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LIGHT AND WELLBEING: EVALUATING ARTIFICIAL, NATURAL, AND AUTOMATED LIGHTING SYSTEMS IN LAHORE'S WORK ENVIRONMENTS

Nabiha Saleem[*1], Umer Mahboob Malik[2], Amna Iqbal[3]

[*1]*MS Scholar, School of Architecture Design & Urbanism, Institute for Art & Culture Lahore Pakistan.*
[2]*Assistant Professor, School of Architecture Design & Urbanism, Institute for Art & Culture Lahore Pakistan.*
[3]*Assistant Professor, Architecture Department, UET Narowal Campus Narowal Pakistan*

[*1]nabihasaleem25@gmail.com, [2]umer.mahboob@iac.edu.pk, [3]amna.iqbal@uet.edu.pk

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Corresponding Author: *
Nabiha Saleem

Abstract

In today's world, where conversations around energy efficiency and sustainability are becoming increasingly urgent due to environmental changes and limited resources, it's essential for us—especially as designers and professionals—to consider the role we play in shaping a better future. One of the areas where we can make a real difference is through the way we design and use lighting in our office spaces. Lighting doesn't just affect energy bills—it impacts how people feel, work, and interact in a space.

Unfortunately, many offices still lack access to natural light, even in areas where people spend most of their day. This doesn't just lead to higher energy consumption; it also affects the experience of the people working there, both mentally and physically.

This paper takes a closer look at how natural light, artificial lighting, and automation are being used in office buildings around Lahore. By visiting actual spaces, reviewing case studies, and diving into existing research, the study explores what strategies are being used and whether architects are working hand-in-hand with electrical engineers to make lighting smarter and more energy-efficient. It also looks at whether automation is helping reduce energy use and how much user experience is being considered in these decisions.

Since lighting has a direct effect on how people feel and perform at work, this study also gathers feedback from users to understand what is working and what is not. It highlights the reasons behind high energy costs and offers suggestions to improve how we approach lighting in offices. Ultimately, it's not just about saving energy—it's about creating spaces that support people and help them thrive.

INTRODUCTION

Lighting is not just about being able to see—it shapes how we feel, how we work, and even how much it costs to keep a building running, called the building's operational cost. In office spaces, where many of us spend most of our day, the kind of lighting used can make a huge difference. Around the world, designers are finding smarter ways to light up spaces, making better use of natural sunlight, using energy-efficient artificial lighting, and adding automation that adjusts lighting based on how the space is being used.

In Pakistan, and particularly in Lahore, we're starting to see some of these ideas take root. But progress is still slow and uneven. As Lahore grows rapidly, many new office buildings continue to rely more on artificial light than on the natural light available, missing out on a valuable opportunity to improve both energy efficiency and the quality of the indoor environment. Moreover, people do not even bother to switch off the lights while leaving or when they are not in use, which shows their acknowledgment of energy saving in today's age.

This research explores how we are using light in our office spaces, why natural light matters, and what is holding us back from doing better? With energy use in buildings rising sharply in Pakistan (World Bank, 2020), there is an urgent need to shift toward more efficient practices. Lighting alone can take up 20 to 30 percent of a commercial building's energy consumption (UNEP, 2022), which makes it one of the easiest places to start making a change.

If we don't think about lighting early in the design process, and with future needs in mind, it can lead to layouts that don't work well and cost more to operate. But the good news is that the solutions already exist. According to the International Energy Agency (2021), daylighting and automation can reduce lighting energy use by over 50%. Research shows that better lighting not only saves energy, it also helps people feel better and work more productively (Al Horr et al., 2016).

In cities like Lahore, where we are constantly building and growing, we have a real chance to do things differently. Energy-efficient lighting is not just a technical fix; it is a smarter, more human way to design the places where we live and work. It is also a dire need of the hour to save resources and the environment.

Problem Statement

In many offices across Pakistan, lighting is still treated as a basic necessity rather than a thoughtful design element. While the rest of the world is moving toward smarter, more energy-efficient systems, our workspaces continue to rely heavily on outdated artificial lighting, with little effort to bring in natural daylight or use automation that adjusts to people's needs throughout the day.

