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Deducing the Efficiency of Using Global Sustainable Lighting Strategies in Administrative Buildings in Egypt

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ABSTRACT

Due to the numerous visual problems resulting from the lack of integrated strategies for addressing sustainable lighting within administrative building spaces, designers in Egypt strive to use a range of technological systems for natural and artificial lighting in buildings. This contributes to building sustainability and achieving the standards of global environmental classification organizations for building sustainability. Following up on the previous research paper titled " Technological Systems Used in Integrating Natural and Artificial Lighting in Administrative Buildings to Achieve Global Sustainable Lighting Strategies" the current research paper will compare the various sustainable strategies used in integrating natural and artificial lighting in administrative buildings in the age of globalization and their relationship to the strategies used in modern Egyptian buildings. More over the paper will address the extent to which these strategies fit the Egyptians climatic zone. This will be done by presenting the sustainable lighting systems used in Egyptian administrative buildings, including building envelope design systems to enhance natural lighting utilization, light enhancement systems within spaces to increase visual effectiveness, light polarization systems to improve natural light distribution, appropriate artificial lighting systems to effectively meet lighting needs, and lighting unit control systems to reduce energy consumption. The research is fed by questionnaires to reach the research goal; as to assess the extent to which Egyptian administrative buildings achieve global sustainable lighting strategies.

Keywords: Lighting Strategies; Administrative Buildings; Egypt.

1. Introduction

Lighting technology is essential for building sustainability and achieving comfort within the work environment specially to overcome visual problems in administrative buildings. The problem is so wearied almost while increasing urbanization and building heights around them, which led to the growing need to use electrical energy which comes at a high cost, particularly in administrative buildings that are among the largest consumers of energy for artificial lighting. This has led countries to adopt sustainable

strategies for building lighting. Despite regional differences among global administrative buildings, the same lighting treatment methods have been observed, resulting in the development of clear strategies for designing natural and artificial lighting in administrative buildings. Egypt, in turn, has sought to keep up with global advancements to achieve building sustainability and energy efficiency. It has begun using new lighting methods in buildings, which will be discussed and compared in this research paper with the sustainable lighting strategies derived from global administrative buildings in the previous study. The buildings studied meet sustainability standards according to global environmental classification systems, such as LEED, or the Egyptian GPRS, to achieve the study's objectives.

1.1 Research problem

This paper concerns two contrast problems, as; various building designers in Egypt face many visual problems while designing administrative buildings as they ignore the global sustainable strategies that integrate natural and artificial lighting systems within building spaces. This results in the gross use of electrical energy and the high costs for artificial lighting; on the other hand sometimes the users of the buildings face discomfort in the used spaces which lead to decreasing the productivity in such buildings. In contrast to such problem few of the latest Egyptian administrative buildings which are coping with the systems for lighting used as sustainable solutions trended globally cannot manage these systems to solve the climatic zone problems that Egypt is oriented in it.

1.2 Research objective

The research paper has two objects were striving to benefit from technological advancements in global lighting systems by evaluating the extent to which sustainable global natural and artificial lighting strategies are applied in Egypt's administrative buildings. This includes a range of treatments to achieve visual comfort for users within the space while reducing building costs. deducing the efficiency of using the global sustainable lighting strategies in the Administrative Buildings in Egypt.

2. Research Methodology

The research paper is divided to four parts, first: displaying the natural and artificial lighting design strategies derived from global administrative buildings, second: analyzing the extent that the Egyptian administrative buildings strives to achieve technological advancement by applying these strategies, Third: concluding the relationship between global natural and artificial lighting strategies and the strategies used in modern Egyptian buildings, forth: deducing the efficiency of using the global sustainable lighting strategies in the Administrative Buildings in Egypt.

