Research Article

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# Evaluation of the Lighting Energy Performance of Educational Buildings with BEP-TR Methodology: The Case of ERU Faculty of Architecture

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***Keywords:***
*BEP-TR, energy efficient lighting, educational buildings, artificial lighting*

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## Abstract

As part of energy efficiency and conservation measures, central and local governments have developed various action plans, international commitments, calculation models, regulations, standards, and certificates and arrangements. Building Energy Performance (BEP-TR), a national calculation method developed according to the conditions of Turkey, is one of them. With BEP-TR, the energy efficiency of the building is measured in existing or alternative situations. In public buildings, the issue of energy efficiency is vital in terms of being an example. In the framework of this study, the Faculty of Architecture of Erciyes University as an educational and public structure was selected as the study area. Lighting is essential in electricity consumption in public buildings, especially educational establishments. This study aims to guide the energy efficiency principles and lighting design on the axis of comfort-cost and consumption for all public buildings, especially educational buildings, by emphasizing that the concept of energy efficiency should be handled multi-dimensionally with its various layers. Current state data to measure using the BEP-TR will be assessed if the lighting is energy efficient, according to visual comfort needs. Lighting energy consumption values were recalculated by checking the alternatives, simulations, and visual comfort criteria developed concerning energy efficiency. With the revision of the lighting design, the amount of savings to be realized by the system that meets the requirements for visual comfort was calculated. While the improvements proposed in the study were handled under the title of the artificial lighting system, other parameters were kept constant. In improvements alternatives, while offering a physical and psychological enhancement for users, it also saves energy in public buildings and bring an ecological proposition to reduce the carbon footprint for nature. Considering the proposal in the context of comfort-consumption-cost and amortization. The calculation of how long the initial investment cost will be amortized with the amount of savings has been made using three different methods. The study shows originality in responding to the designer's aesthetic concerns with the multi-dimensional inputs of energy efficiency.

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## INTRODUCTION

The protection of natural and cultural heritage, urban and environmental values, and observance of the principle of priority of public and public interest are the necessity of the obligations of scientists, especially architects, to society and the essential parts of professional ethics. In our world, where resources are rapidly running out, the energy needed and used is rapidly increasing. Accordingly, the deterioration of the ecosystem balance and the economic dimension of energy costs have also led to new approaches to both the conservation of environmental values and the efficiency of energy use. Terms such as sustainability, energy efficiency, green energy, and green buildings appear in both practice and legal regulations as the results of the processes mentioned [Ozyurt and Kutluay, 2009].

Energy consumption is a significant problem with its cost and environmental impact on a global scale. In order to prevent this problem, it is imperative that energy is consumed as little as possible and that the consumed energy is obtained from renewable sources. A system proposal is needed for the supply of this supply. In particular, studies on the efficient use of electrical energy have gained importance in recent years. Therefore, regulations, standards, and energy performance certification systems are being developed to determine energy performance in countries [Kucuk, 2019], such as the Rio Protocole, the Kyoto Protocole, the Paris Agreement, the European Union Green Deal, and test tubes. The Paris Agreement has been an indicator and the most concrete initiative of the effort of a global climate change fight with Intended Nationally Determined Contributions - INDC of 189 countries responsible for approximately 98% of greenhouse gas emissions [UNEP, 1972]. In order to reduce climate change, INDCs have been determined for each state by international agreements [Hamilton et al., 2021]. The steps of the European Union to combat climate change continue with the European Green Deal (EGD) after the Paris Agreement [Sahin and Onder, 2021]. EGD aims to transform European Union countries and citizens into a fair and competitive environment with zero greenhouse gas emissions by 2050 [Cayiragası and Sakacı, 2021]. These targets have been shaped toward the United Nations Sustainable Development Goals, covering 2015 – 2030 [United Nations, 2015a]. Sustainable Development Goals (SDGs) were adopted as an international action plan at the General Assembly of the Nations held in September 2015. For a comprehensive future vision, 17 SDGs and 169 associated targets have been identified [Europe Sustainable Development Report, 2020]. The SDGs for Europe are expressed as a commitment to guide sustainable development [Europe Sustainable Development Report, 2020]. The common theme in all these agreements is energy-efficient sustainable development [Idowu, Schmidpeter & Zu, 2020; Barbier, 2019]. The European Green Consensus has emerged to meet the European Union's vision of a typical "green growth" strategy;



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the definition of "reaching climate neutrality at the continental scale" was used for this agreement [Desouza, 2020; Storm, 2020].

However, central and local governments put forward various action plans and agreements within the scope of energy efficiency and saving measures. For example, following the 2002/91/EC regulation for the calculation of lighting energy by the EU, EN 15193 Energy Performance in Buildings-Lighting Energy Requirements standard has been published [DEPB, 2002/91/EC] because lighting energy needs are also components that significantly affect the electrical energy consumption of buildings [Sumengen, 2015].

The economic dimension of saving measures in energy consumption is essential for local governments. Promulgated in the official gazette on the date of August 16, 2019, according to the Presidential Circular, in order to use public resources efficiently and to reduce the burden of energy costs on the public sector of public buildings by the end of 2023 seems targeted to 15 percent energy saving [Energy Saving in Public Buildings, 2019]. One of these savings measures is undoubtedly lighting energy.

In 2018, the Ministry of Energy and Natural Resources, General Directorate of Renewable Energy, published the Energy Efficiency Survey Implementation Monitoring Report in Public Buildings. In this report, within the scope of savings potential, structures such as schools, student dormitories, teachers' houses, universities, hospitals, administrative buildings, airports, and prisons, which are affiliated with the Republic of Turkey Ministry of National Education(MNE), which cover the majority of public buildings, are discussed under seven headings [Energy Efficiency Survey Implementation Monitoring Report in Public Buildings – I, 2018]. In order to show the quantity of the savings measures to be taken, there are more than one hundred thousand educational institutions in Turkey as of 2020, serving only institutions and organizations affiliated with YOK and MEB [MEB, 2020]. However, within the scope of the research, only 72 schools affiliated with MEB, 359 buildings affiliated with these schools, nine universities, and 180 buildings affiliated with universities were examined. Lighting is the essential energy consumption item in universities, MNE-affiliated schools, student dormitories, teachers' houses, and prisons. It is the second most crucial item in Administrative Buildings [BEP-TR, 2010].

Erciyes University (ERU) Faculty of Architecture, education, and public structure were chosen as the study area in this paper. The study is a quantitative research subject, and a causal-comparative method was followed. Within the scope of the study, it was desired to examine the current working area in terms of energy efficiency with the BEP-TR calculation model. For this, it is necessary to examine whether the lighting of the current situation provides visual comfort requirements.

