependency Factor (F_o)	1	0.6	0.6	0.6	0.6	0.8	1	0.7

cities in Turkey. Day lengths for Kayseri conditions have been calculated as the average value for the periods 21 December–21 June (06:53 sunrise, 16:20 sunset) and for the periods 21 June–21 December (05:14 sunrise, 20:06 sunset). Based on the assumption that the usage hours are between 08:00 am–11:00 pm, the annual t_D value is calculated as 3729.08 hours, and the t_N value is calculated as 1380.91 hours. Considering that the lobby and circulation areas are in use for 24 hours, the t_D value for these volumes is calculated as 4437.79 hours and the t_N value as 4322.20 hours. Regarding the usage hours, actual values of t_D and t_N play a significant role in building energy performance calculation. Although all rooms may not be used at the same time in the hotel building, the calculation was made considering the maximum use for the energy performance calculation.

4.3.4 Calculation of Occupancy Dependency Factor (F_o)

To calculate the usage-related value in the hotel building examined within the scope of the study, the factor (F_o) depending on the use in lighting was calculated. The factor (F_A), which indicates the rate of use depending on the locations, was selected from the table given in BEP-TR. In the project, which is deemed to be places with a manual on-off switch, the factor (F_o) depending on

FIGURE 4. Regions Benefiting from Daylight of Different Spaces.



the usage was calculated by selecting the lighting control factor (F_{OC}) value. Table 4 contains the values that help determine the factor depending on the usage of the spaces.

4.3.5 Calculation of Daylight Dependency Factor (F_D)

The dimensions of the windows are related to their location and the dimensions of the space. To determine the spaces benefitting from daylight, the daylight dependency factor calculation specified in BEP-TR should be performed. In Figure 4, the hotel room volume and window openings in the sample hotel building are given.

To calculate the annual total energy for illumination ($W_{L,t}$), the daylight dependency factor F_D must be determined. To determine the daylight dependency factor (F_D) of the volumes, it is necessary to calculate the Daylight Factor (D_c) and Daylight Indicator (D) following the BEP-TR lighting calculation method. The daylight factor calculation method is given in the equation below.

$$D_C = \left(4.13 + 20 \times I_T - 1.36 \times I_{DE}\right) \times I_O$$

In this equation:

I_O: Obstruction Index,
I_T: Transparency Index,
I_{De}: Depth Index.

For the classification of the daylight factor found, the properties of the glazing types used in the volume are needed. The classification of the daylight factor is calculated with the formula below:

$$D = D_C \pi k_1 k_2 k_3$$

In this equation;

π: Glass light transmittance (for upright light)
k_1: Reduction factor for the frames or subdivisions (usually 0.7)

TABLE 5. Daylight Factor, Classification of Daylight Factor, Daylight Supply Factor, and Daylight Dependency Factor Values.

Room Name	Daylight Factor (D_C) "no obstacle"	Classification of Daylight Factor (D) "no obstacle"	Daylight Supply Factor	Daylight Dependency Factor Values (F_D) Automatic
Lobby	9.17	3.49	Strong	0.3
Standard Room	5.89	2.24	Medium	0.3
Suit Room	6.02	2.29	Medium	0.3

TABLE 6. Total Lighting Energy Consumption (W) Values and Building Lighting Energy Numerical Indicator (AESG) Value Related to the Building Considered (due to the absence of obstacles).

Volume Type	Total Lighting Energy Consumption (W) (for one volume) (kWh)	Total Lighting Energy Consumption (W) (for total volume) (kWh)	AESG ($kWh/m^2 \times$ year)
Lobby (×1)	8,899.35W	8,899.35W	29.31 kWh/m^2
Standard Room (×8)	336.64W	2,693.14W	
Suit Room (×1)	778.94W	3,115.79W	
Standard Bathroom (×1)	142.26W	1,138.09W	
Suit Bathroom (×1)	159.43W	637.72W	
Hall (×1)	1,747.09W	3,494.18W	
Stairs (×1)	385.43W	2,312.63W	
Storage (×1)	193.15W	1,158.94W	
Other Room	2,933.95W	2,933.95W	
Total		29,383.83W	

k_2: Reduction factor for pollution of the glazing (usually 0.8)

k_3: Reduction factor of non-vertical light incident upon the glazing (usually 0.85)

As a result, the calculated daylight factor, daylight factor classification, daylight effect, and daylight dependency factor values are given in Table 5 for the selected sample volumes.