This is not just about wasting energy—it is about how people feel in the spaces where they spend most of their day. For those working 8 to 12 hours in an office, poor lighting can lead to fatigue, discomfort, and even impact mental well-being. Natural light, when used right, not only reduces energy use but also helps people feel more connected, focused, and healthier.

The reality is that lighting affects far more than just visibility. Yet in most of our offices, it is still overlooked. This gap in design requires urgent attention, not just for energy efficiency, but to create workplaces that truly support the people who work in them. Lighting, along with automation, is also a requirement to save energy and minimize the potential waste of resources.

Objective and Scope

This research focuses on the office buildings in the city of Lahore, where the most energy is consumed. The scope includes examining the design approaches, technologies used, and energy implications of lighting choices in commercial workspaces. A comparison with an internationally acclaimed smart office building is also included to highlight best practices and possible adaptations for local contexts.

The objectives of this study are:

- To analyze the current use of artificial and natural lighting systems in office buildings in Lahore, Pakistan.
- To assess the level of integration of automation and smart lighting controls in commercial office spaces.
- To compare local practices with international benchmarks of energy-efficient lighting.
- To recommend strategies for architects and designers to improve energy efficiency through intelligent lighting design by maximizing the natural light's smart utilization.

LITERATURE REVIEW

Indoor luminance is a crucial need for any workspace, enabling people to work comfortably and effectively. Studies have shown that adequate exposure to natural light in the workplace improves worker performance and significantly influences their mood, psychological health, and overall well-being. (In Search of Natural Light in the Office, 2025). In today's world, with reliance on advanced technology, we use artificial light as a primary source of light in our spaces. With time, the use of artificial light has increased to a level where we have started neglecting natural light as a source of work. Along with the depleting sources, as the core reason to reduce our energy consumption, there are multiple other reasons as well, such as a better environment and work efficiency by using natural light. Energy-efficient indoor

and outdoor lighting design focuses on ways to improve both the quality and efficiency of lighting. (Lighting Design, n.d.). Hence, the use of light efficiently is not just the need of the hour for efficiency but also for a better, healthier environment.

2.1: Daylighting in the Office

Natural light is one of the most effective and easy ways to reduce energy consumption in buildings. It not only reduces the operational cost of the building but also boosts the health and comfort of the people working inside. The sunlight is a green light source, which has high light efficiency, a good visual effect, and is not easy to cause visual fatigue. The human eye is also accustomed to seeing things under natural lighting. (Lighting Design, n.d.). Natural daylighting significantly reduces energy consumption for lighting and HVAC systems, as evidenced by studies showing reductions in energy use by up to 50% with adaptive facades. ("An Adaptive Facade Configuration for Daylighting Toward Energy-Efficient: Case Study on High-Rise Office Building in HCMC," 2022). Moreover, access to natural light has been linked to enhanced employee productivity, mood, and overall health, as it positively affects visual comfort and reduces eye strain. (Wu & Kim, 2020). There are more positive impacts of using natural light as the primary source of light, as compared to completely relying on artificial sources. Hence, daylighting should be considered one of the primary focuses while designing the buildings.

Artificial Lighting Design

Artificial light use becomes necessary when daylight cannot fulfill the luminance requirement of the indoor space. Although energy efficiency and consumption are one of the first things we need to consider while designing any building that needs to rely on artificial light at some point. Artificial light also affects human activity and behavior in the same way. Areas with higher light intensity, light color within the white spectrum, and a more even light distribution have more activity variety. (Novrial & Affif, 2023). It plays a significant role in improving productivity and navigation within buildings (Sholanke et al., 2021). Along with the source, artificial light also offers a more controllable environment according to the inhabitants' needs. Its intensity, color, or number can be adjusted according to the need and the function of the building and its users. Lighting designs that align with human biological needs can enhance worker productivity and well-being. For instance, commercial kitchens require specific lux levels to ensure optimal working conditions (Parlakyıldız, 2023). A sensible and intelligent approach towards lighting design can affect the consumption as well as the behavior of the inhabitants.