Visual comfort requirements are the essential requirement for lighting energy performance when measuring lighting energy performance. Visual comfort conditions are required to improve visual and spiritual performance in educational structures, keep learning performance high and increase motivation and working productivity. In this context, determining lighting performance is a comprehensive and detailed method that allows one to examine the behavior of lighting in the interior space and the lighting of the building in a quantitative and qualitative context [Kucuk, 2019]. Therefore, in the scope of the study, the visual comfort conditions provided by the existing lighting system were determined, and the annual lighting energy consumed was calculated based on the BEP-TR method. In order to provide visual comfort conditions, the current situation with the standards was evaluated, and alternative lighting system suggestions were developed by making revisions according to energy-efficient lighting principles to reduce lighting energy consumption. By making cost analyzes of the proposed revisions, the importance of multidimensional handling of the concept of energy efficiency has been revealed in the context of comfort-consumption-cost. Suggested improvements; within the scope of the artificial lighting system, other parameters such as daylight factor, geographical location, orientation, control systems, usage hours, and spatial features are kept constant in the study.

The study includes general information and literature studies; lighting was examined within the scope of concept studies and energy efficiency principles. There is a field study, and the current levels of illumination in the spaces were calculated using simulations using the DiaLux program, depending on the lighting elements in the spaces in the selected area, the colors of the materials selected in the spaces, and the preferred colors on the surfaces. At the same time, lighting energy consumption was determined by the BEP-TR method, and all aspects of the current situation were considered by evaluating whether the data of the current situation met the visual comfort requirements according to the standards.



This assessment utilizes energy-efficient and cost-efficient lighting system designs for energy-efficient light sources to determine the selection of lighting fixtures typology, mounting methods, visual comfort conditions and psychological design alternatives have been developed. Following a similar method in this alternative lighting design proposal, the visual comfort criteria were checked with the help of simulations, the lighting energy consumption was determined with the BEP-TR method, and the values were calculated. Also, the cost-performance analysis of these calculations' energy-efficient improvement proposals is examined. As a result, the lighting design revision was implemented in real terms, and the process was documented with the help of visuals. As a result of these calculations and evaluations, this study; underlines that the concept of multidimensional efficiency should be handled with its various layers; it is aimed to be a guide for all public structures, especially educational ones.

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## CURRENT SITUATION ANALYSIS OF LIGHTING DATA IN RELEVANT SPACES

The structure chosen as the study area in order to evaluate the efficiency of lighting performance data in educational buildings is the Erciyes University Faculty of Architecture. Shown in Figure 1, there is the site plan of Erciyes University Faculty of Architecture. The Faculty of Architecture is located at 38.711013 North Latitudes and 35.537286 East Longitudes at an altitude of 1092 m.

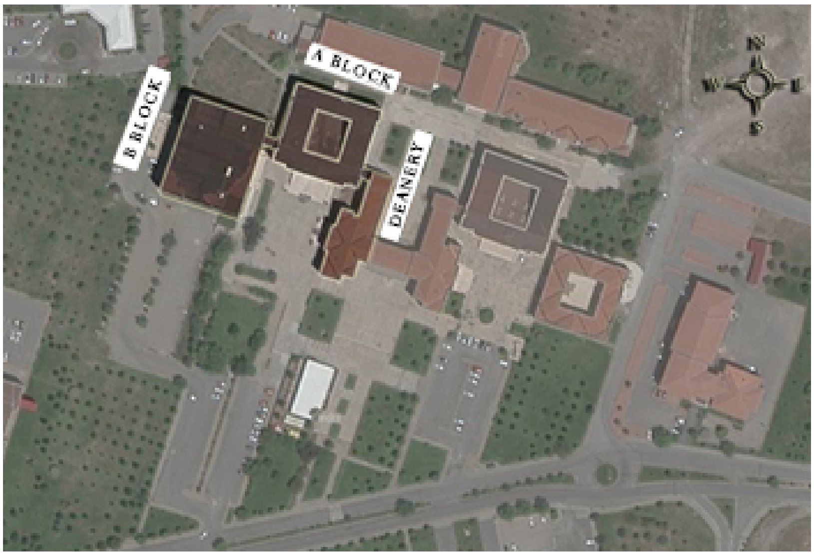


**Figure 1.** Erciyes University Faculty of Architecture Satellite Figure



It was designed as a complex with the transitions established on the first floor of three separate buildings, A Block, B Block, and Dean's Office, to surround the ceremonial area in the southwest of the Faculty of Architecture and is located in the northeast of Erciyes University Melikgazi campus, in the west of the Faculty of Fine Arts, again with the transition to the Faculty of Fine Arts. Within the scope of our study, the Dean's Office of the Faculty of Architecture was excluded from the scope, and the A and B Block buildings were discussed. The reason for choosing the A and B Blocks in the Faculty of Architecture building complex is that the courses that require attention, such as architectural education, are taught in the classrooms and studios of these blocks. There are educational spaces with lots of different functions within these blocks. Since the units in educational buildings are spaces used throughout the day, they should have adequate and uniform lighting. In order to obtain information about the general illuminance level of the building, spaces with different functions were selected. Along the relevant floors are classrooms, studios, seminar hall, archive rooms, library, rooms for teaching staff, specialized units, interior canteen, security room, club rooms, laboratories, exhibition rooms, and wet areas. Light colors are generally used on walls, floors, ceiling surfaces, and furniture in the work area. Except for the studios on the second floor of Block A, daylight is provided to the spaces through the window openings on only one wall, shown in Figure 2, views of Erciyes University Faculty of Architecture.

**Figure 2.** Views of Erciyes University Faculty of Architecture

It was designed as a complex, including two educational buildings and an administrative building. These three structures were designed to form a courtyard:

Administrative building: It was named the Dean's Office, its entrance was placed east of the courtyard, and its entrance was taken from the west side of the building.

Block A, the education building, is located north of the courtyard and has its entrance from the south side of the building.

Block B is located west of the courtyard and receives its entrance from the eastern part of the building in a controlled manner. This entrance, which is mostly closed due to security measures, is accessible from the first floor of Block A. The transition between Block A and the Dean's Office is also located on this floor.



As shown in Figure 3, There is a circulation area and archive rooms in the second basement (SB) floor plan of Block A, which has a floor area of 781 m2. There are 8 units on the floor with a floor height of 2.50 m. SB floor of Block B has a floor area of 756 m2, with a floor height of 2.50 m.

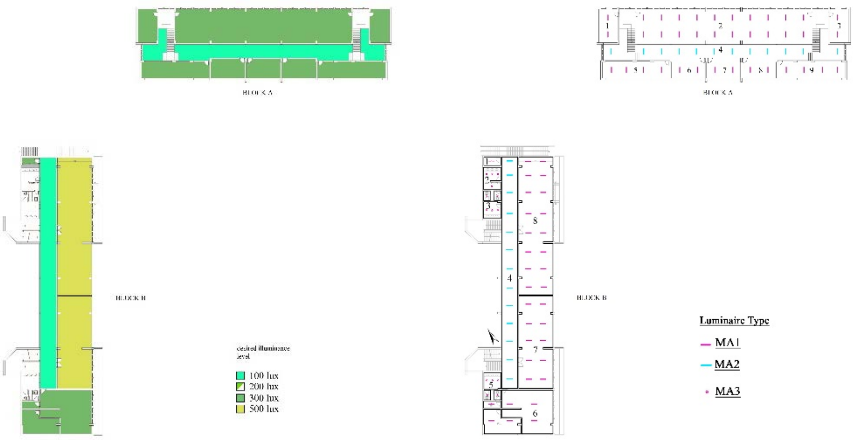


**Figure 3.** Second Basement Floor Plan and Existing Artificial Lighting Layout

Figure 4 shows studios located symmetrically around the basement(B) inner courtyard/hall of Block A with a floor area of 1793 m2. The studios have an area of 250 m2, and the space height is h=4.30 m. 17 ribbed beams are used along the ceiling, and artificial lighting is provided with the existing luminaire placed on the surface between the beams with a height of 60 cm. On the ground floor of Block A, there are

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two symmetrical wet areas and corridors leading to these areas. In the basement of Block B, which has a floor area of 2725 m2, studios are located symmetrically around the inner courtyard/hall. These studios have an area of 255 m2, and the space height is h=4.30 m. The floor heights in the corridor where the stairs to the west and east of the studio lead are 2.80 m. Classrooms are located in the east of Block B. In the west of Block B, the rooms between the wet areas and the stairs are used as storage areas.