4.3.6 Total Lighting Energy Consumption (W) and Lighting Energy Numerical Indicator AESG Determination of Values

According to the BEP-TR method for the calculation of the total illumination energy consumption, first, the calculation of the "non-obstacle" condition for the existing hotel building has been calculated, and the total illumination energy consumption is shown in Table 6.

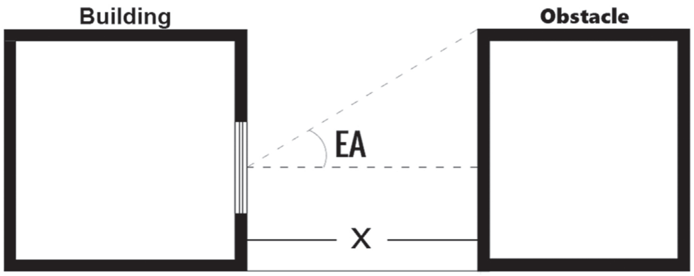
5. DETERMINING EFFECT OF DAYLIGHT SUPPLY AND LIGHTING ENERGY CONSUMPTION DUE TO THE OBSTRUCTION PARAMETER VARIABLES

In this section, the effect of the external obstruction parameter in the sample project on the daylight and lighting energy performance according to the variables of "height and obstacle distance" are examined following the method specified in other sections.

5.1 Determining the Obstruction Index

The Daylight Factor (Dc) and Daylight Indicator (D) calculated in the building under consideration vary in line with a possible obstruction. The Obstruction Index (IO) in the Daylight Factor (Dc) account specified in BEP-TR determines the effect of the obstacles that reduce the daylight penetration. In case of an obstacle in front of the window, the angle between the midpoint of

FIGURE 5. Finding the Angle of Obstruction in case of the Existence of Obstacle.



the window and the upper elevation of the obstruction must be determined to calculate the obstacle effect. In Figure 5, the way of finding the obstruction angle is shown schematically:

Depending on the building obstruction angle,

- If, obstruction altitude angle $EA_{building} > 60° \ I_{O,OB} = 0 \ (F_D = 1)$
- If, obstruction altitude angle $EA_{\ building} < 60°, I_{O,OB} = \cos(1.5 \times EA_{bina})$

The obstruction Index (I_O) specified in the BEP-TR calculation method is found by the calculations above.

5.2 Effects of the Obstruction Parameter on Lighting Energy Consumption

In the hotel project discussed in this section, obstruction alternatives are defined at different distances and different floor heights. The angle between each window and the upper level of

FIGURE 6. x = 400 cm Obstacle Distance; Annual AESG Change Graph Based on Height.