Lighting Automation Systems

The use of automation in building lighting systems of building has become more crucial in today's age because of the excessive energy consumption and depleting resources through which we are able to produce electricity. The need of the hour has fueled the addition of an automated system in a lot of buildings worldwide. An automated system offers more control, convenience, and efficiency in residential, industrial, and commercial settings. A system utilizing machine learning to predict user movement and adjust lighting accordingly, enhancing comfort and energy efficiency (Zhu et al., 2024). Automation systems enable users to control lighting remotely via mobile applications, ensuring convenience and adaptability to user needs (Kumaran, 2024). Motion sensor lights and appliances save energy and reduce the chances of unconscious wastage of energy. Worldwide examples like Japan shows the importance of automated systems now. The Japan Lightning Protection Systems Market is witnessing robust growth, primarily driven by the increasing frequency and intensity of lightning strikes due to climate change. (Japan Lighting Protection Systems Market 2026: Automation Trends, AI Use & Key Growth Areas, 2025). Similarly, automation in lighting is increasing day by day, offering a better, more efficient, and controllable system in every space.

METHODOLOGY

This research employs a qualitative case study analysis and observational review of selected office buildings in Lahore. It also compares international best practices as a case study to provide contextual insights. Looking at the commercial buildings of Lahore, where architects and other professionals spend most of their time, was taken into consideration; their reviews and experience offered a better understanding of how light can change the behavior and experience inside the space. The methodology includes:

- Visits and photographic documentation

- Interviews and general experience discussions with the users.
- Analysis of space through the lens of light usage and efficiency.

The focus of this study is mainly to analyze where we are lacking or ignoring the possibility that we can further improve our environmental condition by reducing energy consumption. Lighting represents a major source of energy consumption, with estimates indicating that it accounts for 20% of electricity in industrial settings, 30% in retail, and up to 40% in office environments (Kaya et al., 2021).

CASE STUDIES

By analyzing both international and local case studies, the research will explore various lighting strategies and highlight their differences, applying these insights to the target audience and the sites visited.

The Edge (Amsterdam)

The Edge is the -greenest building in the world, according to British rating agency BREEAM, which gave it the highest -sustainability score ever awarded: 98.4 percent. (Randall, 2015). A building that produces more energy than it consumes and works smartly through phone apps for its users, allowing a completely automated system from car park to work desk allocation. Its distinctive southern facade features a series of solar panels and windows, equipped with a panel-covered roof as well. The building's orientation and glass facade maximize natural light without compromising internal temperature control. The Edge consumes 70% less electricity than typical office buildings.

Figure 1: The Edge - Amsterdam (Gallery of The Edge / PLP Architecture - 1, 2016)

It maintains its perfect climate while being eco-friendly because of the secret that lies under 130 meters underground, where two groundwater sources serve as thermal energy storage for warm and cold water. These aquifer thermal energy storage pumps regulate the building's temperature by circulating water based on internal and external conditions. Powered by self-generated solar energy, this system uses LED light panels with sensors to provide detailed temperature and humidity readings across each floor. This precision control eliminates natural hot and cold spots, particularly near windows, contributing to high employee satisfaction with the building's climate management. (Mahlerlan, 2020)

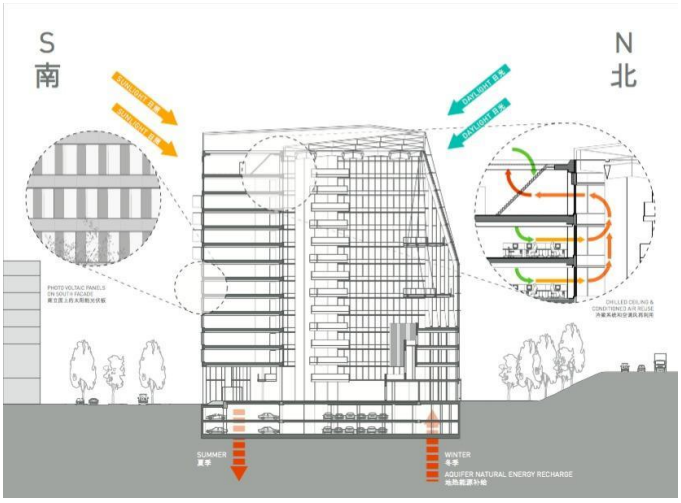

Figure 2: The Edge - daylight (Gallery of The Edge / PLP Architecture - 1, 2016)

The Edge combines numerous smart technologies in tandem to create an adaptable and intelligent working environment.

