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Energy Efficiency Analysis in the Case of Sustainable Lighting Design Butterfly Valley Park (Konya)

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ABSTRACT

The concept of lighting is of great importance in providing the security that people need so that they can have a quality of life and in meeting their aesthetic needs. Lighting design is related to the physical structure and the environment, and thanks to the lighting design, the aesthetic and functional needs of people will be met and the quality of life will be increased. The need to reflect the historical, cultural and aesthetic values of the city has brought the issue of urban lighting to the agenda. Lighting systems, which are applied without paying attention to the necessary lighting standards and criteria, cause some problems in urban spaces. One of these problems is light pollution; It is generally defined as the use of light in the wrong place, in the wrong amount, in the wrong direction and at the wrong time. Light pollution adversely affects the natural life and daily lives of people, and it is necessary to take various measures to eliminate such negativities in human life, to detect and eliminate these problems. In this study; The standards for the lighting of the city parks obtained by the literature studies were determined, the current lighting situation of the Butterfly Valley Park and the recommended lighting design produced by the Relux software in accordance with the standards. According to the findings; In the current lighting project, the total power consumed as a result of the lighting of all the lamps of the area has been calculated as 96 005.0 W. In the proposed lighting project, the total power consumed as a result of the burning of all lamps was calculated as 27 630.0 W. The obtained energy gain was found to be 96 005.0 W – 36 700.0 W = 68 375.0 W. As a result of working in the light of this information, energy savings of 1 in 3 have been achieved.

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Introduction

Light is a fundamental source of energy, and in today's world, it is inconceivable to imagine life without it (Aksay et al., 2007). The 20th century witnessed a significant increase in urbanization and technological advancements, leading to new developments in the field of lighting. Lighting is essential not only for illuminating urban areas but also for purposes such as road lighting, billboard illumination, and security.

Furthermore, the need to showcase the historical, cultural, and aesthetic aspects of a city has brought urban lighting into the spotlight. Urban lighting not only serves functional purposes but also emphasizes the distinctive qualities of the city's architecture and ambiance (Dokuzcan, 2006). As a result, lighting applications should be designed to meet specific needs and serve their intended purposes effectively.

It is crucial to emphasize that a successful lighting design should take into account human psychology and physiology (Alişan, 2013).

According to Ataç (2008), one of the fundamental requirements for ensuring the well-being of individuals is the provision of a safe living environment. This necessitates not only the meticulous planning of physical spaces but also the deliberate inclusion of safety measures within urban planning. Inadequate lighting during the late hours of the night can transform urban areas into high-risk zones for criminal activities. Therefore, it becomes imperative to formulate urban spaces that prioritize safety as a means to mitigate crime and the associated fear that permeates the citizenry, as highlighted by Yenioğlu (2010).

In this context, lighting emerges as one of the most effective and appropriate reinforcing elements capable of fulfilling this crucial role in urban safety enhancement.

Incorrect or insufficient lighting installations not only fall short of establishing an aesthetically pleasing atmosphere but also lead to wasteful consumption of energy, as noted by Demircioğlu Yıldız and Yılmaz (2005). An effective lighting design seeks to provide the exact amount of illumination needed for a particular space (Güngör et al., 2019). It is evident and unequivocal that illuminating unoccupied areas or surpassing the necessary lighting levels in occupied spaces results in significant and unnecessary energy wastage, as emphasized by Rajkhowa (2014), Meier et al. (2014) and Güngör and Öner (2020).

In the present era, urban street lighting alone accounts for approximately 4% to 6% of a city's total energy consumption. However, when considering the energy expended on illuminating building facades, advertisements, and billboards, this percentage can escalate to as much as 10%. Research conducted by the International Dark Sky Association reveals that a concerning 30% of the energy consumed in these lighting practices is wasted (Çetin et al., 2003). This proliferation of misguided lighting approaches, flawed lighting system designs, and the underutilization of advancing lighting technologies has given rise to light pollution, which is now recognized as a significant form of pollution in the contemporary world (Önder and Konaklı, 2002).

In the fields of Landscape Architecture and Architecture, a noticeable deficiency exists in adequately recognizing the significance of light. Neglecting the pivotal role of light, which is an essential element in foundational design principles, across various applications can result in shortcomings in Landscape Architecture endeavors, as emphasized by Demircioğlu Yıldız and Yılmaz (2005).