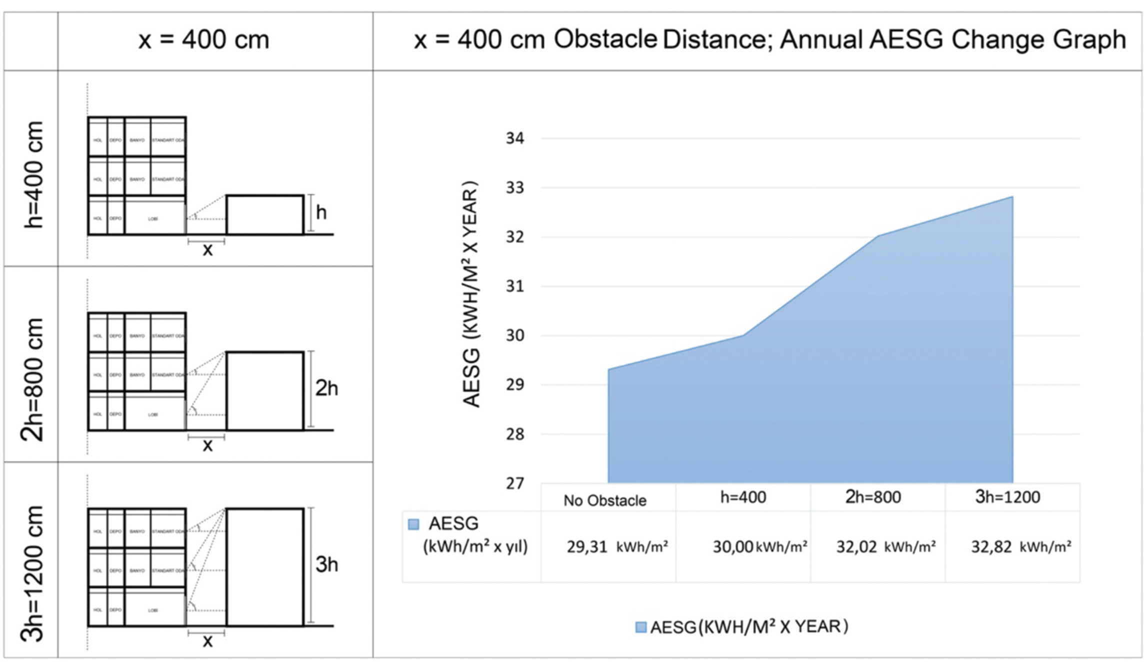


FIGURE 7. 2x = 800 cm Obstacle Distance; Annual AESG Change Graph Based on Height.

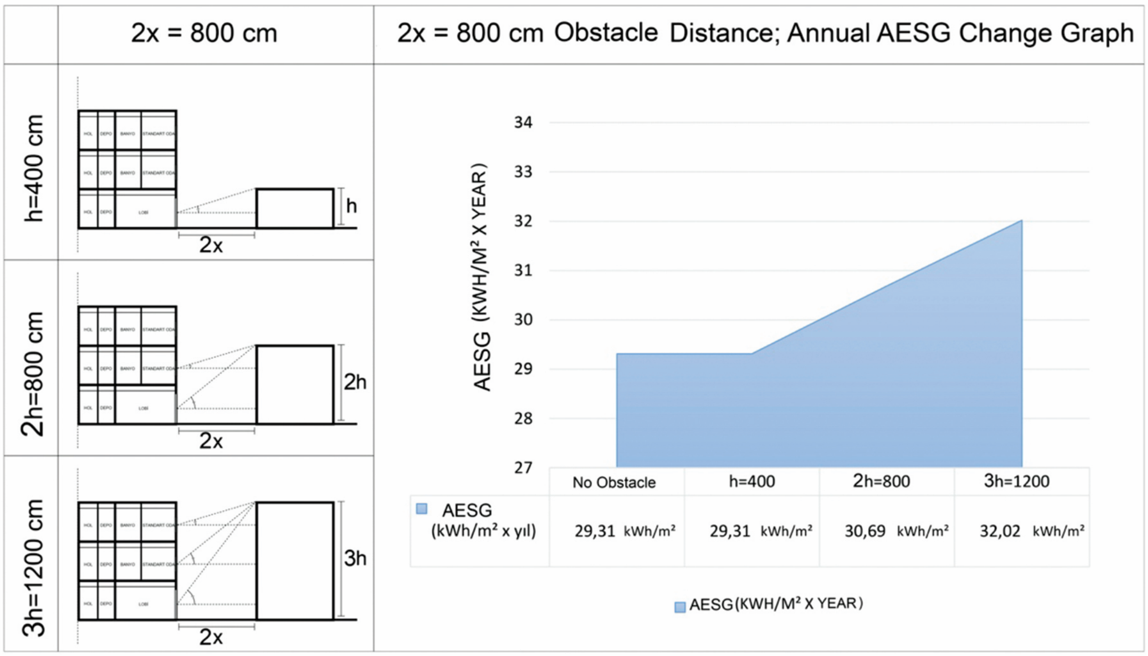


FIGURE 8. 3x = 1200 cm Obstacle Distance; Annual AESG Change Graph Based on Height.