4.2: Arfa Software Technology Park (Lahore)

Arfa Software Technology Park is the Country's largest Information and Communications Technology Park. This seventeen-story building is the first international standard facility in Pakistan and it is located in Lahore. ASTP is a smart, efficient, secure, and functional business venue that hosts a diverse range of modern business necessities under one roof. To ensure a failsafe and efficient environment, the Building Management System (BMS) is installed at ASTP, which enables the centralization and optimization of various processes like monitoring, operating, and managing the entire building. The high-performance HVAC digital control system manages the building's heating, ventilation, zoning, humidification, and air cleaning systems while reducing energy and equipment costs. (Arfa Software Technology Park | PITB, n.d.).

Figure 3: Arfa Technology Tower - (By Author, 2023)

Window glazing is also positioned to reduce heat and maximize light intake, thereby reducing the reliance on artificial lighting. It also uses centralized HVAC with zoning and automated control to reduce energy wastage while maintaining comfort. (Arfa Karim Tower Lahore – Shahid International, n.d.). However, for lighting, there is not much use of automation that can save more energy. Users do find natural light in the corridors, which does not require additional reliance on artificial

light; however, indoor offices and spaces do need artificial light to function properly.

LIGHTING PRACTICES IN LAHORE

Implementing energy-efficient lighting systems can lead to substantial savings, with LED technologies offering reductions of up to 80% in energy use compared to traditional lighting (Manolescu & Sisak, 2016). With lighting accounting for 15% of global energy consumption and 5% of carbon dioxide (CO2) emissions, transitioning to more energy-efficient lighting is more than just a cost-saving measure; it is an environmental necessity. (Ali, 2007). With the progress of transitioning from incandescent bulbs to LED, we now need to proceed further by improving efficiency, which can be easily achieved by maximizing the utilization of natural light and leveraging automation for artificial light.

Current Architectural Trends- Data Collection

Today, in many modern commercial buildings in Lahore, natural light is often underutilized due to poor orientation and deep plan structures. There is almost no natural light inlet, and inhabitants completely rely on artificial light throughout the day. Full reliance and intensity of light at every hour increases the operational cost as well as energy consumption.

For this research, several well-maintained and prominent office spaces in Lahore were analyzed to assess lighting efficiency and usage. The study focused on architectural firms and selected marketing offices. Each office was physically visited, and user feedback was gathered to support the analysis and gain insight into the impact of lighting on occupants.

Table 1: Office categories and location

No.	Category	Location	No. of Inhabitants
Office 1	Architecture firm	Gulberg	15
Office 2	Architecture firm	Muslim Town	20
Office 3	Marketing office	Bahria Town	12
Office 4	Architecture firm	Mall road	15

The observations were carefully recorded under the lens of the use of artificial and natural light, or whether automation or conscious use of energy consumption was taken into consideration by the users or not.

Office 1, being an architectural firm in a well-maintained and posh area like Gulberg, is expected to be well-designed and integrated in terms of design and light usage. However, the natural light inlet observed was almost zero.

