DIN V 18599-4 STANDARD-BASED BUILDING ENERGY EVALUATION PERFORMANCE IN TERMS OF ILLUMINATION

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Abstract

The deficiency of energy resources which is a result of the increase in world population and the rapid development of technology impels the human being to use the available resources in an efficient way. From this point, Berlin-based DIN issued a standard with the name DIN V 18599 Energy Efficiency in Buildings. In this study,a building in Istanbul, TURKEY is considered to evaluate the energy need for lighting requirements based on the related standard. Study was conducted on an actual structure. The annual amount of energy required for lighting the entire plaza is calculated. The most important result of this study is that there are many parameters like as type of the use of space, façade direction, and slope of the roof, which affect the result of the energy needed for lighting in the buildings. These parameters must be considered for attentive and in-depth analysis, otherwise significant errors can occur in the results. The results showed that energy consumption of the spaces, that are illuminated by daylight and not illuminated by daylight, can be different from each other.

Keywords: Building energy performance, illuminating energy performance, Matlab GUI application, energy efficiency formula algorithm, DIN V 18599 formulas.

1. INTRODUCTION

Energy efficiency is defined as doing the same work using less energy. While Turkey's primary energy demand has been increasing 4-5% per year and the demand for electrical power has also been increasing %8 per year for the last decade. Besides, energy demand growth rate has exceeded the official estimates in the last two years and a deficit in energy has occurred. As a result of the importance of energy efficiency in buildings, energy identity certificate has become fairly supported in recent years also by the government in Turkey. According to a survey made in 2008, the share of lighting consumption within the total electricity consumption in Turkey was approximately calculated as 23%. Energy efficiency which holds a significant place in the World agenda, have also been discussed by the International standard institutes and certain standards have been published. Increasing energy consumption have pushed states to take some measures and these standards are considered as the guide.

The 'NuOffice' which was built in Munich, Germany and has the LEED Platinum certification is one of the example offices with energy efficiency. The most significant difference of the NuOffice from a traditional office is its 90% energy efficiency. In Turkey, there are around 50 buildings with LEED certification. 75% of these certificates are in gold class. In terms of energy identity certification in Turkey, the national building energy performance calculation method BEP-TR which was prepared in accordance with the EN 15193 standard, provides a calculation model that suits the conditions in Turkey. Calculating the energy performance of buildings can be made with this method. This paper is based on the standard DIN V 18599. This standard provides a calculation methodology and guides in order to determine energy requirements in buildings for heating, cooling, air conditioning, ventilation, domestic hot water and lighting. This paper covers the energy requirement for lighting. In the first part of this paper, the lighting criteria of the standard is explained. The calculation methodology is described in the second part. In the third part, an application to a sample building is analyzed and is simulated. Finally, conclusions and recommendations are discussed.

2. LIGHTING CRITERIA IN DIN V 18599 STANDARD

Efficient usage of daylight in buildings is important for saving energy. The required value of energy for lighting is calculated according to the variables such as the amount of daylight, lighting systems in the office, control systems, geographic location. With the developing technology, variety of new lighting techniques have been found in order to ensure maximum use of daylight. Contemporary lighting systems such as light shelves and light tubes are not taken into consideration in this paper. There are four types of control systems that keep the consumption of lighting systems minimum. Among them, manual and dimmer control systems have been taken into consideration.

3. CALCULATION METHODOLOGY

Total energy requirement for lighting of a building or space is calculated according to Equation 1.

$$Q = p \times [A_{TL} \times (t_{eff,Tag,TL} + t_{eff,Nacht}) + A_{KTL} \times (t_{eff,Tag,KTL} + t_{eff,Nacht})] \quad (1)$$

p_j : electrical evaluation power (W/m^2)

A_{TL} : area which is illuminated by daylight (m^2)

A_{KTL} : area which is not illuminated by daylight (m^2)

$t_{eff,Tag,TL}$: the effective operating time of the lighting system, during the day-time, which is illuminated by daylight (h)

$t_{eff,Tag,KTL}$: the effective operating time of the lighting system, during the day-time, which is not illuminated by daylight (h)

$t_{eff,Nacht}$: the effective operating time of the lighting system, during the night-time (h)

The calculation flowchart of energy needed for lighting is showed in Figure 1.