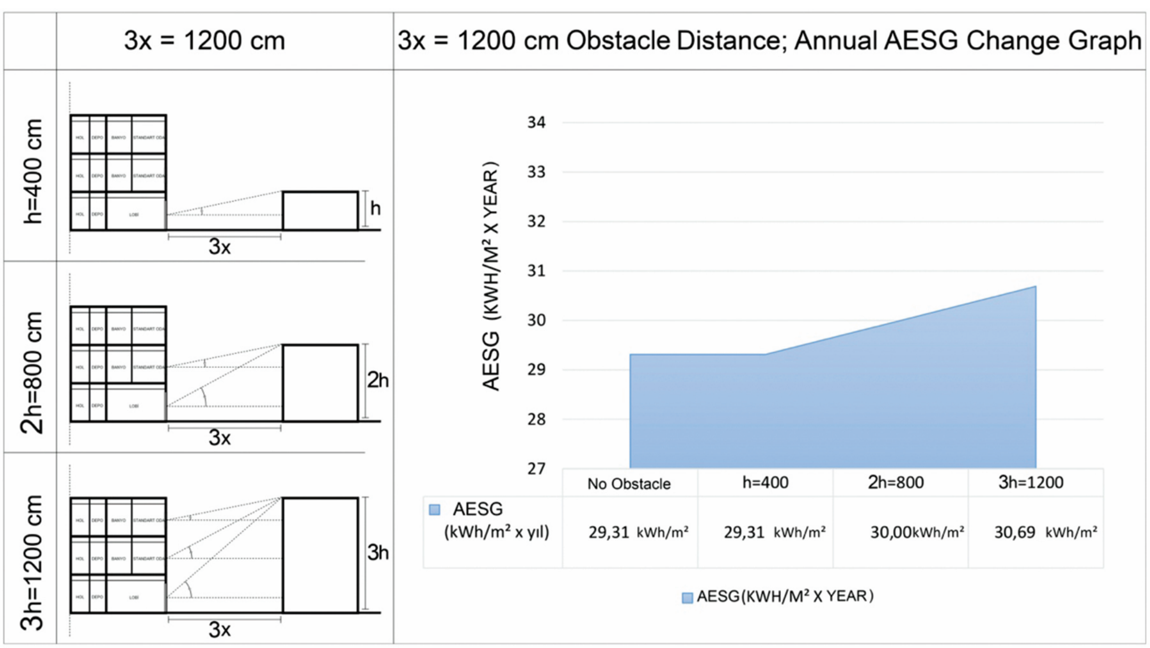
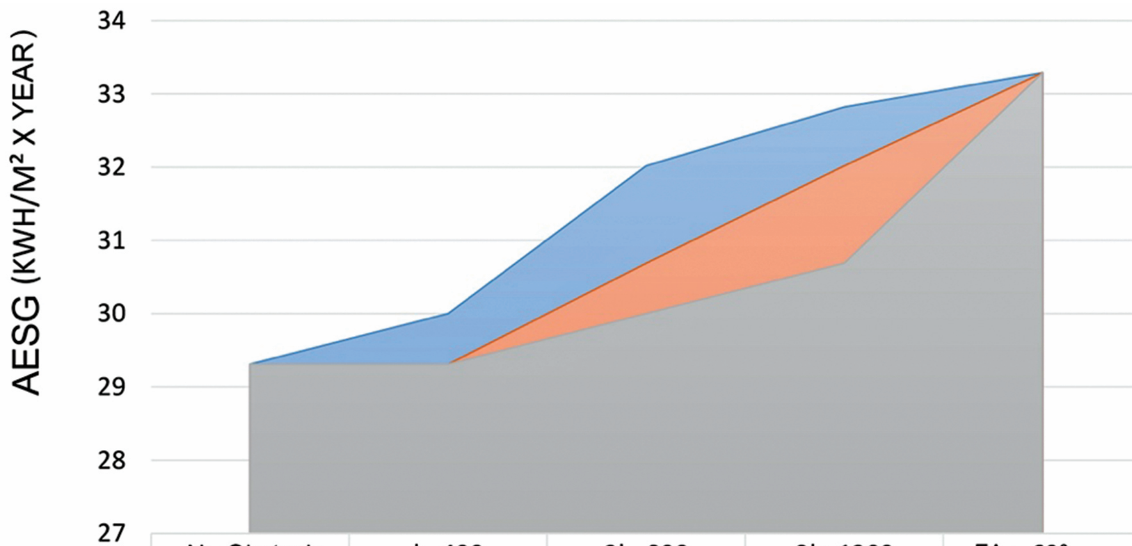