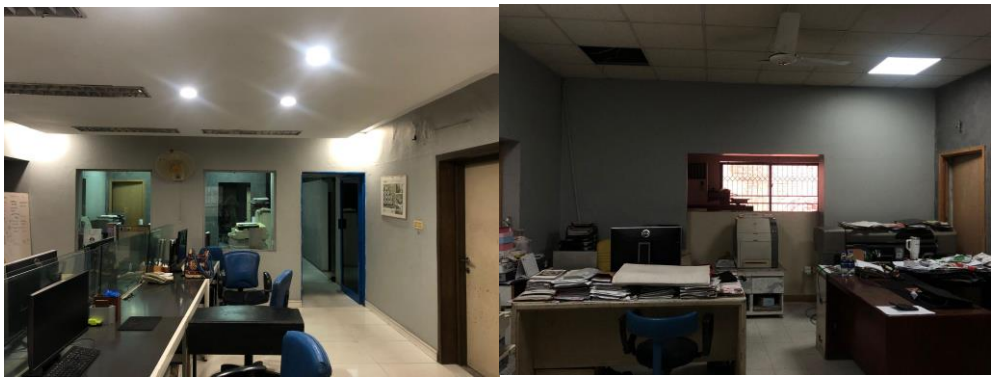

Figure 4: Office 1- Gulberg (By author- 2025)

One window at the very back end does not allow much illumination in the space, and the users rely on artificial light sources such as ceiling LED lights to work throughout the day.

Office 2, also an architecture firm in Muslim Town, had a bit better condition in terms of the natural light source, as the window orientation and placement allowed the light to illuminate the space a bit. Moreover, the desk's placement near the window also allowed the users to have a better environment. Although there was still no strategic use of natural light, which could reduce the use of artificial light to some extent.

The experience of the space for users was also observed to be better than compared to Office 1.

Figure 5: Office 2- Muslim Town (By author- 2025)

Office 3, a newly constructed marketing office in Bahria, was very well maintained and executive style. With a well-planned sitting layout for the employees, it was excessively illuminated with a good number of ceiling and rope lights. Not a single window allowing natural light to enter was observed.

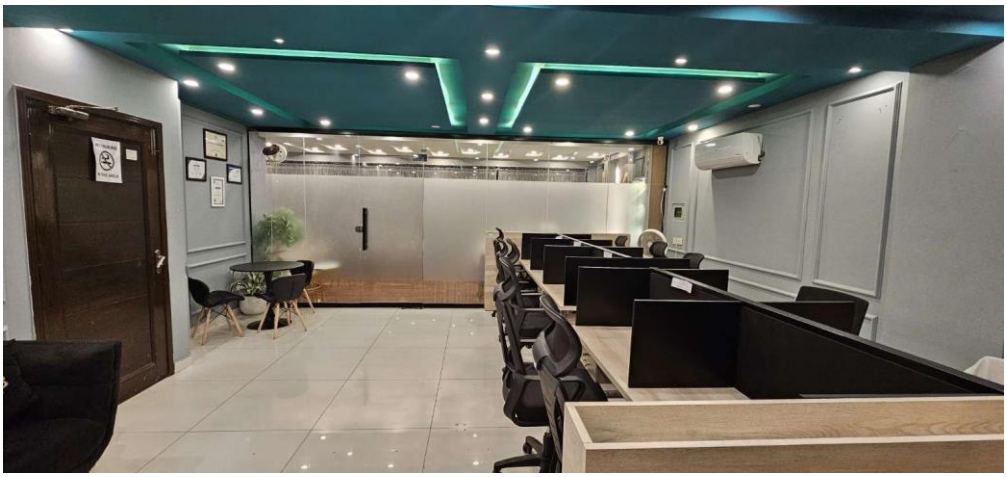

Figure 6: Office 3- Bahria Town (By author- 2025)

Office 4, an architectural firm on Mall Road, was found to be much better in terms of relying on natural light for the possible hours. Natural light intake reduced the artificial light intensity, which had a positive impact on users' mental health. One of the office spaces did not even require any artificial light at a specific time range throughout the day.

Figure 7: Office 4- Mall Road (By author- 2025)

From the observations and data collection, including interviews with the users, a few things were observed:

- Natural light inlets can reduce energy consumption due to artificial lighting.
- Artificial light used excessively affects user behavior and health.
- No use of an automated system was observed anywhere.
- Unconscious use keeps the lighting system on even when not in use by the inhabitants.
- Most of the users preferred sitting near the natural light source.