It's worth noting that one of the crucial elements in landscape architecture is the inclusion of plants. The absence of adequate light or insufficient illumination can have detrimental effects on the vital life activities of plants, causing them to undergo stress. Therefore, light serves as the source of life not only for humans but also for plants and, by extension, for all living organisms, as articulated by Çorbacı et al. (2012).

Light pollution, a prominent urban environmental predicament, stands as a substantial ecological challenge that undermines landscaping initiatives. Light serves as a tool facilitating enhanced visual perception of our surroundings and cultivating a heightened sense of security among urban inhabitants. In succinct terms, the concept of "light pollution" pertains to the inappropriate deployment of light in terms of location, quantity, and form. The misuse of light encompasses superfluous energy wastage stemming from erroneous lighting designs (Kellert, 2008).

The primary objective of this study is to propose viable solutions addressing the challenges identified through a comprehensive analysis of outdoor lighting and light pollution, informed by a thorough examination of pertinent literature. The underpinning theoretical framework has been established by delving into subjects encompassing outdoor lighting's conceptual foundations, its established standards and methodologies, challenges encountered during both the design phase and practical implementation, along with the corresponding remedial measures. This exploration extends to artificial light sources, comparative evaluations of lighting sources, illumination master planning, and lighting techniques specific to urban parks.

The study endeavors to showcase the contemporary lighting project undertaken at the Butterfly Valley Park, situated within the confines of the Selçuklu District of Konya Province, and subsequently contrast it with a proposed park lighting project meticulously aligned with established standards. As part of the research scope, the areas within the park afflicted by inadequate lighting and light pollution were identified. Furthermore, the quantification of energy loss stemming from light pollution was computed using specialized software applications.

Material and Method

The main material of the research is Butterfly Valley Park located in Selçuklu District of Konya Province. Butterfly Valley Park (latitude and longitude) is located at 37° 56' 54.61", 32° 27' 42.45" coordinates. Located within the borders of Sille Parsana District, the park has an area of 385 thousand square meters. The location of Butterfly Valley Park is shown in Figure 1 with satellite images taken from Google Earth Pro and Konya City Guide application.

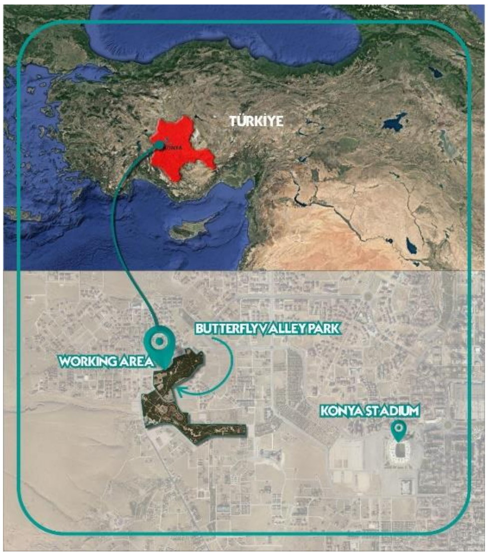

Figure 1. Google Earth Location of Konya and Butterfly Valley Park

To create the theoretical foundations;

The research material for this study comprises various sources and tools. These include the existing literature on the subject, structural and landscaping project documents obtained from the Butterfly Valley Park administered by the local government, lighting design projects, detailed plans, quantity survey files, and related materials. Additionally, data collected during face-to-face interviews, satellite imagery of the research area captured during both daytime and nighttime, photographs, catalogs, and information obtained from lighting element companies and online sources will be utilized.

In terms of software applications, the research will employ Autocad, Relux, Microsoft Office, Photoshop, Corel Draw, and, when necessary, SketchUp, Lumion, and 3D Studio Max computer programs to analyze, visualize, and present the research findings.

The utilization of lighting design software programs has significantly increased in recent times, with many programs now offering practical luminance measurement capabilities for the luminaires entered into the software, as noted by Erten (2014). To achieve higher levels of energy efficiency and savings, it is imperative to calculate potential gains accurately, especially during the preliminary phases of indoor and outdoor lighting design, as emphasized by Uygun and Görgülü (2016).

Compared to traditional mathematical methods, lighting calculations performed using computer programs result in fewer errors and yield more accurate outcomes, as mentioned by Buyukbicakci (2010). Furthermore, developing the lighting design of a project within a computer environment and conducting measurements using these tools not only saves time but also proves to be cost-effective (Dursun, 2005).