FIGURE 9. Annual Building Lighting Energy (AESG) Values Changing Based on the Obstruction Parameter.



	No Obstacle	h=400	2h=800	3h=1200	EA > 60°
x = 400	29,31 kWh/m²	30,00 kWh/m²	32,02 kWh/m²	32,82 kWh/m²	33,29 kWh/m²
2x = 800	29,31 kWh/m²	29,31 kWh/m²	30,69 kWh/m²	32,02 kWh/m²	33,29 kWh/m²
3x = 1200	29,31 kWh/m²	29,31 kWh/m²	30,00 kWh/m²	30,69 kWh/m²	33,29 kWh/m²

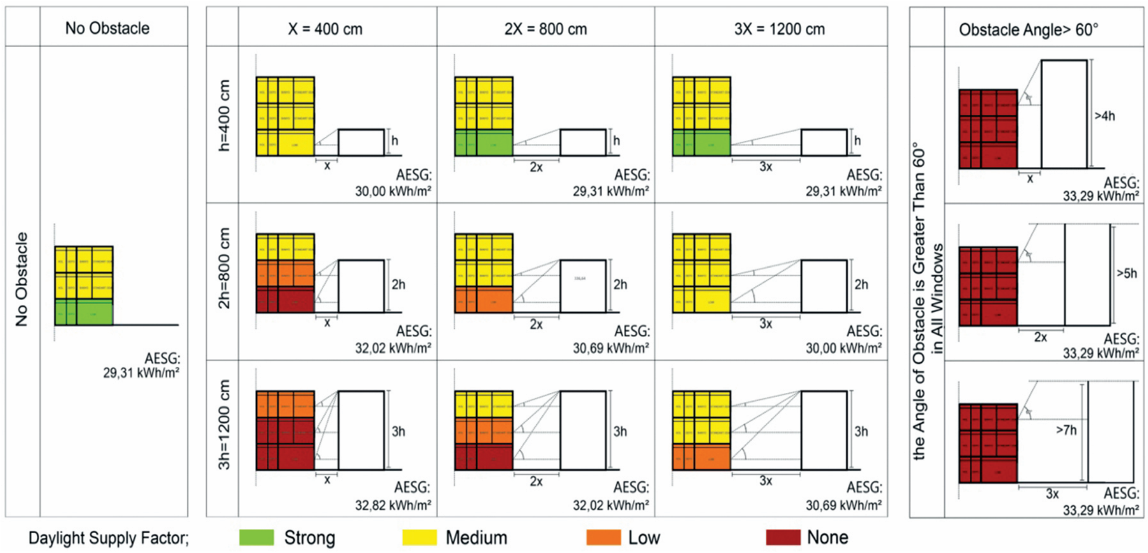
the obstacle changes the daylight effect class of the space while determining the Obstruction Index (I_O) coefficient in the spaces receiving daylight. Decreasing the effect of daylight increases energy consumption and increases the annual building lighting energy numerical indicator (AESG) value.