The ratio of office spaces using natural or artificial light sources is shown in Figure 8:

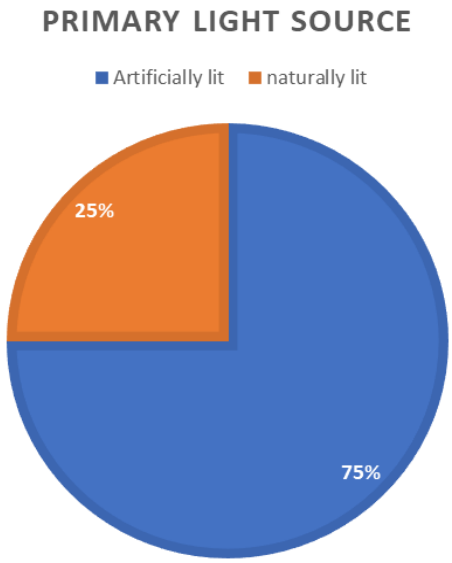

Figure 8: Primary light source ratio in offices

Observations and interview data showed that most of the inhabitants in the offices were relying completely on artificial light sources like LED lights, ceiling lighting, linear lights, and rope lights, rather than using natural light, which was not available.

However, the inhabitants' preference in terms of lighting is shown in **Figure 9**:

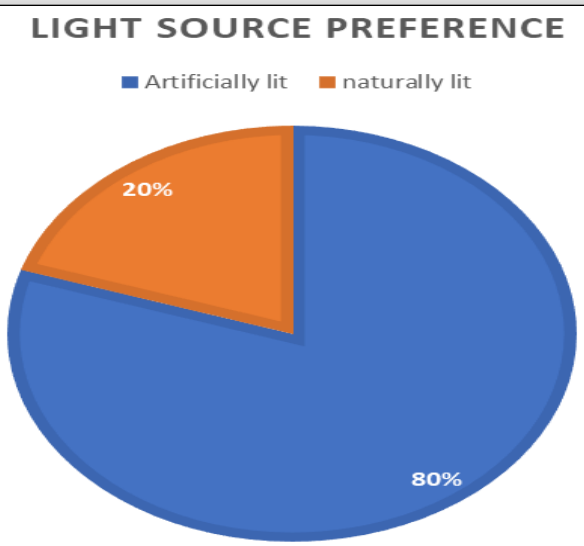

Figure 9: Light source preference by users

The users of the offices, when asked, most preferred that there should be some source of natural light which can be used instead of complete illumination by artificial light. They put forward the idea that they would want to work in a space that has a visual connection with the outside world and a light inlet for the space.

However, the main drawback observed here was that, since there was no automated system installed in any of the offices, most of the users did not turn off the lights or appliances when not in use. (as shown in **Figure 10**) The unconsciousness of energy wastage results in further negative impact of artificial light reliance. Along with that, the users having more naturally lit spaces were found to be happier with the environment as compared to those who were enclosed in an artificially lit space (**Figure 11**).

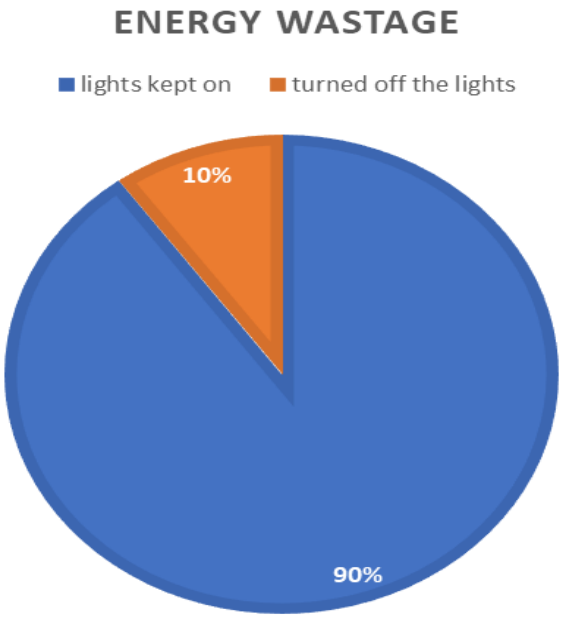

Figure 10: user's choice of wastage

As shown in Figure 10, the majority of the inhabitants do not bother switching off the lights or systems when not in use, which eventually wastes more energy as well. AC works 9 to 12 hours a day in offices with no automation and temperature control. Lights irrespective of the number of people in the office are kept on.