In this context, the Relux program has been chosen as the primary tool for this study due to its widespread use in recent years for lighting design and calculations. The Relux program allows the exchange of files with CAD-based programs in Windows metafile, dxf, 3ds, and ASCII formats. Additionally, ReluxCAD 2.0, which operates in AutoCAD versions from 2000 to 2022, generates drawings within the AutoCAD program and facilitates the transition to the Relux program for calculations. It's worth noting that the existing Reluxcad 2.0 is also compatible with AutoCAD 2022 (Işık, 2009).

To gather the necessary information for the study area, a comprehensive approach was employed. This involved examining multiple sources, including articles, projects, theses, papers, reports, maps, and other relevant documents, both from local and international contexts, related to fields akin to the subject of the study. The review of literature and documents encompassed several aspects, including the concept of lighting, the utilization of lighting in outdoor and open-green spaces, and general design standards. Furthermore, the research involved the examination of design and application examples derived from similar studies.

The initial phase of the research began with the delineation of the research area, a process that entailed clarifying the study's objectives and scope. The establishment of theoretical foundations was achieved through extensive reviews of both domestic and foreign literature.

The second stage of the research involved the creation of a current lighting project using the Relux software. This was accomplished by utilizing the existing lighting project of the research area to identify areas susceptible to light pollution and lighting deficiency. The identification of regions afflicted by light pollution and insufficiency was accomplished by superimposing the lighting maps obtained from the software.

Moving on to the third stage of the research, an energy efficiency assessment was conducted using the Relux software. Utilizing the consumption data acquired, comparisons were made between the current lighting situation and the proposed plan in accordance with established standards. Any potential energy losses during usage periods were quantified and assessed.

Finally, in the last stage of the research, an in-depth analysis of the gathered data was undertaken. Following the analysis, discussions, conclusions, and recommendations were formulated based on the outcomes of the study.

Consequently, the illumination levels for Konya Butterfly Valley Park were determined based on the existing lighting plan. The initial project parameters (lm/m²-lux) from the Autocad program were transferred to the Relux software for further calculations. The current lighting map for Konya Butterfly Valley Park was generated using the illuminance data obtained through the lighting software.

The positions of the lighting fixtures specified in the lighting project provided by the local government were integrated into the Relux program, taking into consideration the appropriate models, luminaires, and power specifications. Subsequently, all the luminaires within the software were activated. Ultimately, the current lighting map was formulated utilizing the calculation tools within the software. Throughout this process, the characteristics and brands of the luminaires were duly taken into account.

The luminance values, which were entered into the software based on the existing luminaire types, sizes, brands, and their respective locations within the park, were used to construct a luminance map. Subsequently, with the aid of the Relux software, all luminaires within the current lighting map were operated to generate an illuminance level map.

Photographs were taken both during the day and at night at various times within the park to ascertain the locations and types of luminaires utilized in the study area. The lighting elements in Butterfly Valley Park were evaluated with regard to their functional, aesthetic, and technical attributes, as well as their brightness levels and energy efficiency. These assessments were conducted in accordance with established standards for various park areas, including pedestrian and bicycle paths, recreational zones, children's playgrounds, sports facilities, flower gardens, seating and gathering areas, entrances, and parking lots.

Following the evaluation of the current lighting map and the proposed lighting map for Butterfly Valley Park, an analysis was conducted to determine the energy savings achieved by the park. Additionally, the daily and monthly electrical energy consumption was calculated and expressed in terms of the equivalent traditional TL (Turkish Lira) currency.

Results and Discussion

Established in 2015, Butterfly Valley Park is situated within the Selçuklu District of Konya Province. It is located within the confines of the Sille Parsana District and spans an expansive area of 38.5 hectares. The park boasts a notable attraction known as the Konya Tropical Butterfly Garden, which consists of four distinct components. These components include a production zone where each stage of the butterflies' life cycle, from pupa to expiration, is observed, an enclosed flight area, an open flight zone, and a butterfly museum. The park encompasses a vast expanse of 270 000 m² of green space, complemented by 105 thousand square meters of paved surfaces, and an additional 10 000 m² dedicated to aquatic features.

Furthermore, Butterfly Valley Park offers a diverse range of amenities, including an amphitheater, a miniature cinema, ponds, and water features, exercise equipment installations, children's play areas, circus, and go-kart sections, as well as a greenhouse. Figure 2 provides an illustration depicting the structural implementation plan of the designated research area, Butterfly Valley Park.