3. Sustainable Strategies Used in Lighting Global Administrative Buildings

Sustainable lighting strategies play a crucial role in reducing energy consumption in buildings, as their implementation enhances lighting quality significantly while conserving energy. Using daylighting techniques such as dynamic daylight metrics can achieve high daylight environments, increasing annual exposure to sunlight and reducing reliance on artificial lighting, thereby lowering energy consumption. Additionally, using LED technology in artificial lighting and integrating smart lighting control systems in sustainable office buildings not only increases energy efficiency but also ensures a comfortable work environment for space users in line with global sustainable development goals [1-3]. Therefore, it was necessary to develop clear methods to achieve sustainability standards in administrative buildings, which was accomplished in the previous research study " Technological Systems Used in Integrating Natural and Artificial Lighting in Administrative Buildings to Achieve Global Sustainable Lighting Strategies" [4]. Each strategy includes a set of systems that vary in the number of methods used to achieve sustainability (**Figure 1**).

4. Sustainable lighting in Egyptian buildings

Egyptian smart buildings are witnessing a shift towards sustainability and energy efficiency through the integration of smart systems and technologies in their design and construction. This transformation aligns with the global trend towards smart cities [4]. This involves focusing on improving energy management through energy generation technologies like using renewable resources such as solar energy efficiently and bioclimatic engineering to enhance sustainability. This means designing buildings in a way that leverages natural climatic conditions to achieve energy efficiency [5]. Furthermore, the use of smart materials in building envelopes helps improve energy efficiency and thermal comfort inside buildings, as they can adapt to environmental changes and contribute to reducing energy consumption. This demonstrates a shift towards green architecture aimed at minimizing the environmental impact of buildings [6].

In Egypt, many administrative buildings have been developed to implement sustainable design methods aimed at enhancing indoor environmental quality and achieving user comfort. Research has shown that using sustainable design strategies, such as green building standards and energy simulation, can significantly improve building performance and reduce environmental impact [7,8].