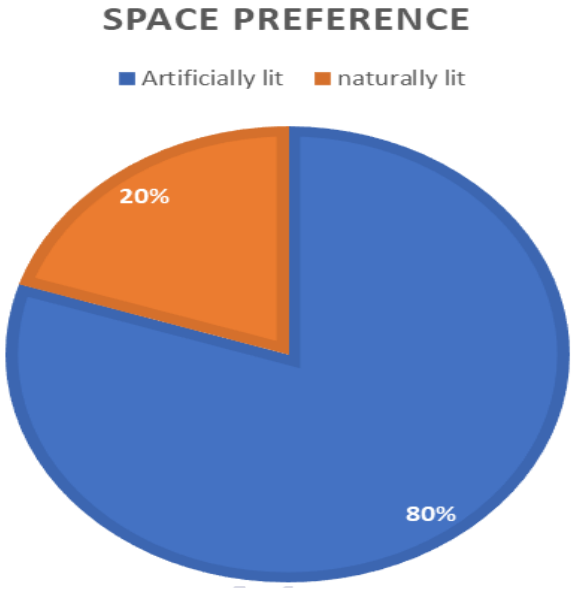

Figure 11: user's choice of space

As shown in Figure 11, most often users in the offices that were naturally lit were found to be happier with the office environment and work. They were generally less tired and more motivated to work as compared to those working in artificially lit offices.

Role Of Natural Light

Natural light in any space not only illuminates it but also influences the aesthetics, functionality, and comfort of the users in the environment. Along with the reduced energy consumption, it adds visual comfort for the mental well-being of the people as well. Since, natural light significantly enhances visual comfort, reducing issues like eyestrain and headaches, which can lead to increased productivity (Vicaningrum & Marcillia, 2024). Designing the spaces properly by thinking about the orientation and maximum natural light utilization can significantly add more positive impacts to both in terms of energy efficiency as well as user comfort. Utilizing natural light can lead to a significant decrease in electricity usage, with studies indicating up to a 3% reduction in CO2 emissions for increased daylight factors (Bashir et al., 2024).

It is evident from the data collected that the role of natural light in commercial spaces of Lahore is not acknowledged and applied. Most of the offices completely rely on artificial light sources with no addition of automated systems to control energy wastage.

Artificial Lighting Use

For artificial lighting systems, LED lights and fluorescent lights are commonly used in Lahore. By using efficient lighting strategies and technologies, such as LED lamps, energy efficiency is improved, reducing overall electrical energy use and minimizing the impact on HVAC systems (Vishwas & Soori, 2012).

However, designers often over-illuminate the space by excessive addition of rope lights and ceiling lights without considering natural light utilization and occupant capacity of the space. There is very little collaboration between the architects and electrical consultants, especially with the motto of reduced energy consumption. Although the shift to LED lights has significantly reduced the consumption of depleting resources, now we need to proceed further by cutting down the excessive use.

Automation & Controls

The research clearly showed that there is almost zero acknowledgment of automation being used in commercial

spaces for the betterment. Although implementing systems with astronomical relays and motion sensors can decrease electricity usage by up to 50% (Burmaka et al., 2020), one of the main reasons in Pakistan is the cost, and also very little acknowledgment about it among the clients and users. Most of the clients don't want an additional cost in construction which eventually results in increased operational cost of the building.

With the advancement in technology, automation in the lighting industry has increased the chances of energy saving. Japan has made significant strides in automation across various sectors, particularly in building operations and vehicle automation. The integration of digital technologies, such as Building Information Modeling (BIM) and the Internet of Things (IoT), has transformed building management systems, enhancing operational efficiency and data management (Shigaki & Yashiro, 2020). By adding this to our buildings, we can also save the energy which is wasted every second.