Figure 2. Butterfly Valley Park Structural Application Project

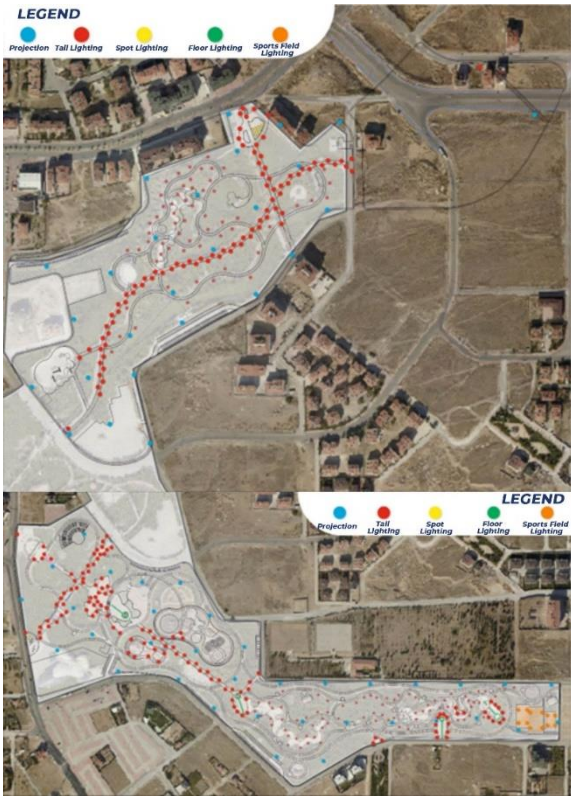

Figure 3. Locations of Existing Lighting Elements in Butterfly Valley Park

Butterfly Valley Park, situated within the open-green area framework of the Selçuklu district in Konya province, is conceived as a recreational destination catering to diverse activities and prioritizing elements such as accessibility. It was meticulously designed as a haven for repose and amusement, aligning with fundamental principles of park design.

In the landscape architecture design of Butterfly Valley Park, the layout was developed based on input and guidance from local authorities. As a result, the park's composition includes a total of 14 433 coniferous trees belonging to 7 distinct species, 10 956 broad-leaved trees representing 21 different species, 18 810 evergreen shrubs and bushes sourced from 23 diverse species, 5 699 foliage elements representing 19 various species of verdant shrubbery, and 50 875 ground cover flowers encompassing 6 discrete species. The park, with its vast green expanse covering 270 000 m², also features a vibrant flower garden adorned with a multitude of colorful botanical specimens.

Lighting Project and Current Situation of the Park

The lighting scheme for Butterfly Valley Park was conceptualized and executed by the Selçuklu Municipality. Subsequently, comprehensive assessments were conducted based on the received projects. The existing lighting fixtures within Butterfly Valley Park were visually documented, mapped, and categorized based on the observations made within the study area. This process involved on-site examinations, consultations with authorized individuals, and an examination of the provided lighting project.

The inventory of available lighting elements and their colors on the map are as follows:

- Tall Lighting – 208 poles length 4.5 m and power MHR-150W Bulb luminaire (Red)
- Projector – 62 pieces of mast length 20 m and power MHR-250W x 4 pieces of Bulb luminaire (Blue)
- Spot Lighting – 24 underground 27 cm above ground 23 cm and 5W luminaires (Yellow)
- Floor Lighting – 71 x 5W Power LED luminaires (Green)
- Field Lighting - 20 poles 6-12 m in length and 250Warmatur (Orange)

The distribution of the above luminaires in the Butterfly Valley Park;

- 208 number 1 lighting elements around the walkway,
- 62 number 2 lighting elements distributed homogeneously throughout the area,
- 24 lighting elements numbered 3, located under the trees in two different areas,
- 71 number 4 lighting elements used in squares,
- 20 number 5 lighting elements positioned on the poles inside the sports fields,

In Figure 3, the location of the lighting elements in the Butterfly Valley Park is shown with their colors.

Analysis of the Current Lighting Condition of the Park

While Butterfly Valley Park is a relatively recent addition, it has come to our attention that certain areas within the park suffer from inadequate lighting due to malfunctioning existing lighting fixtures. Conversely, areas where maintenance and repair have been carried out exhibit improved lighting conditions. Notably, the newly installed lighting elements showcase a modern aesthetic that seamlessly integrates with the park's design. These elements have been carefully sized and positioned in relation to pedestrian walkways, cycling paths, footpaths, green spaces, and trees, ensuring a harmonious blend with the park's natural environment.