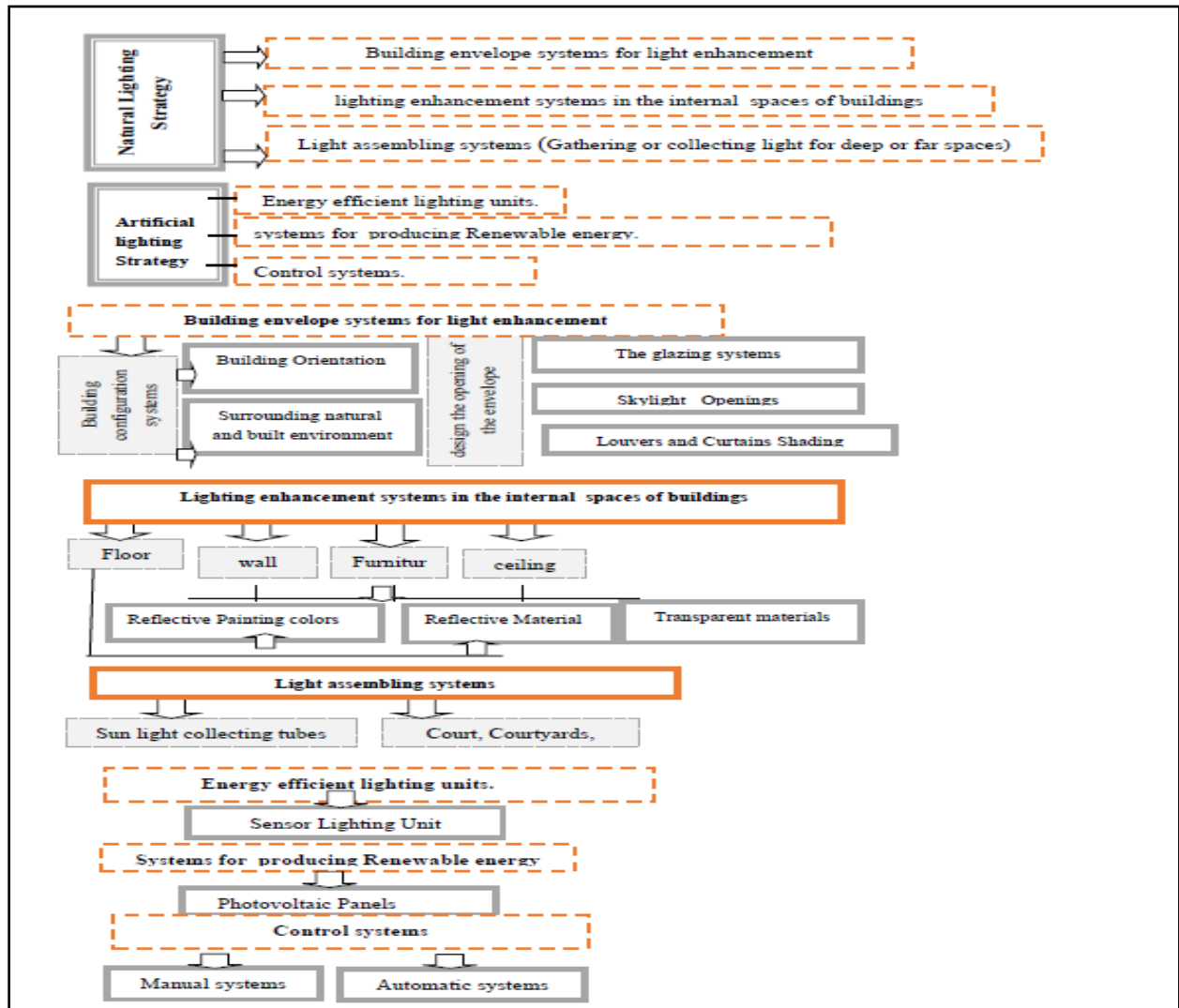







Figure (1): Sustainable Strategies Used in Lighting Global Administrative Buildings.

5. The Case studies:

A group of Egyptian administrative buildings that rely on technological lighting systems have been selected based on specific criteria to achieve the study's objectives. These buildings are classified as sustainable according to global or Egyptian environmental rating systems, such as LEED (Leadership in Energy and Environmental Design) and GPRS (Green Pyramid Rating System), or are candidates for such classification. The required data for these buildings is presented, facilitating the derivation of clear lighting strategies used in them. The research focused on analyzing six famous administrative buildings in Egypt known as sustainable buildings (**Table 1**).

Table 1: Sustainable buildings in Egypt

Buildings	Location	Architectural designer	Opening year	Evaluation	Area
 <p><i>Dar Al-Handasah building.</i></p>	Smart Village, Cairo, Egypt.	Perkins+Will Architects.	2015	LEED gold certification, 62 points/ GPRS- Three Pyramids.	41,800 m ² .
 <p><i>Crédit Agricole Egypt New Head Office building.</i></p>	5th Settlement of New Cairo, Egypt.	Atelier Tom Sheehan & Partenaires.	2016	LEED-NC Platinum rating with 81 points / GPRS 2016 Triple Pyramid certification with 61-64.25% points.	20,385 m ²
 <p><i>EMEC Headquarters building.</i></p>	Smart Village, Cairo, Egypt.	EA sustainable building consultants.	2012	The LEED Gold certification with 66 points / GPRS Triple Pyramid certification.	6713 m ²
 <p><i>Mall Infinity Tower New Capital building.</i></p>	The New Administrative Capital, Egypt.	Collaboration with the renowned Canadian architectural and engineering firm NORR.	2024, fully operational by the beginning of 2026	The building is a candidate for LEED Platinum certification.	52,000 m ²
 <p><i>Bank Egypt Global Service Centre (HSBC) building.</i></p>	Smart Village, Cairo, Egypt.	Archimid	2010	Golden LEED certificate	19500 m ²

6.1 Natural lighting systems:

6.1.1 The design of the building and its envelope

Dar Al-Handasah Building: The building's sides face northeast, northwest, and south. The main facade is located on the northwest side. The building envelope is made of glass on all three facades, and a single glass surface is used to illuminate multiple interior spaces. The southern orientation helps maximize natural light within the building's spaces (**Fig. 2**). Large areas of green plants surround the building to diffuse sunlight, and a water surface reflects light onto the openings. surface reflects light onto the opening [9].

Crédit Agricole Egypt New Head Office: The main facade is located on the southeast side of the building, and the facades face northeast, northwest, southeast, and southwest. Various lighting treatments are used according to the orientation. The building is designed around an external courtyard (**Fig. 2**). The facades of adjacent buildings increase the reflected light on the building's envelope, and the surrounding ground helps light penetrate into the building's spaces [10].