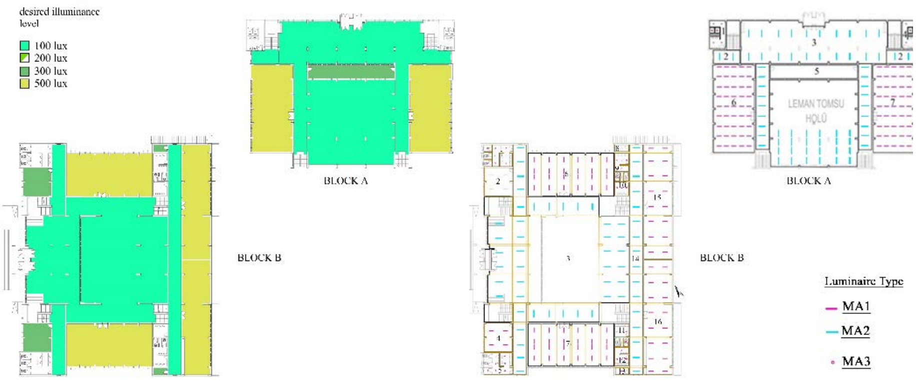


**Figure 4.** Block Basement Floor Plan and Existing Artificial Lighting Layout

Shown in Figure 5; at the ground floor level of Block A, which has a floor area of 703 m2. The floor height is 2.80 m. The ground floor area is 2280 m2. The floor height is 2.80 m, excluding studios and seminar halls. The studio's floor height is 4.30 m, and the maximum height is 4.30 m in the seminar hall.



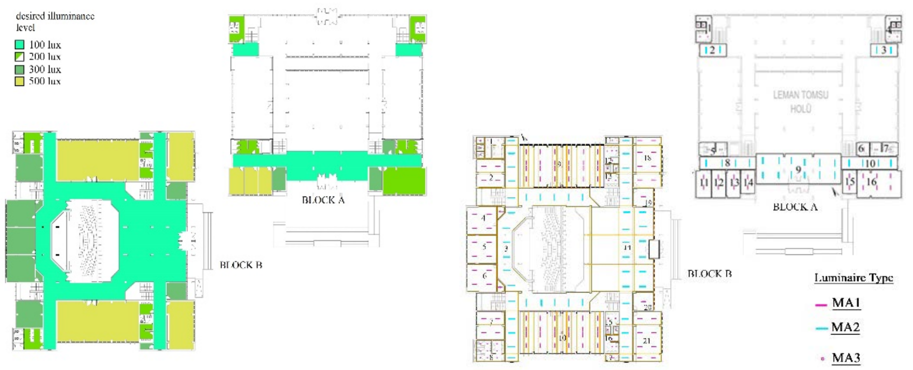


**Figure 5.** Ground Floor Plan and Existing Artificial Lighting Layout

It is shown in Figure 6, On the first floor level of Block A with a floor area of 2099 m2. The floor height is 4.30 m in the studios and the corridors between the atrium and the studios, while the floor height in other areas is 2.80 m on the first floor with a floor area of 1494 m2. The floor height is 2.80 m, excluding the seminar halls.

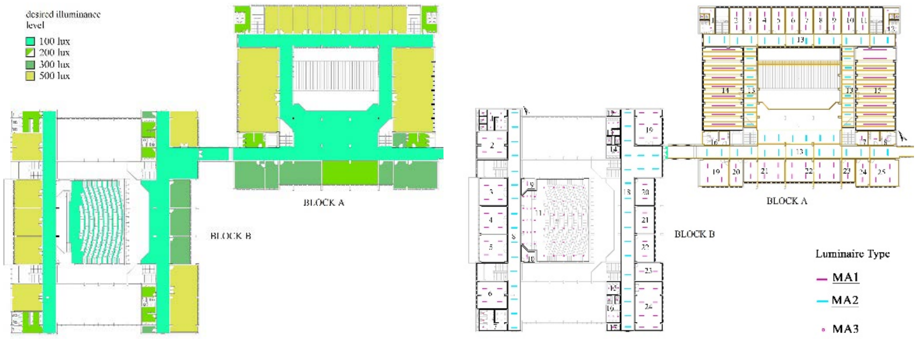


**Figure 6.** First Floor Plan and Existing Artificial Lighting Layout

On the second floor level of Block A, which has a floor area of 1884 m2. While the top floor height is 3.30 m in studios, it is 2.80 m in other areas. Shown in Figure 7; on the second floor with a floor area of 1962 m2. The top floor height is 3.30 m due to the roof. First of all, the spaces are handled separately in different blocks and on different floors, and the value of the illuminance level they need according to the quality of the units is shown.

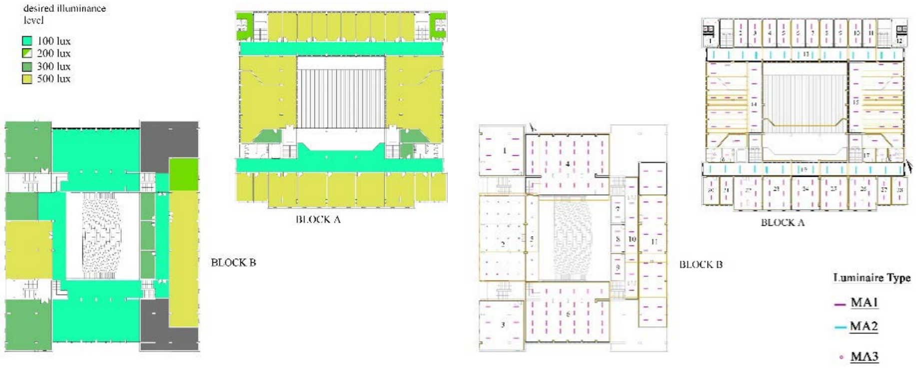


**Figure 7.** Second Floor Plan and Existing Artificial Lighting Layout



Some spaces in A and B Blocks are actively used during the months of September-June, as some spaces are used by administrative and academic staff throughout the year, and some spaces are reserved for the use of undergraduate and graduate students. Sufficient and uniform lighting is generally required for units in educational buildings. In this study, the data on the desired illuminance levels in the standards referenced within the scope of BEP-TR will be taken as a basis to meet the required visual comfort conditions in the spaces. As seen in Table 1, the building is designed at different elevations for different ceiling height requirements.