However, the presence of high mast projectors scattered throughout the park has introduced an aesthetic imbalance, hindering the creation of a visually pleasing ambiance within the park. Concerning their installation, the lighting fixtures in Butterfly Valley Park are anchored to concrete bases, but a discernible pattern in their arrangement is lacking. Upon activating the existing lighting fixtures in the Relux program, the resulting visual representation corresponds to the depictions presented in Figure 4 and Figure 5.

Proposal Lighting Project for Butterfly Valley Park

The results generated by activating the lamps positioned throughout the design layout and analyzed using the Relux software are illustrated in Figure 6. With all the lamps illuminated, the cumulative luminous flux emitted by the lamps amounts to 5,167,812.00 lumens, and the total power consumption measures 27,630.0 watts (W).

The inventory of the proposed lighting elements and their colors on the map are as follows:

1. Tall Lighting – 261 poles length 4.5 m and power MHR-30W Bulb luminaire (Red)
2. Projector – 10 pieces of mast height 20 m and power MHR-250W x 4 pieces of Bulb luminaire (Blue)
5. Field Lighting - 12 poles length 6-12 m and 200 W luminaire (Orange)

General

Calculation algorithm used	: Average indirect part
Maintenance factor	: 0.80
Total luminous flux of all lamps	: 5167812.00 lm
Total power	: 27.630.0 W
Total power in the area (1064972.00 m²)	: 0.03 W/m²/ (100lx)

Energy Gains Obtained from Butterfly Valley Park with Proposal Lighting Project

With the preparation of current and proposed lighting maps of Konya Butterfly Valley Park, the electrical energy consumed in the park was calculated. When the amount of power consumed as a result of the current and recommendation map prepared in the Relux program is compared, it has been revealed that the total power obtained with the recommendation map is approximately 1/3 more efficient than the current one (Table 1). The proposal lighting project, prepared in accordance with the standards, reveals the importance of the study as it brings energy efficiency to the fore and saves energy, which is one of the current problems of the study.

In the current lighting project, the total power consumed as a result of the lighting of all the lamps of the area has been calculated as 96005.0 W. In the proposed lighting project, the total power consumed as a result of the burning of all lamps was calculated as 27630.0 W. The obtained energy gain was found to be 96005.0 W – 36700.0 W = 68375.0 W.

As a result of the power consumption over a 1-hour period in the project, the energy consumed in 1 hour amounts to 27 630 watts (W). The calculation conducted for the month of August, which is typically when parks are most frequently used, yields a total energy consumption of 273 500 W between the evening hours (21:00-01:00), multiplied by 4, to be 1 093 000 watts or 1 093 kW for 1 day. Consequently, the electrical energy consumed over 1 month is calculated as 1 093 kW multiplied by 31 days, which equals 33 883 kW or 33 883 000 watts.