At the EMEC Headquarters: the main facade of the building faces the northeast direction, while the remaining facades face southeast, southwest, and northwest. The facades of the neighboring buildings increase the reflected sunlight onto the building's envelope, and the surrounding ground allows light to penetrate the building's spaces.

6. Analysing the lighting strategies used in the chosen buildings

Mall Infinity Tower New Capital: The building tilts towards the northeast, with the main facade facing southwest. The remaining facades face southeast and northwest. The extensive surrounding land contains green spaces that diffuse sunlight, allowing the building to receive a significant amount of natural light. **Bank Egypt Global Service Centre (HSBC):** The building is oriented towards the northwest, and the main facade is facing the southeast. Surrounding land extension allows light to penetrate the building's spaces, and it includes green areas to diffuse the light rays (**Fig. 2**).



Figure 2: The building orientation: the natural and built environment surrounding the building, (a) Dar Al-Handasah, (b) Crédit Agricole Egypt New Head Office, (c) EMEC Headquarters, (d) Mall Infinity Tower New Capital, and (e) HSBC Bank .

6.1.2 Advanced glass systems for sustainable natural lighting

Dar Al-Handasah Building: The building's glass facade spans the full height of all three sides to maximize natural light inside the building's spaces. It features high-tech, low-emissivity double glazing to conserve energy [11].

Crédit Agricole Egypt New Head Office: The variety of glass shapes and sizes used according to the building's facade. Deep vertical openings were employed across most of the building's facades to bring natural light deep into the interior spaces. Continuous glass openings were used in certain areas like meeting rooms, and full-height glass curtain walls were installed in the northern and southern atrium walls to illuminate the building's interior spaces [10].

EMEC Headquarters :The full-height glass curtain walls were designed across the entire facade in

the north, east, and west directions to maximize daylight utilization, while the size of openings on the south side was minimized. High-performance glass was used to allow ample natural light while reducing heat gain; this tinted glass also mitigates glare throughout the working hours, aiding in maintaining comfortable interior temperatures and reducing the need for artificial lighting during the day. The double-glazed glass facade was also used in the entrance area[12].

Mall Infinity Tower New Capital: Double-pane insulated glass was used, designed as panels spanning the facade with dimensions of 1.60×4 meters. It features high transparency to maximize natural light while providing heat and sound insulation, as well as glare protection. Bank Egypt Global Service Centre (HSBC): The building utilizes full-height glass facades in the office and reception areas. It is also used in the upper openings to illuminate the interior courtyard (Fig. 3).



Figure 3: Size of the glass openings for the building envelope; (a) Dar Al-Handasah, (b) Crédit Agricole Egypt New Head Office, (c) EMEC Headquarters, (d) Mall Infinity Tower New Capital, and (e) HSBC Bank .

6.1.3 Shading systems:

Dar Al-Handasah: Horizontal louvers were used on the southern facade to provide visual comfort on work surfaces and glare protection, especially for computer users. Vertical fins were employed to shade the southern facade and the courtyard wall in the northwest direction, creating a sense of shadow play and providing shade for approximately 75% of the building over more than 50% of the total surface area. Plants such as palm trees were used for shading parts of the southern facade. Additionally, curtains were used to shade all exterior facade openings for glare protection, automated in meeting rooms while manually adjustable in open office spaces[12].

Crédit Agricole Egypt New Head Office: The sides of the deep exterior openings function as horizontal and vertical louvers to shade the openings and reduce direct sunlight on the southeast and southwest facades. Horizontal louvers were used on the rooftop extending deeply to increase shading on the southwest facade. Vertical louvers were also used to shade the northeast and northwest facades, adding color for diversity and movement. Internal curtains are used to shade the exterior openings in office spaces and can be controlled based on user needs. Palm and tree shading was used on the east, west, and south facades, while plants were used in the external courtyard and inside the building on the garden floor, visible from the internal courtyard, to provide pleasant views for users[10].