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**Table 1.** Block A General Information

| Floor | Units – Rooms | Height (m) | Units | Height (m) | Total Area ($m^2$) |
|---|---|---|---|---|---|
| SB | Circulation area and archive | 2.50 | - | - | 781 |
| B. | Wet areas, corridors, passage and entrance | 2.80 | Studios, corridors | 4.30 | 1793 |
| Ground (G) | Entrance, wet areas, personal offices, cleaning, security, photocopy and stationery | 2.80 | - | - | 703 |
| First (F) | Personal offices, atrium, wet areas, cleaning, administrative, staff and canteen | 2.80 | Studios, corridors | 4.30 | 2099 |
| Second (S) | Personal offices, wet areas, cleaning, classrooms. | 2.80 | Studios (at Loft) | 1.60-3.30 | 1884 |

In the proposal for the improvement of the A-Block lighting system, in units with a floor height of 2.80 m in general, surface-mounted(SM) LED luminaires were proposed instead of surface-mounted, ceiling-mounted(CM) luminaires. In order to reduce the distance between the working plane and the luminaire in the spaces with a ceiling height of 4.30 m, 1 m suspended LED luminaires are recommended. LED luminaires are also recommended in wet areas. The number of devices has been revised in accordance with visual comfort requirements.

As seen in Table 2, Block B is designed at different elevations for different ceiling height exigency.



**Table 2.** Block B General Information About Floors

| Floor | Units - Rooms | Height (m) | Units | Height (m) | Total Area ($m^2$) |
|---|---|---|---|---|---|
| SB | Classrooms | 2.50 | - | - | 756 |
| B | Wet areas, corridors, passage and entrance | 2.80 | Studios, | 4.30 | 2725 |
| G | Entrance, club rooms, waiting, wet areas, administrative staff and classrooms. | 2.80 | Studios, seminar hall, | 4.30 | 2280 |
| F | Seminar hall seating areas, graduate classrooms, waiting, wet areas, administrative staff and classrooms. | 2.80 | - | - | 1494 |
| S | Library, technical, computer lab, blueprint and two unfunctional. | 2.80 | Studios (at Loft) | 1.60-3.30 | 1962 |

*SB: Second Basement, B: Basement, G: Ground, F: First, S: Second.*

In the B Block lighting system improvement proposal, in units with a floor height of 2.80 m generally, SM LED luminaires were proposed instead of SM, CM luminaires. In order to reduce the distance between the working plane and the luminaire in the spaces with a ceiling height of 4.30 m, 1 m suspended LED luminaires are recommended. LED luminaires are also recommended in wet areas. The number of devices has been revised following visual comfort requirements [BEP-TR, 2010]. Educational Buildings require a different illuminance level and color rendering for each unit. As can be seen in Table 3, such as at corridors and circulation areas, an illuminance level of 100 lux and color rendering of 80 is required. For exhibition rooms, canteen, toilets, and shelf spaces of libraries illuminance level of 200 lux and color rendering of 80 are required; at the foyer, other living rooms, seminar audience areas, auxiliary spaces (archive, etc.), technical rooms, warehouses are required illuminance level 200 lux, color rendering 80 is required. At studios, classrooms, personal offices (single person), library reading rooms, and seminar presentation areas illuminance level of 500 lux and color rendering of 80 are required [BEP-TR, 2010]. The desired illumination level is high in places that require attention and in places where active lessons are held.

**Table 3:** The Required Illuminance Levels in Spaces on the Scope of BEP-TR

| Spaces | Colour Rendering | Illuminance Level |
|---|---|---|
| Corridors and Circulation Areas | 80 | 100 |
| Exhibition Rooms, Canteen, Toilets, Shelf Spaces of Libraries | 80 | 200 |
| Foyer, Other Living Rooms, Seminar Audience Areas, Auxiliary Spaces (Archive etc.), Technical Rooms, Warehouses | 80 | 300 |
| Studios, Classrooms, Personal Offices (Single Person), Library Reading Rooms and Seminar Presentation Areas | 80 | 500 |

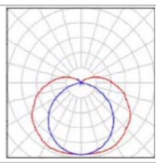
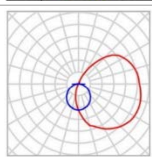
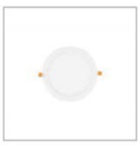
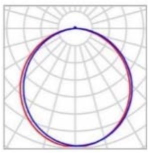
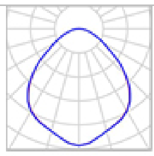
**Table 4:** Existing Artificial Lighting Fixtures and Attributes in the Work Area

| Name | Dimensions (m) | Power (W) | Luminous Flux (lm) | Type | Mounting Location |
|---|---|---|---|---|---|
| MA1 | 1,20 x 0,14 x 0,10 | 72 | 4095 | SM | CM |
| MA2 | 1,20 x 0,056 x 0,06 | 36 | 2397 | SM | CM |
| MA3 | 0,30 x 0,30 x 0,014 | 24 | 1706 | SM | CM |
| MA4 | 0,307 x 0,307x 0,43 | 15 | 442 | Stalactite | 50 cm from the Ceiling |

SM: Surface Mounted CM: Ceiling Mounted



**Table 5:** Characteristics and Luminous Intensity Distribution Diagram of Existing Artificial Lighting Fixtures

| **Luminaire Name** | **Luminaire Figure** | **Type** | **Light Emission Curve** |
|---|---|---|---|
| MA1 |  | T8 SM / Waterproof |  |
| MA2 |  | T8 SM |  |
| MA3 |  | Spiral Lamp in SM Download Spot |  |
| MA4 |  | Energy Saving Inside Conical Pendant Spiral Lamp |  |

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As can be seen, Table 4 includes data about the artificial lighting fixtures and their qualities available in the study area.

The luminaires used in the existing artificial lighting system are given in Table 5 with their luminous intensity disteibution and mounting method. MA1 type luminaire; It is used in classrooms, studios, living rooms, and technical rooms. MA2 type a luminaire; It is used in cleaning rooms and circulation areas. MA3 type armature; It is used in restrooms and seminar halls.

The MA4 type luminaire was used only on the second floor of Block B, in the computer laboratory, blueprint output room, and the corridor that leads to the computer laboratory. The MA4 type luminaire has a 50 cm pendant length. An energy-saving spiral lamp is used inside the cone surrounding the E27-type socket.