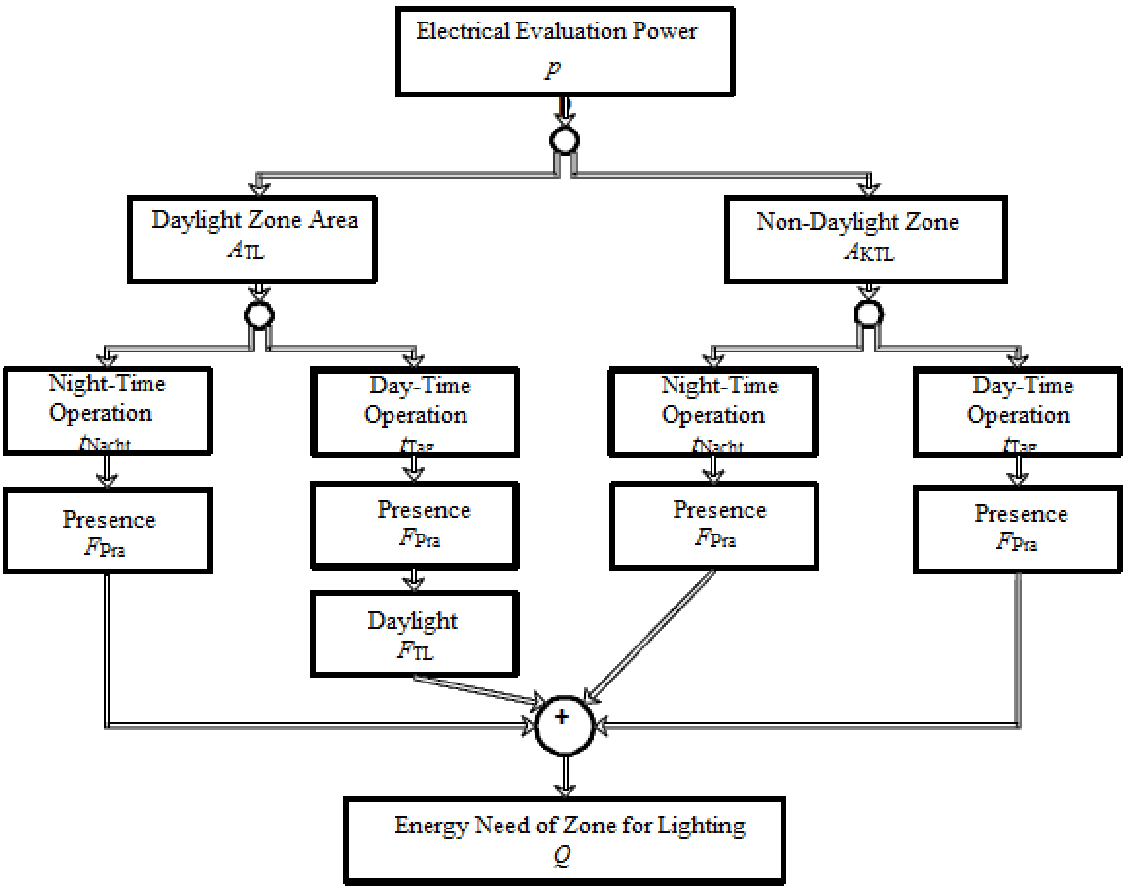

Figure 1. Flowchart showing calculation of the energy need for lighting

Following parameters are involved in the calculation of p that is used in equation 1. Electrical evaluation power (p) is calculated with Equation 2.

$$p = p_{lx} \text{ x } \bar{E}_m \text{ x } k_A \text{ x } k_L \text{ x } k_R \quad (2)$$

p_{lx} : specific electrical evaluation power (W/m^2)

$\bar{E}_m$: maintained illuminance, lx

k_A : reduction factor to account for the proportion of the task area

k_L : the correction factor taking into account the type of lamp

k_R : the correction factor taking into account the type of space

Operating times, the partial-operation factor to account for illumination by daylight and the partial-operation factor to account for the presence of persons, contribute to the calculation of effective operation time of lighting system

$$t_{eff,Tag,TL} = t_{Tag} \text{ x } F_{TL} \text{ x } F_{Pra} \quad (3)$$

$$t_{eff,Tag,KTL} = t_{Tag} \text{ x } F_{Pra} \quad (4)$$

$$t_{eff,Nacht} = t_{Nacht} \text{ x } F_{Pra} \quad (5)$$

T_{Tag} : is the operating time during the day-time

t_{Nacht} : is the operating time during the night-time

F_{TL} : is the partial-operation factor to account for illumination by daylight

F_{Pra} : is the partial-operation factor to account for the presence of persons (occupancy)

Calculation of partial-operation factor to account for the presence of persons (F_{Pra}) depends on ($C_{Pra,kon}$) values which depend on the relative absence (C_A) and the lighting control. C_A value is determined according to the usage type of the building that is being measured, while $C_{Pra,kon}$ value is obtained according to whether there is presence sensor as shown in the following table.

$$F_{Pra} = 1 - (C_A \text{ x } C_{Pra,\,kon}) \quad (6)$$

Table.1 Factor $C_{Pra,\,kon}$ to account for the efficiency of presence detection systems

Space	$C_{Pra,\,kon}$
Without presence sensors	0,5
With presence sensors	0,95

In order to caculate F_{TL}, $C_{TL,Vers}$ and $C_{TL,\,kon}$ values must be known.

$$F_{TL} = 1 - (C_{TL,Vers} \text{ x } C_{TL,kon})$$

F_{TL} : partial operation factor to account for illumination by daylight

$C_{TL,\,Vers}$: daylight supply factor

$C_{TL,\,kon}$: factor representing the effect of the daylight-responsive lighting control system

Calculation of daylight supply factor is made through a detailed process of operations. Shortly, parameters such as types of façade components, daylight class, glazing type effect daylight supply factor. The values for $C_{TL,kon}$ is provided in Table 2 based on daylight class and whether artificial lighting control system is manual or dimmed.