EMEC Headquarters: Louvers and light shelves were used on the southeast and southwest facades to reflect natural light into the interior and shade the openings for sun glare protection. Curtains with manual control are used in office spaces, while those in managerial offices are adjusted with light sensors [14]. Mall Infinity Tower New Capital: The glass is used to provide shading while allowing appropriate amounts of natural light into the space. It works together with curtains to protect against glare and provide visual comfort for the space users. Bank Egypt Global Service Centre (HSBC): Horizontal louvers were used on the southern facade to shade the spaces, along with the use of curtains for shading and glare prevention. Figure (4) shows the shading systems used in buildings.



Figure 4: Shading systems used in buildings; (a) *Dar Al-Handasah*, (b) *Crédit Agricole Egypt New Head Office*, (c) *EMEC Headquarters*, (d) *Mall Infinity Tower New Capital*, and (e) *HSBC Bank*.

6.1.4 Lighting enhancement systems in the internal spaces of buildings

Dar Al-Handasah: Glass was used in the roof of the internal atrium with wide structural beams, and a suspended ceiling in white within the interior spaces of the building to enhance the spread of natural light. The interior walls are white, complementing laminated glass walls that separate spaces to facilitate internal light distribution and foster greater connectivity among workers. The floors are gray and beige in some areas, with gray carpet used in office spaces. Furniture units varied to suit each space, with white used in open office units to increase light diffusion, and beige and brown in some closed offices, meeting rooms, and managerial areas, avoiding reflective paints to prevent glare [15,16].

Crédit Agricole Egypt New Head Office: Glass walls were used to separate office spaces to increase lighting and connectivity between users, as well as in openings overlooking the internal space to naturally illuminate it. Suspended ceilings in white were used to reflect light and enhance its distribution within the space. The floors are gray in office spaces and beige in other areas. Office units are white in open office areas and brown in managerial offices and meeting rooms. Additionally, all office units include individually adjustable task lighting [10].

EMEC Headquarters: The internal glass walls are used to separate office spaces, enhancing light distribution and fostering connectivity among workers. Curtains are used to shade exterior openings in certain spaces like meeting rooms, preventing glare. Suspended ceilings are employed in internal building spaces, and some rooms like meeting rooms can be illuminated through a movable ceiling to introduce natural skylight through a glass opening. Beige and brown colors are used for the floors, with brown carpet in office spaces to minimize light reflection on workers' eyes. White is used on ceilings and walls to increase light reflection and distribution within the space. Furniture units vary to suit the use of each space, with white used in open office units to enhance light diffusion, and beige and brown in some closed offices, meeting rooms, and managerial areas, avoiding reflective paints to prevent glare (**Fig. 4**).

Mall Infinity Tower New Capital: The office spaces in the building feature diverse designs, using light and reflective colors on walls and ceilings such as yellow, gray, and brown on the floors. Furniture units vary in materials and colors. Glass walls were used to separate internal spaces, facilitating connectivity among workers along with the open design without columns [17].

Bank Egypt Global Service Centre (HSBC): Light colors were used to reflect and spread light, such as white on the ceilings and walls with yellow, and beige was used for the floors. The use of reflective materials in the furniture, along with the varied colors of blue, white, and gray, also helped to increase the interior lighting. Glass walls were also used to separate the interior spaces [18].

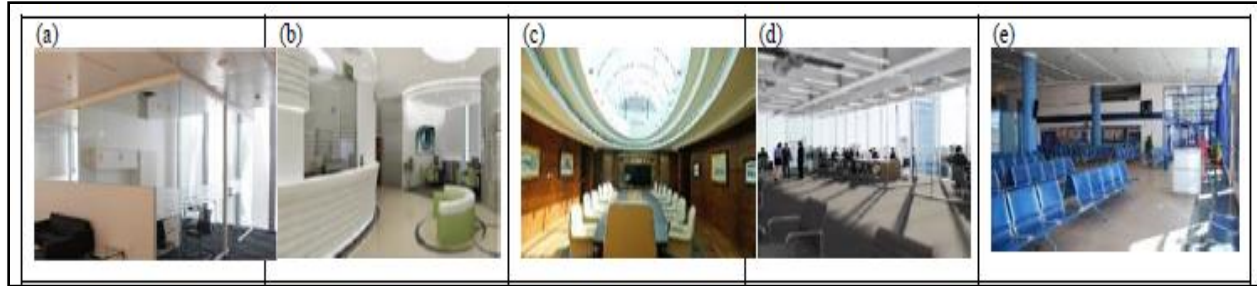


Figure 5: The lighting enhancement systems in the internal spaces of buildings; (a) *Dar Al-Handasah*, (b) *Crédit Agricole Egypt New Head Office*, (c) *EMEC Headquarters*, (d) *Mall Infinity Tower New Capital*, and (e) *HSBC Bank*.