**Table 6:** Calculation of Usage Hours Based on Dates to ERU Faculty of Architecture

| Date | Sun Rise Time | Sunset Time | Usage Type | Total Usage Times | | |
|---|---|---|---|---|---|---|
| | | | | $t_D$ | $t_N$ | t |
| 23 Sept. | 06:27 | 18:34 | Official | 660 | 0 | 660 |
| | | | Education | 726 | 0 | 726 |
| 21 Dec. | 07:53 | 17:20 | Official | 590 | 70 | 660 |
| | | | Education | 616 | 110 | 726 |
| 21 March | 06:40 | 18:51 | Official | 660 | 0 | 660 |
| | | | Education | 726 | 0 | 726 |
| 21 June | 05:14 | 20:06 | Official | 612 | 0 | 612 |
| | | | Education | 242 | 0 | 242 |
| Total | | | Official | 2522 | 70 | 2592 |
| | | | Education | 2310 | 110 | 2420 |

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**Table 7:** $F_A$ Value and $F_O$ Value Based on Space Types for the Study Building

| Room Type | $F_A$ Value | $F_O$ Account Range | $F_{OC}$ | $F_O$ Value |
|---|---|---|---|---|
| Entrance hall, Waiting Halls, Library (read), Hallway (Not Dimmer) | 0.00 | $1- [(1- F_{OC}) \times F_A/0.2]$ | | 1.00 |
| Activity Room, Office Room For 2 People | 0.30 | | | 0.90 |
| Office Room For 1 Person, Hallway, Staff Rooms, Copy Room | 0.40 | $F_{OC} + 0.2 - F_A$<br>$F_{OC} + 0.2 - F_A$ | 1.00 | 0.80 |
| General Use Rooms | 0.50 | | | 0.70 |
| Library (archive) | 0.90 | | | 0.30 |
| Technical Service Room | 0.98 | $[7 -(10 \times F_{OC})] \times (F_A - 1)$ | | 0.06 |

Ref: BEP-TR, 2010, 36-39.

In the lighting part of the BEP-TR calculation method, a method prepared based on the EN 15193 standard and developed for the conditions of Turkey is presented. This calculation method introduces the calculation steps for evaluating the amount of energy consumed for interior lighting purposes in buildings and a numerical indicator that can be used for certification regarding the lighting energy requirement. This document also provides a method for calculating the lighting energy to be used in determining the total energy performance of the building [BEP-TR, 2010]. In Table 6, the total usage time is calculated as tD when there is daylight, tN when there is a lack of daylight, and the total usage time t is calculated. The calculation of March 21 represents March, April, and May. June 21 Calculation represents June, July, and August as the summer period. September 23 calculation is between September, October, and November as the autumn period. The calculation of December 21 represents the months; of December, January, and February in winter. Within the scope of our study, it is accepted that the education structures aren't available in July and August. The active training period was taken between September 1 and June 30. Half-hour extra working hours before and after the lesson and working hours are included.

In order to make these calculations in the relevant standards, the range of the FA value is checked first. Table 7, three different equations are used according to three different calculation intervals. With these equations, it is possible to calculate the factors related to usage (FO Value). Finally, the lighting control system factor (FOC Value), depending on the usage, should be known. Since the lighting control system of the spaces in Erciyes University is a manual on-off switch, the FOC value is calculated as 1.00.



In order to provide visual comfort and reduce the amount of power drawn from the network, an improvement proposal was made by using LED luminaires. It has been observed that the existing luminaires are mounted on the surface and are not sufficient to provide the illuminance level since they are located between the ribbed beams at the height of h=4.30. In the improvement proposal, between the beams, It is recommended to install pendant luminaires with a suspension length of 1 m. The distance between the working plane and the luminaires, which is 0.85 m, was fixed at 2.45 lower. Assembly alignments and fixture numbers remained the same. RA1, RA2, RA3, and RA4 coded LED luminaires that provide homogeneous light distribution are recommended instead of existing luminaires. Table 8 shows the data regarding the recommended luminaire in the improvement proposal.

**Table 8:** Suggested Luminaires and Their Attributes

| Luminaire Name | Dimensions (m) | Power (W) | Luminous Flux (lm) | Light Efficiency (lm/W) |
|---|---|---|---|---|
| RA1 | 1,20 x 0,20 x 0,05 | 22 | 2799 | 127.2 |
| RA2 | 0,60 x 0,60 x 0,05 | 30,5 | 3698 | 121.3 |
| RA3 | 1,20 x 0,30 x 0,05 | 35,5 | 4198 | 118.3 |
| RA4 | 0,162 x 0,162 x 0,10 | 9,5 | 1100 | 115.8 |

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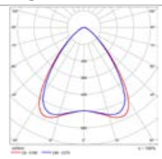
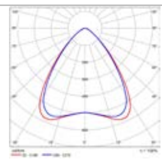
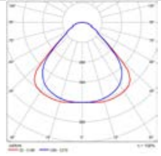
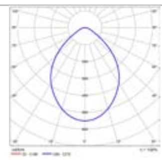
Attributes of luminaires in the improvement proposal and light emission curve shown in Table 9.

**Table 9:** Attributes of Luminaires in the Improvement Proposal

| Name | Figure | Type | Information Leaflet | Light Emission Curve |
|---|---|---|---|---|
| RA1 |  | SM<br>LED<br>Glare CCT :<br>3000K–4000K | Waterproof<br>Polycarbonate Body<br>Compatible<br>CRI: 100 |  |
| RA2 |  | SM LED<br>Glare CCT :<br>3000K–4000K | Waterproof<br>Polycarbonate Body<br>CRI: 100 |  |
| RA3 |  | Stalactite<br>LED<br>Glare CCT :<br>3000K–4000K | Waterproof<br>Polycarbonate Body<br>Compatible CRI: 100 |  |
| RA4 |  | Recessed<br>LED<br>Glare CCT :<br>3000K–4000K | Polycarbonate Body<br>CRI: 100<br>(Downlight) |  |



## EFFECT OF IMPROVEMENT SUGGESTIONS ON LIGHTING CONSUMPTION

Regarding improvement suggestions, The approximate cost calculation items prepared according to the Ministry of Environment and Urbanization, Presidency of Higher Science Council, and Construction and Installation Unit Prices 2019 data and the exposure definitions defined are taken as the basis. While making improvement suggestions, luminaires with suitable luminous flux, luminous efficiency, and consumption values specified LED luminaires were selected, and cost calculations were made with the current unit prices of assembled. The sample luminaires used in Dialux Evo calculations were also selected within the framework of the definitions in accordance with the specified item numbers, and the selected luminaires were specified for comparison.

In the improvement suggestions made in Table 10, the RA1 type luminaire has a luminous flux of at least 2700 lm consumption value of at most 30 watts LED surface waterproof polycarbonate. The unit price of the body ceiling luminaire for 2021 is 230.00 ₺. A total of 186 RA1-type fixtures were used in the improvement proposals in Block A, and the assembled total cost of these fixtures is 42,780,00 ₺. RA2 type luminaire is 3300 lm light flux, maximum 36-watt consumption value, surface-mounted minimum 60x60 LED ceiling luminaire in 2021. The current assembled unit price is 286.00 ₺. A total of 73 RA2-type fixtures were used in the improvement proposals in Block A, and the assembled total cost of these fixtures is 20,878.00 ₺. RA3 type luminaire was approved by the Ministry of Environment and Urbanization with a light flux of at least 3600 lm and a consumption value of at least 40 watts. The current assembled unit price is 269.00 ₺. A total of 144 RA3-type fixtures were used in the improvement proposals in Block A, and the assembled total cost of these fixtures is 38,736,00 ₺. RA4-type luminaire has a light flux of at least 800 lm and a consumption value of 12 watts at the most. The unit price of the ceiling fixture, part of which is cast aluminum, is 113,00 ₺ for 2021. 92 RA4-type fixtures were used in the improvement proposals in Block A, and the assembled total cost of these fixtures is 10.396,00 ₺. Clearly, to calculate the value in Table 10, in the improvement suggestions made, the total approximate cost in Block A was calculated as 112,790,00 ₺.