Figure 4. Night Intensity Map of Existing Illuminations

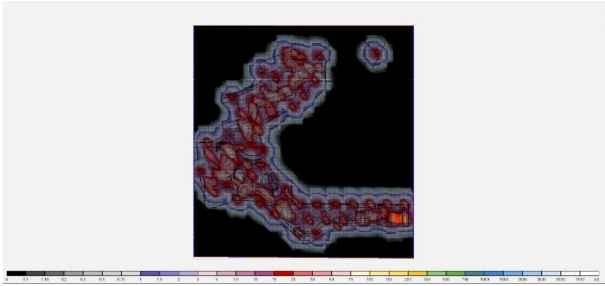

Figure 5. Illuminance Level Map of Existing Illuminations

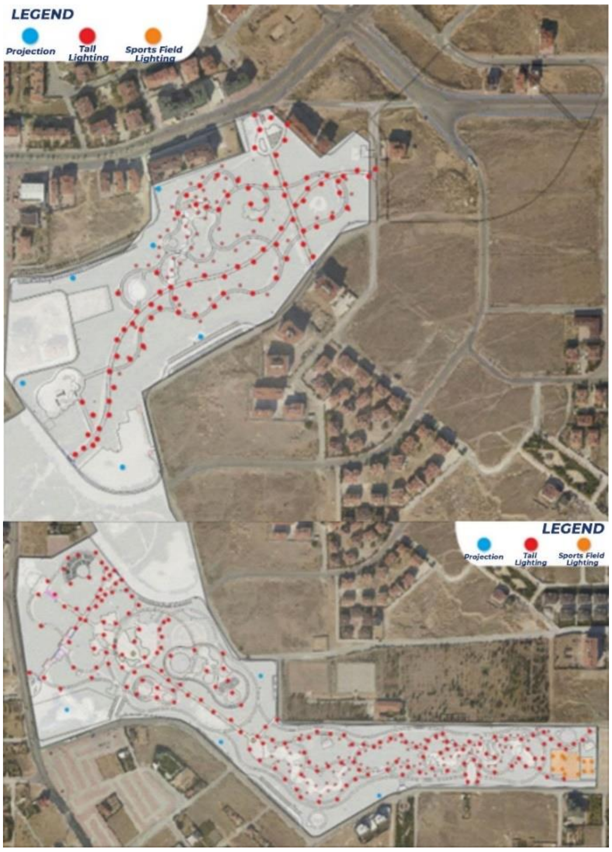

Figure 6. Locations of Butterfly Valley Park Proposed Lighting Elements

In accordance with the market prices obtained from MEDAŞ (Meram Electricity Retail Sales Joint Stock Company), it is evident that for 1 watt of electrical energy used within the park, up to 240 kWh costs 1.37 Turkish Lira (TL), and beyond 240 kWh, it costs 2.06 TL (1 kW equals 1000 watts).

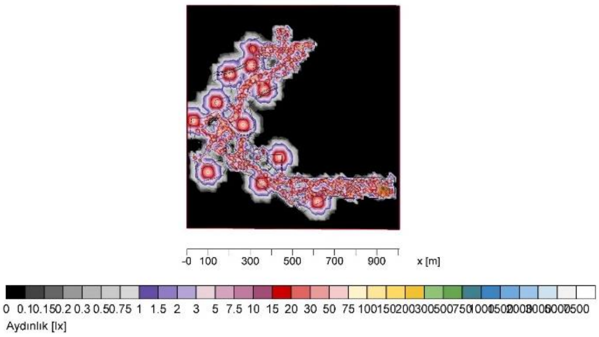

Figure 7. Settlement and Illuminance Levels Map of the Proposed Lighting Project

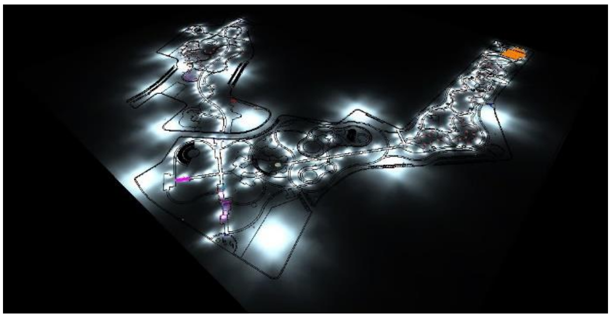
Figure 8. Light Intensity Map of the Proposal Lighting Project

Table 1. Current and Proposed Lighting Map Total Power Outputs

	Calculation Algorithm	Maintenance Factor	Total Luminous Flux (lm)	Total Power (W)	Total Power in Area
Available Lighting Project	Average indirect part	0.80	7529092.00 lm	96005.0 W	0.09 W/m² (1.77 W/m²/100lx)
Suggestion Lighting Project	Average indirect part	0.80	5167812.00 lm	27630.0 W	0.03 W/m² (0.87 W/m²/100lx)

Therefore, the earnings for August were calculated as 33 883 000 watts (or 33 883 kW) multiplied by 2.06 TL, which amounts to 69 712.98 TL. In light of this result, the 1-month revenue generated by a lighting application developed in compliance with energy efficiency and standards is approximately 69 712.98 TL. This highlights the significance of preparing the lighting design during the project phase in alignment with energy efficiency guidelines and standards, which can help prevent unnecessary expenditures and energy losses.

Conclusion and Suggestions

Urban lighting design should functionally meet the sense of sight, which is one of the most basic needs of people at night, and create a sense of visual comfort and security for the people of the city. In terms of aesthetics, it enables the citizens to benefit from visual and aesthetic values in terms of urban memory and silhouette by making urban elements visible and understanding at night as well as during the day. The use of urban areas in the evening and at night as well as during the day depends on the security it creates. At this point, the level of illumination should be at a sufficient level in order to ensure the security of the park and to perceive the park in the best way. This lighting level is set out within the scope of the project. However, within the scope of the thesis, it has been observed that energy saving and cost remain in the background in the lighting design and applications made for the park.