Table.2 Correction factor $C_{TL,kon,j}$

Type of control		Classification of Daylight								
		Low			Medium			Strong		
		300 lx	500 lx	750 lx	300 lx	500 lx	750 lx	300 lx	500 lx	750 lx
Manual		0,50	0,47	0,44	0,55	0,52	0,49	0,60	0,57	0,54
Dimmed	No total switch off	0,65	0,70	0,73	0,70	0,73	0,75	0,73	0,75	0,76
	Total switch off	0,71	0,74	0,76	0,77	0,78	0,79	0,81	0,81	0,81

4. SAMPLE BUILDING APPLICATION

The simulation is applied to a plaza structure in Istanbul, Turkey. Building has seven independent parts which includes two basement floors, a ground floor, three normal floors and an attic. Each independent section has been considered as a zone. Each zone was separated into evaluation areas within itself. Energy requirement for lighting of each evaluation area is calculated individually. Basements are considered as car parking space. The ground floor has one store, one personal office and two toilets. Normal floors have one workgroup office, one personal office and two toilets. In the attic, there is a space of about 150 m2, that can be considered as living area. There are 4555 hours of daytime, and 4205 hours of night time in a year in Istanbul. At the times daylight is long, the buildings that benefit from daylight can save energy. In this paper each usage type is calculated separately for day and night time.

Table.3 Properties of zones

Building Condition	New Building
Illumination Type	Direct
Type of Lamp	Tubular Fluorescent
Type of Balast	Electronic
Type of Control	Dimmed
Type of Dimmer	Total switch off
Presence Sensor	Available

As an example, characteristics of NF2 zone evaluation areas which is called 2. Normal floor zone are shown in Table.4. After calculating the amount of energy required for lighting with the data available, the same procedure is repeated for all other zones. The results obtained are provided in Table 5.

Table.4 Characteristics of evaluation areas for the usage of calculating energy requirements for lighting

Evaluation Areas	Depth	Width	Height	Type of Space	Façade Direction	Type of Glass	Type of Façade Component
NF2_1	11,18m	11,70m	3,00 m	Workgroup Office	North	Double Glazing	Solar Protection Glazing
NF2_2	3,60m	3,30m	3,00 m	Personal Office	West	Double Glazing	Solar Protection Glazing
NF2_toi1	1,5m	1,0m	3,00 m	Toilets	East	Double Glazing	Solar Protection Glazing
NF2_toi2	1,5m	1,0m	3,00 m	Toilets	East	Double Glazing	Solar Protection Glazing
NF2_hol	1,25m	2,30m	3,00 m	Auxiliary Space	*	*	*
NF2_ups	5,80m	3,50m	3,00 m	Circulation Area	East	Double Glazing	Solar Protection Glazing

* Type of glazing, façade component and façade direction are not given any value, since the building do not has daylighting and they do not have effect on the results.

Table.5 Total monthly and annual energy requirement for lighting for all zones

Month	Zones							Monthly Total
	B2	B1	GF	NF1	NF2	NF3	Roof	
Jan	57,228	63,989	172,899	190,459	190,459	190,459	129,380	**994,87**
Feb	57,228	63,989	151,266	174,683	174,683	174,683	125,889	**922,42**
Mar	57,228	63,989	134,902	162,735	162,735	162,735	123,174	**867,49**
Apr	57,228	63,989	123,806	154,613	154,613	154,613	121,234	**830,09**
May	57,228	63,989	116,595	149,355	149,355	149,355	120,071	**805,94**
June	57,228	63,989	114,652	147,923	147,923	147,923	119,683	**799,32**
July	57,228	63,989	117,978	150,319	150,319	150,319	120,071	**810,22**
Agu	57,228	63,989	125,188	155,577	155,577	155,577	121,234	**834,37**
Sep	57,228	63,989	137,667	164,662	164,662	164,662	123,174	**876,04**
Oct	57,228	63,989	155,134	177,341	177,341	177,341	125,695	**934,06**
Nov	57,228	63,989	178,149	194,080	194,080	194,080	129,186	**1010,79**
Dec	57,228	63,989	204,769	213,449	213,449	213,449	133,259	**1099,59**
Annual Total	**686,73**	**767,87**	**1733,00**	**2035,19**	**2035,19**	**2035,19**	**1492,04**	**10785,24**

Total energy requirement for lighting of the building is 10.785,24 kwh as shown in Table.5. The lowest consumption is in summer times, particularly with 799,320 kwh in June, the highest consumption is in winter particularly with 1099,591 kwh in December. The results indicated that the amount of sun light in summer is more compared to the winter months.

5. CONCLUSION

This paper is based on DIN V 18599 standard of the energy efficiency which is issued by German Standards Institute. Energy requirement for lighting of a new building that is built in Istanbul is calculated. The most significant conclusion of this paper is that there are several parameters that effect the result of energy requirement for lighting in buildings such as usage type of space, façade direction, slope of roof. For a cautious and in-depth analysis, these parameters should be considered, otherwise significant errors may occur in the results. Results also show that there is a major gap in energy consumption between basements without daylight and floors with daylight.

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