**Table 10:** Total Luminaire Numbers and Cost Calculation with A Block Improvement Proposal

| Name | Total | Item Number | Power (W) | Luminous Flux (lm) | Assembled Prise (₺) | Total Prise (₺) |
|---|---|---|---|---|---|---|
| RA1 | 186 | 35.170.1602 | 22 | 2799 | 230 | 42.780 |
| RA2 | 73 | 35.170.1105 | 30.5 | 3698 | 286 | 20.878 |
| RA3 | 144 | 35.170.1603 | 35.5 | 4198 | 269 | 38.736 |
| RA4 | 92 | 35.170.1501 | 9.5 | 1100 | 113 | 10.396 |
| | | | | | Total | 112.790 |



As can be seen in Table 11, in the improvement suggestions made, the RA1 type luminaire has a minimum luminous flux of 2700 lm and a consumption value of 30 watts at most. The unit price of the waterproof polycarbonate ceiling luminaire for 2021 is 230.00 ₺. A total of 272 RA1-type fixtures were used in the improvement proposals in Block B, and the total cost of these fixtures as assembled is 62,560,00 ₺. RA2 type luminaire, 3300 lm light flux, maximum 36-watt consumption value, surface-mounted minimum 60x60 LED ceiling luminaire in 2021. The current assembled unit price is 286.00 ₺. 89 RA2-type luminaires were used for improvement suggestions in Block B. The assembled total cost of these fixtures is 25,454.00 ₺. RA3 type luminaire, with a light flux of at least 3600 lm and consumption value of at least 40 watts. The current assembled unit price is 269.00 ₺. A total of 96 RA3-type luminaires were used in the improvement proposals in Block B, and the assembled total cost of these luminaires is 25.824.00 ₺. RA4-type luminaire has a light flux of at least 800 lm and a consumption value of 12 watts at the most. The unit price of the ceiling fixture, part of which is cast aluminum, is 113,00 ₺ for 2021. A total of 173 RA4-type fixtures were used in the improvement proposals in Block B, and the assembled total cost of these fixtures is 19,549.00 ₺. According to Table 11, in the improvement suggestions made, the total cost in Block B was calculated as 133,387.00 ₺.

With the improvement proposal, the amount of energy saving in Block A is 63,024%. And the amount of energy saving in B Block is 61,784%. In total, the annual lighting energy consumption of 105,272.73 kWh decreased to 39,628.42 kWh annual lighting energy consumption

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with the improvements applied. This is when the improvement proposal is compared with the current situation; It shows that a 62,356% reduction is achieved in the annual energy consumption calculations obtained according to the BEP-TR lighting calculation method.

**Table 11:** Total Number of Luminaires Proposed for B Block Improvement and Cost Calculation

| Name | Total | Item Number | Power (W) | Luminous Flux (lm) | Assembled Prise (₺) | Total Price(₺) |
|---|---|---|---|---|---|---|
| RA1 | 272 | 35.170.1602 | 22.0 | 2799 | 230 | 62.560 |
| RA2 | 89 | 35.170.1105 | 30.5 | 3698 | 286 | 25.454 |
| RA3 | 96 | 35.170.1603 | 35.5 | 4198 | 269 | 25.824 |
| RA4 | 173 | 35.170.1501 | 9.5 | 1100 | 113 | 19.549 |
| | | | | | Total | 133.387 |

### Calculating the Lighting Energy Numeric Display

LENI is the numerical indicator of lighting energy, and its unit is kWh/m2.year. Calculations made according to the BEP-TR method are based on the hours of use in the classrooms and studios, except for summer months and weekends. As can be seen in Table 12, the annual lighting energy consumption in the current situation is quite high compared to the LED luminaire, although it does not meet the visual comfort conditions. As can be seen in Table 12, with the improvement proposal, a saving of 30,608,19 kWh is achieved in Block A, and the difference obtained in LENI is 4.01 kWh/m2.year. With the improvement proposal, the amount of energy saving in Block A is 63.02%.



**Table 12:** Total Amount of Energy Consumed in A Block Floors Available and Revision LENI Value

| Floors | SB (kWh) | B (kWh) | G (kWh) | F (kWh) | S (kWh) | Total (kWh) |
|---|---|---|---|---|---|---|
| Current Total $W_{L,T}$ | 800,39 | 13034,18 | 3379,27 | 19164,63 | 12187,14 | 48565,61 |
| Revision Total $W_{L,T}$ | 452,07 | 5140,27 | 1167,58 | 6673,66 | 4523,83 | 17957,41 |
| Retrench of $W_{L,T}$ | 30608,19 | | | | | |
| m² Total | 780,97 | 1793,67 | 702,93 | 2099,21 | 1884,25 | 7261,03 |
| m² Total Units of $F_0$ 0,10 over | 227,51 | 1793,67 | 702,93 | 2099,21 | 1884,25 | 6707,57 |
| Current LENI | 1,02 | 7,27 | 4,81 | 9,13 | 6,47 | 6,69 |
| Revision LENI | 1,99 | 2,87 | 1,66 | 3,18 | 2,40 | 2,68 |
| Retrench of LENI | 4,01 | | | | | |

*SB: Second Basement, B: Basement, G: Ground, F: First, S: Second.*

As seen in Table 13, the annual lighting energy consumption in the current situation is quite high compared to the LED luminaire, although it does not meet the visual comfort requirements. As seen in Table 13, 35,036.12 kWh savings are achieved in B Block with the improvement proposal, and the difference obtained in LENI is 3.74 kWh/ m2 year. With the improvement proposal, the amount of energy saving in B Block is 61.78%. Comparing the improvement proposal with the current situation, it is observed that a 62,356% reduction is achieved in the annual energy consumption calculations obtained according to the BEP-TR lighting calculation method.

**Table 11:** Total Amount of Energy Consumed in B Block Floors Available and Revision LENI Value

| Floors | SB (kWh) | B (kWh) | G (kWh) | F (kWh) | S (kWh) | Total (kWh) |
|---|---|---|---|---|---|---|
| Current Total $W_{L,T}$ | 5456,30 | 15018,59 | 11535,13 | 9218,44 | 15478,67 | 56707,12 |
| Revision Total $W_{L,T}$ | 3029,00 | 7218,93 | 4316,87 | 3158,50 | 3947,71 | 21671,00 |
| Retrench of $W_{L,T}$ | 35036,12 | | | | | |
| m² Total | 756,23 | 2725,11 | 2280,28 | 1494,20 | 1962,44 | 9218,26 |
| m² Total Units of $F_0$ 0,10 over | 622,11 | 2725,11 | 2280,28 | 1494,20 | 1879,10 | 9000,80 |
| Current LENI | 7,22 | 5,51 | 5,06 | 6,17 | 7,89 | 6,15 |
| Revision LENI | 4,87 | 2,65 | 1,89 | 2,11 | 2,10 | 2,41 |
| Retrench of LENI | 3,74 | | | | | |

*SB: Second Basement, B: Basement, G: Ground, F: First, S: Second.*

### Refund Calculation

Erciyes University Faculty of Architecture as electricity user type Double Term Single Time Commercial House Type Medium Voltage Electricity Receiving from the End Source Tariff is Eligible Consumer. As seen in Table 14 the backward inflation difference in 4 years and 4 months is 82.60%.