It has been determined that the illuminance levels provided by the currently used lightings are at a higher level than the proposal map, and it has been observed that there are negative situations in terms of energy efficiency. As a result of the cost calculation of energy losses, it has been revealed that there are significant expenditures for local governments.

The study investigated the compliance of Konya Butterfly Valley Park with park lighting criteria and standards, revealing that the landscaping areas were not illuminated in accordance with the specified standards and criteria. Negative outcomes in terms of user and visual comfort were observed not only during the design and implementation phases but also in the usage phase. When comparing the existing lighting project with the proposed lighting project, approximately a 1/3 energy savings and cost savings were achieved with the proposed lighting project.

For the Butterfly Valley Park (Konya), first of all, the extra lighting elements should be removed, and the values for the brightness levels should be increased in the areas that we call blind spots and which create a feeling of insecurity. In some areas, the illuminance levels should be increased, and while doing this, attention should be paid to obtaining the appropriate quality of light. While making these applications, attention should be paid to energy efficiency, and LED luminaires that are suitable for today’s modern age and consume less energy should be used. In urban design and applications to be made, cooperation with local governments should be done and regulations, specifications, etc. The use of energy-saving luminaires with high efficiency should be expanded in documents.

In the Butterfly Valley Park, there are security-related problems in areas that are not illuminated. In order to solve this trust problem and to create a suitable design, the number of lighting elements should be increased where necessary. In this way, the areas remaining in the blind spot should be illuminated. Square in the park, etc. Attention should be paid to the illumination levels of meeting areas, playgrounds used by parents and children, and sports fields in accordance with the standards, and the lighting design should be made in the most appropriate way and the necessary lighting elements should be used. Since safety is one of the most important issues in children’s playgrounds, lighting with 250W luminaires on 12-meter poles with high IP feature will be appropriate in terms of design. In order to avoid blind spots, the luminous intensity should be between 15-50 lux. Pedestrian, walking and bicycle paths, which are the areas most frequently used by park users, should also be adequately illuminated. The entrance, pedestrian and bicycle paths should be less than 5-10 lux illuminated. It is very important that the areas they mostly use are bright so that visitors feel safe in the park. Some errors were observed in the lighting of the plant materials in the Butterfly Valley Park. These vegetal areas should be illuminated from top to bottom in a way that does not reflect the eye, while also adding visuality to the foreground. If tree lighting is done to create a focal point and emphasis, positive results will emerge in the park in terms of aesthetics. In addition to all these, considering the ecological condition of the trees, high voltage lamps should not be used. Therefore, it should be arranged so that the maximum luminous intensity for trees is 5 lux. Sitting areas, which are another frequently used area, should be illuminated with a luminous intensity of 15-20 lux so that visual comfort can be provided to the visitors who spend time sitting. In the lighting design to be made, besides the amount of light of the luminaire, its angle, spread and aesthetic values should be taken into consideration.

In the existing lighting design of the park, a special lighting design for the entrance could not be found. Therefore, a suitable entrance lighting design should be made and entrances should be emphasized. Since the park has entrances and exits to be zero to the street, lighting design should be done considering the vehicles passing through the street. When the entrances of the park are designed with appropriate lighting, it will be more comfortable to perceive and will separate the park from other urban areas. In addition, the entrance-exit lighting is very important in terms of guiding the visitors who come to the park at night. In the current design, attention should be paid to the positions of the lighting elements intertwined with the plants during the application and design phases, and the project phases should proceed in sync.

In order for the lighting elements in the park to have a positive effect in terms of visual, aesthetic and functional, their maintenance should be done regularly and new ones should be replaced with damaged, broken or irreparable elements. Lighting elements that can be easily mounted and intervened in case of any malfunction should be preferred during the design phase.

In the design process of lighting elements, lighting master plans prepared in line with urban analysis should be used. All decisions should be taken on the basis of basic urban data obtained in line with the plan, such as the region of the urban area where the element will be used, its location in the city, physical environmental conditions and areas of use, the location of the lighting elements in the area, their detection forms, numbers, sizes, etc. data should be evaluated.