DISCUSSION

Synthesizing from the findings, visits, and literature review done for the research, it is examined that the buildings of Lahore are not designed by prioritizing lighting efficiency. There is not much collaboration between the architects and the electrical engineers or planners who decide the future efficiency of the building. Along with the comparison of international studies, we can also find more opportunities for improvement in the lighting strategies of commercial workspaces in Pakistan.

Comparative Analysis

The comparison between local offices in Lahore and international examples like The Edge in Amsterdam reveals how much of a gap exists in the energy-conscious design. While The Edge intelligently uses daylight and smart automation for both energy saving and also for user comfort, Lahore's office buildings largely rely on manual lighting systems and unnecessary additional lighting use. Even buildings with better integration of daylight cannot perform efficiently because of the unconscious use by the people. The gap highlights the missed opportunities, lack of knowledge, collaboration, and disadvantages caused by the operational phases of office buildings in Pakistan.

Role of the Architect

Lighting design should consider the circadian needs of occupants, using both natural and artificial light to support human health and well-being. This involves strategic placement of windows and artificial light sources to optimize light exposure throughout the day (Alkhatatbeh & Asadi, 2021). For efficient planning and energy saving, architects, while designing, should consider aspects like utilizing daylight to its fullest and minimizing reliance on artificial energy to reduce operational costs and also to provide a comfortable environment for the users of the building. It is also equally important for lighting engineers and designers to play a pivotal role in designing. The collaboration between architects and lighting specialists is crucial for achieving a harmonious balance between form and function in lighting design.

Unfortunately, in most of the projects in Pakistan, lighting decisions are deferred to electrical consultants without any active collaboration and energy-efficient changes. Architects must lead the charge in daylight-sensitive design and promote a human-centric lighting strategy at a practical level, taking it as their core responsibility.

Room for Improvement

Since it is evident that office spaces in Pakistan are not designed in a way that can improve energy efficiency, there are some areas where we can improve for our betterment, which are:

- **Policy & Regulations**: Enforcing daylight analysis and lighting efficiency checks should be added during building approvals.
- **Design education**: During training and practices, the introduction of lighting design and automation should be added as essential components.
- **Client Awareness**: Encouraging investments in smart lighting through demonstrations of long-term cost savings and improved employee well-being.
- **Incentives**: Government subsidies or tax reliefs for green lighting solutions could promote adoption.
- **Integration of Tools**: Architects can employ tools like automation apps or one-touch sensors to simulate lighting scenarios and improve daylight integration and artificial lighting layouts.

CONCLUSION

Lighting design is not merely a requirement or technical aspect that needs to be fulfilled while designing - instead, it is a vital component that significantly affects the energy efficiency, operational cost, user comfort, and overall environment.

This research paper examined the current state of artificial lighting, daylighting, and automation systems in the office buildings of Lahore, highlighting the existing gaps and possible improvements for the future.

The study shows that while awareness around sustainability and energy-efficient architecture is increasing, there is still a step back in the practical implementation that needs to be taken as soon as possible. Most office buildings still rely on outdated artificial lighting systems, lack proper daylight integration, and seldom use automation to optimize energy consumption. Architects often overlook the importance of early-stage collaboration with electrical engineers, resulting in inefficient layouts and increased operational costs. Moreover, user well-being—especially related to lighting—is rarely prioritized, despite clear evidence of its impact on productivity, mental health, and comfort.

When compared to international benchmarks like The Edge in Amsterdam, it becomes evident that Pakistan has much room to grow in terms of adopting smart lighting technologies and design-thinking approaches that prioritize both sustainability and human-centered design. However, the potential exists. With greater emphasis on interdisciplinary collaboration, enhanced design education, supportive policies, and increased client awareness, Pakistan can take meaningful steps toward more energy-efficient and user-friendly office spaces.

Moving forward, architects must lead this change—not only through design decisions but also by advocating for smarter building practices. Lighting must be seen not just as an operational necessity, but as a tool for transformation, offering opportunities to reduce energy loads, enhance work environments, and ultimately contribute to a more sustainable built environment.

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