**Table 14:** Refund period estimation over backward inflation difference

| Date | March 2017 | March 2018 | March 2019 | March 2020 | March 2021 | July 2021 |
|---|---|---|---|---|---|---|
| Inflation Difference | %0.00 | %10.23 | %31.97 | %47.61 | %71.51 | %82.60 |

Source: Central Bank of Turkish Rebuplic. Inflation Calculator.

It can be predicted that the future reflection of this on electricity prices will be as follows at Table 15.

**Table 15:** Forward-Looking Unit Price Forecast Based on Inflation Difference

| Date / ₺ | July 2021 | July 2022 | July 2023 | July 2024 | July 2025 | Nov. 2025 |
|---|---|---|---|---|---|---|
| Unit Price | 0,879 | 0,969 | 1,160 | 1,298 | 1,508 | 1,605 |

In the forecast, against the possibility of retrospective inflation to occur in the same way in the future, it is foreseen that the tariff, which is 0,87841 ₺ at the end of 52 months, will continue to their tariff at 1,603 ₺. The initial investment cost in Table 16; Based on the current inflation difference, the current electricity price that will emerge when the same amount of inflation occurs prospectively, the amount of savings made according to years, and the repayment amount have been calculated. Accordingly, the improvements made at the end of the 4th year have expected to realize a savings of 36,568.11 ₺ by providing their depreciation.

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**Table 16:** Reimbursement of Initial Investment Based on Inflation Difference

| | Electricity Price ₺(f+g) ₺ | Total Difference kWh | Savings Amount ₺ | Amount to be Reimbursed ₺ |
|---|---|---|---|---|
| Cost | 0,8793674 | 65.644,31 | 0.00 | -246.177,00 |
| 1.Year | 0,8793674 | 65.644,31 | 57.725,47 | -188.453,53 |
| 2.Year | 0,96932 | 65.644,31 | 63.630,78 | -124.820,75 |
| 3.Year | 1,160501 | 65.644,31 | 76.180,30 | -48.640,45 |
| 4.Year | 1,298034 | 65.644,31 | 85.208,56 | +36.568,11 ₺ |

In Table 17, the kWh - electricity unit price final price usage fee of the Eligible Consumer group who receives electricity from the Double Term Single Time Commercial House Type Medium Voltage Final Source Tariff for the last 4 years is given retrospectively.

**Table 17:** Double Term Single Time Mv Activity Based Consumer Tariff Final Price By Year

| Date/ ₺ | 2017 July | 2018 Jan. | 2019 Jan. | 2020 Jan. | 2021 Jan. | 2021 July |
|---|---|---|---|---|---|---|
| Unit Price- ₺ | 0,297 | 0,322 | 0,512 | 0,679 | 0,763 | 0,879 |
| Exchange Rate | 100 | 108,43 | 172,42 | 228,69 | 256,85 | 295,80 |

**Source:** EPDK, Address: https://www.epdk.gov.tr/Detay/Icerik/3-0-1/tarifeler. Access Date: 15.07.2021.

Based on these values, the future electricity unit price estimation is given in as seen in Table 18. In case of the possibility that the retrospective electricity unit price difference may occur in the same way in the future, it has foreseen that the Eligible Consumer group who purchases electricity from the Double Term Single Time Commercial Center Type Medium Voltage Final Source Tariff, which is 0,87841 ₺, at the end of 3 years, will continue to its tariff at 2,03607 ₺.



**Table 18:** Forward Electricity Unit Price Forecast with Retrospective Electricity Price Difference

| Date | July 2021 | July 2022 | July 2023 | July 2024 |
|---|---|---|---|---|
| Unit Price- ₺ | 0,879367 | 1,139138 | 1,309837 | 2,03674 |

**Table 19:** Reimbursement of Initial Investment Based On Change in Electricity Unit Difference

| | Electricity Price ₺(f+g) ₺ | Total Difference kWh | Savings ₺ | Amount to be Repaid ₺ |
|---|---|---|---|---|
| Cost | 0,8793674 | 65.644,31 | 0.00 | -246.177,00 |
| 1.Year | 0,8793674 | | 57.725,47 | -188.453,53 |
| 2. Year | 1,139138 | | 74.777,96 | -113.673,58 |
| 3.Year | 1,309837 | | 85.983,33 | -27.690,25 |
| 4.Year | 2,03674 | | 133.700,40 | +106.010,14 ₺ |

If this is the case, the new payback period of the initial investment cost has indicated in Table 19. The initial investment cost in Table 19; based on the current electricity unit price difference retrospectively, the current electricity price that will emerge when the same amount of inflation occurs prospectively, the amount of savings made according to years and the repayment amount have calculated. Accordingly, it has foreseen that the improvements made at the end of the 4th year will

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realize a savings of 106,010.14 ₺ approximately 5,863 € (1 € = 18,08 ₺) by providing their depreciation.

## CONCLUSION

In educational buildings, energy-efficient lighting is essential. Moreover, visual comfort keeps learning performance high, motivation of employees and students, and essential working productivity. As in other existing structures, educational buildings aim to reach the values of international standards and ensure minimum energy consumption in this study area. In this context, in our study, the concept of energy efficiency is discussed in a multifaceted way. In addition, studies on energy efficiency in public buildings examined, especially the current situation in energy efficiency in lighting energy given in detail in our study.

The illuminance levels on the working plane of the spaces in Blocks A and B within the Erciyes University Faculty of Architecture have been calculated, and the findings were evaluated. In order to provide visual comfort conditions primarily, by the energy-efficient design principles and at the same time taking into account the spatial characteristics, the use of LED luminaires and the use of pendant luminaires considering the floor height has been deemed appropriate. Comparing the improvement proposal with the current situation, it provides a 62,356% reduction in the annual energy consumption calculations obtained according to the BEP-TR lighting calculation method. In addition, the improvements made calculated a 4.01 LENI decrease in AESG value in A Block and a 3.74 LENI decrease in B Block. That means a total annual saving of 65,644.31 kilowatt-hours for both blocks in the lighting energy consumption only.

The approximate cost of the luminaires used in the improvement proposals was calculated in three different ways with the savings amount. The first one is the repayment calculation with current electricity prices without any inflation difference, the second one is the forward-looking calculation based on the backward inflation difference, and the last one is the forward-looking calculation based on the year-to-year price changes in the tariff fees in electricity prices. With the simple calculation method, when the current electricity unit price is accepted as constant over the years without any inflation difference, it is calculated that the first investment cost will be paid back in 1557 days (52 months) with the electrical energy savings in lighting energy. With the improvement proposal made later, the system will bring profit.