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References

Alişan B. 2013. İstanbul'daki Tarihi Vapur İskelelerinin Dış Cephe Aydınlatması Açısından Değerlendirilmesi ve Ortaköy Vapur İskelesi Örneği. Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü, İstanbul Teknik Üniversitesi, İstanbul, Türkiye.

Aksay CS, Ketenoğlu O, Kurt L. 2007. Işık Kirliliği. Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi. 7(2), 231-236.

Ataç E. 2008. Kent, güvenlik ve güvenli kent planlaması; Bursa örneği. Yayımlanmamış Yüksek lisans tezi. Gazi Üniversitesi, Ankara.

Büyükbıçakcı Z. 2010. Bilgisayar Destekli aydınlatma programlarının aydınlatma tekniğindeki Yeri ve önemi. Doktora Tezi, Fen Bilimleri Enstitüsü, Marmara Üniversitesi, İstanbul, Türkiye.

Çetin FD, Gümüş B, Özbudak YB. 2003. Işık Kirliliği Problemi ve Diyarbakır Ölçeğinde İncelenmesi. TMMOB Elektrik Mühendisleri Odası Ulusal Aydınlatma Sempozyumu ve Sergisi, Diyarbakır.

Çorbacı ÖL, Duran Gökalp D, Göker P. 2012. İç Mekanda Bitkilerle Tasarımda Işığın Önemi, Eğitim Odağında Artvin Sempozyumu Bildirileri II, s. 211-222.

Dokuzcan H. 2006. Işık Kirliliği Açısından Kent Aydınlatması ve Taksim Meydanı Örneği

Dursun B. 2005. Dahili Ortamlarda Aydınlatma Hesaplama Tekniklerinin Analizi ve Bir Uygulama Örneği. Doktora Tezi, Fen Bilimleri Enstitüsü, Marmara Üniversitesi, İstanbul, Türkiye.

Erten ŞY. 2014. Aydınlatmada enerji verimliliğinin incelenmesi: Endüstri yapısı örneği. Yüksek Lisans Tezi. Fen Bilimleri Enstitüsü, Trakya Üniversitesi, Edirne, Türkiye.

Güngör S, Polat AT, Demir M. 2019. Investigation of Positive and Negative affect of Plants and City Furnitures By Design Criteria of Landscape Architecture In The Main Transportation Arteries of Afyon/Turkey. Uluslararası Peyzaj Mimarlığı Araştırmaları Dergisi (IJLAR) E-ISSN:2602-4322, 2(1), 07–14. Retrieved from https://ijlar.org/index.php/ijlar/article/view/135

Güngör S, Öner B. 2020. The Change in Recreational Activity Usage in the Normalization Process After Covid-19 and Individuals' Cravings for Urban Green Areas. Turkish Journal of Agriculture - Food Science and Technology, 8(sp1), 8–12. https://doi.org/10.24925/turjaf.v8isp1.8-12.3889

Işık U. 2009. Aydınlatma programlarının gelişmiş ışık simülatörleri ile olan ilişkisinin değerlendirilmesi.

Kellert SR. 2008. Dimensions, elements, and attributes of biophilic design. Biophilic design: the theory, science, and practice of bringing buildings to life, 3-19.

Meier J, Hasenöhrl U, Krause K, Pottharst M. (Eds.). 2014. Urban lighting, light pollution and society. Routledge.

Önder S, Konaklı N. 2002. Görsel kirlilik ve Konya kenti örneğinde incelenmesi üzerine bir araştirma. Selcuk Journal of Agriculture and Food Sciences, 16(30), 28-37.

Rajkhowa R. 2014. Light pollution and impact of light pollution. international Journal of Science and Research (IJSR), 3(10), 861-867.

Yenioğlu F. 2010. Kent parklarında aydınlatma elemanlarının kullanımının peyzaj mimarlığı açısından irdelenmesi: Ankara-Altınpark örneği.

Yıldız ND, Yılmaz H. 2005. Işık kirliliği, ortaya çıkardığı sorunlar ve çözüm önerileri. Atatürk Üniversitesi Ziraat Fakültesi Dergisi. 36(1), 117-123.

Uygun E, Görgülü S. 2016. Daylight simulation performance comparison of DIALux and RELUX Illumination simulation programs. The Journal of Graduate School of Natural and Applied Sciences of Mehmet Akif Ersoy University. S1, 1-8.