As an obstacle distance (floor height of the building = 400cm); by taking x = 400 cm, 2x = 800 cm and 3x = 1200 cm and also with obstacle heights as h = 400 cm, 2h = 800 cm and 3h = 1200 cm, external obstacle variables were created. Consequently, a: x = 400 cm distance; keeping the outer obstacle distance parameter constant; (x) height, with h = 400, 2h = 800 and 3h = 1200 cm obstacle alternatives were created. The effect of these obstacle status variables on annual lighting energy consumption is shown in the graph in Figure 6.

b: 2x = 800 cm distance; keeping the outer obstacle distance parameter a constant (2x) height, obstacle alternatives with h = 400, 2h = 800 and 3h = 1200 cm were created. The effect of these obstacle status variables on annual lighting energy consumption is shown in Figure 7. c: 3x = 1200 cm distance; keeping the outer obstacle distance parameter a constant (3x) height; obstacle alternatives with h = 400, 2h = 800 and 3h = 1200 cm were created. The effect of these obstacle status variables on annual lighting energy consumption is shown in Figure 8.

The effects of the obstructions placed at different distances and different floor heights on annual building lighting energy numerical consumption (AESG) values are given in Figure 9 comparatively. It must be added here that obstruction angles greater than 60° are quantified based on the assumption described in the EN 15193:2008 Standard; therefore, they have the same values.

FIGURE 10. Daylight Supply Factor and AESG Values Determined Based on Obstruction Parameter.



According to the values stated in Figure 9, while the Annual lighting energy numerical indicator (AESG) = 29.31 kWh/m^2 in the absence of obstacle—which is accepted to be located in Kayseri Province—the annual illumination energy indicator is calculated as (AESG) = 33.29 kWh/m^2 in the absence of daylight (obstruction angle > 60°).

6. CONCLUSION AND EVALUATIONS

In this study, the effect of obstruction on daylight exposure and lighting energy consumption was calculated by the method specified in BEP-TR. According to this method, only the obstruction parameter varies, while other parameters such as artificial lighting power, user factor, usage hours are kept constant. In order to satisfy the requirements of thermal and visual comfort conditions of the occupants, optimization of the performance of the building envelope should be achieved in the early design stages of buildings. In this manner, design proposals should target optimizing the total building loads while providing visual and thermal comfort conditions provided by the glazing. According to the data obtained in the study, the effect of the

TABLE 7. Obstruction Parameter-Daylight Supply Factor and Energy Consumption Correlation.

Daylight Supply Factor	Height / Distance	Energy Consumption Increase
Strong & Medium	0.5 ≥ **h/x** > 0	**% 0**
Medium & Low	1≥ **h/x** > 0.5	**% 2,3 - % 4,7**
Low & None	4≥ **h/x** > 1	**% 9,2 - % 11,9**
None	**h/x** > 4	**% 13,5**

height and distance variables of the obstruction parameter on energy consumption and daylight supply factor is as in Figure 10.

In line with the calculated data, obstruction parameter variables were obtained between daylight supply factor and lighting energy consumption in the correlation shown in Table 7. Here, it must be stated that values in the category of "none" in terms of daylight supply factor represent the conditions for obstruction angles greater than 60 degrees, resulting in an energy consumption increase of 13.5%.

Accordingly, it is observed that the daylight supply factor decreases, and annual consumption increases at specific intervals due to the rise in the height/distance (h/x) ratios of the obstruction situation in a window located in the volume with a floor height (h). In these calculations, the increase of lighting energy consumption value is determined according to the building, which is considered to have obstructions. As can be seen in these calculations, obstruction parameter variables affect both daylight supply factor and annual lighting energy significantly. Accordingly, when determining the building ranges and heights, it is recommended to determine the situations where the building does not have an obstruction, by considering these rates, its effect on daylight, and lighting energy consumption.

In this correlation, the structures in the design process, building ranges, and heights are anticipated to be predictable conditions for daylight effects and annual energy consumption. In this regard, they can be used as a facilitated method to zoning regulations for buildings planned in urban areas.

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