In the second calculation method, in the calculation made based on the backward inflation difference, calculations were made on the change in the electricity unit fee that would occur in case of inflation with the same rates prospectively. As a result of these calculations, it has been calculated that the amount of energy consumption saved in the improvement proposals and the initial investment cost will be provided



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at the end of 1305 days, and the improvement proposal system will bring profit after 1305 days (43 months).

Finally, in the third calculation method, based on the backward electricity unit price difference, calculations are made in case of changes in electricity unit prices with the same forward-looking rates. As a result of these calculations, it has been calculated that the amount of energy consumption saved in the improvement proposals will provide the first investment cost at the end of 1171 days, and the improvement proposal system will bring profit after 1171 days (38 months).

In the basic calculation made without considering the inflation difference and the electricity unit price difference over the years, the savings made at the end of the fourth year and the initial investment costs could be repaid, and the system became profitable in the improvement proposals. In the calculations made for years by including inflation, the amount of savings made at the end of the third year and the initial investment costs could be repaid, and the system turned into profit in suggestions for improvement. In the calculation made by considering the change in the electricity unit price difference over the years, the amount of savings made at the end of the third year and the initial investment costs could be paid back, and the system turned to profit in the improvement proposals.

In investments with a payback period of more than five years in public buildings, the system's length prevents the system's efficiency and the system's preference in terms of applicability decreases as the period gets longer. Within the scope of our study, it is thought that the payback period of the initial investment cost in all three calculations is below five years, which will cause these improvement proposals to be preferred in terms of applicability for public buildings.



Simultaneously in the study, according to the multidimensional approach of the concept of energy efficiency, suggestions for improvement, and cost analysis. It was noted that initial investment, assembly, dismantling and repair costs are also considered in all these processes. Based on the need to obtain a holistic approach to improving the lighting energy performance of existing buildings, it will be aimed that this selected educational structure study will shed light on other studies and constitute an exemplary approach in the context of comfort-consumption-cost for improvement proposals of all existing buildings.

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## REFERENCES


Barbier, E. (2019), "How to Make the Next Green New Deal Work", Nature, 565 - 6, Access address https://www.nature.com/articles/d41586-018-07845-5. https://doi.org/10.1038/d41586-018-07845-5

BEP-TR- National Calculation Method of Energy Performance in Buildings, Annex 05-Lighting, 07 December 2010 Thursday, Official Gazette, Issue: 27778, 2010. Table F.1.

Cayıragası, F., Sakacı, S. (2021). Avrupa Yesil Mutabakati (Green Deal) ve Birlesmis Milletler Surdurulebilir Kalkinma Hedefleri Perspektifinde Surdurulebilir Dijital Pazarlama Stratejileri. Gaziantep University Journal of Social Sciences, 20(4), 1916-1937.

Central Bank of Turkish Rebuplic. Inflation Calculator. Access Adress: http://www3.tcmb.gov.tr/enflasyoncalc/enflasyon_hesaplayici.html. Date of Access: 05.08.2021.

Desouza, D. (2020). "The Green New Deal Explained", Access address https://www.investopedia.com/the-green-new-deal-explained-4588463#citation11

Directive on Energy Performance of Buildings, 2002/91/EC, Brüksel, 2002.

Energy Efficiency Survey Implementation Monitoring Report in Public Buildings - I. (2018). T.R. Ministry of Energy and Natural Resources, General Directorate of Renewable Energy.

Energy Savings in Public Buildings (2019, 16 August). Official Gazette (No: 30860). Access Address: https://www.resmigazete.gov.tr/eskiler/2019/08/20190816-10.pdf Access Date: 10.03.2020.





EPDK, Tarifeler Listesi. Access Address: https://www.epdk.gov.tr/Detay/Icerik/3-0-1/tarifeler. Access Date: 15.07.2021.

Europe Sustainable Development Report (2020). "Six SDG Transformations for the EU", Part 3, Access address https://eu-dashboards.sdgindex.org/chapters/part-3-six-sdgtransformations-for-the-eu

Hamilton, I., Kennard, H., McGushin, A., Höglund-Isaksson, L., Kiesewetter, G., Lott, M., ... Watts, N. (2021). The Public Health Implications of the Paris Agreement: A Modelling Study. The Lancet Planetary Health, 5(2), e74-e83.

Idowu, S. O., Schmidpeter R., Zu, L. (2020), "The Future of the UN Sustainable Development Goals Business Perspectives for Global Development in 2030", CSR, Sustainability, Ethics & Governance, ISBN 978-3-030-21153-0 ISBN 978-3-030-21154-7 (eBook), Springer Nature Switzerland AG 2020https://doi.org/10.1007/978-3-030-21154-7, 6, 12, 16, 101.

Kucuk, A. A. (2019). "Egitim Yapılarında Aydınlatma Performansının BEP-TR Yontemiyle Degerlendirilmesi- ERU Mimarlık Fakultesi Tasarım Atolyeleri Ornegi". 12. Ulusal Aydınlatma Kongresi Programı. 18-19 September, 2019. Istanbul.

Milli Egitim Istatistikleri Orgün Egitim 2018-2019. Access Address: http://sgb.meb.gov.tr/www/icerik_goruntule.php?KNO=361. Access Date: 10.03.2020.

Ozyurt, G., Kutluay, K. (2009). "Enerji Verimliligi, Binalarin Enerji Performansı ve Türkiye'deki Durum". TMMOB, Insaat Muhendisleri Odası, Turkiye Muhendislik Haberleri 457.54: 32-34.


DOI: 10.15320/ICONARP.2022.212

Sahin, G. Onder, H. G. (2021). Atik Yonetimi, Sera Gazi Emisyonlari ve Türkiye: Avrupa Yesil Mutabakati Cercevesinde Bir Degerlendirme. The Journal of Academic Social Sciences. Year: 9, Vol: 9, p. 194-216.

Storm, S. (2020). "The EU's Green Deal: Bismarck's 'what is possible' versus Thunberg's 'what is imperative'", Workin Paper No.117, Institute for New Economic Thinking, https://doi.org/10.36687/inetwp117

Sümengen, O. (2015). Türkiye İçin Konut Binalarının Aydınlatma Enerjisi Gereksinimi Açısından Degerlendirilmesine İliskin Bir Yaklasım. Ph.D. Thesis.Istanbul Technical Univercity. Graduate School of Science Engineering and Technology. s. 1.

UNEP. (1972). MFA. Access Address: http://www.mfa.gov.tr/birlesmis-milletler-cevre-programi.tr.mfa#:~:text=Bunun%20%C3%BCzerine%2C%20BM%20Genel%20Kurulu,bir%20%E2%80%9Cprogram%E2%80%9D%20olarak%20olu%C5%9Fturulmu%C5%9Ftur. Access Date: 01.06.2021.

United Nations. (2015a). "Transforming Our World: The 2030 Agenda for Sustainable Development". Access Address: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for %20Sustainable%20Development%20web.pdf. Access Date: 06.07.2021

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