6.1.5 Light assembling systems:

Dar Al-Handasah building: Atrium spans the full height of the northwest direction, providing natural lighting through its glass roof and walls into the office spaces overlooking it.

Crédit Agricole Egypt New Head Office: The covered atrium serves as the main entrance to the building. It acts as a connecting area between the north and south facades, both extensively using curtain wall glass across the building's height to provide natural light to the interior spaces overlooking it. The building is also designed around a courtyard to enhance light penetration into its spaces.

EMEC Headquarters: Double-height glass was used in the main facade to enhance natural lighting on the lower floors of the building. **Mall Infinity Tower New Capital:** features an atrium with a glass roof to illuminate the lower floors[19].

Bank Egypt Global Service Centre (HSBC): The main facade of the building features a double-height area with large glass walls that illuminate the entrance space and some of the adjacent office spaces[20]. The atrium is also used to illuminate the surrounding internal spaces through glass openings located above the courtyard. **Fig.(6)** shows the lighting enhancement systems in the internal spaces of buildings.

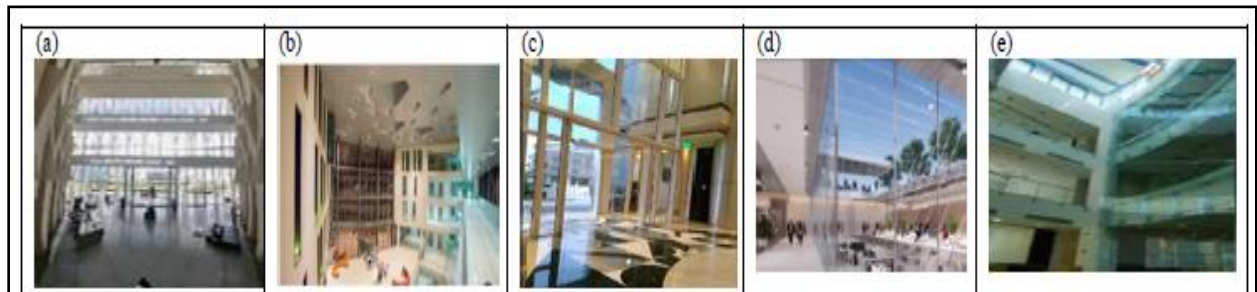


Figure 6: The light assembling systems used in buildings; (a) *Dar Al-Handasah*, (b) *Crédit Agricole Egypt New Head Office*, (c) *EMEC Headquarters*, (d) *Mall Infinity Tower New Capital*, and (e) *HSBC Bank*.

6.2 Artificial lighting systems

6.2.1 Energy efficient lighting units

Dar Al-Handasah: relied on energy-saving LED lighting units throughout all its spaces, as well as the use of high-efficiency task lighting, which led to a reduction in ambient lighting levels (**Fig.7**). **Crédit Agricole Egypt New Head Office:** The energy-saving LED light fixtures were used to illuminate the building's spaces in various forms according to the spaces' uses[21].

EMEC Headquarters: The energy-saving LED lighting units were used, which are connected to light control systems and occupancy sensors[14]. **Mall Infinity Tower New Capital:** LED lighting was used, which is connected to both automatic and manual control devices, allowing employees to control it[17].

Bank Egypt Global Service Centre (HSBC): The building uses energy-efficient lighting units and connects them to control systems to save energy (**Fig.7**).



Figure 7: The light assembling systems used in buildings; (a) *Dar Al-Handasah*, (b) *Crédit Agricole Egypt New Head Office*, (c) *EMEC Headquarters*, (d) *Mall Infinity Tower New Capital*, and (e) *HSBC Bank*.

6.2.2 Systems for producing Renewable energy

Dar Al-Handasah: Photovoltaic cells provide electrical energy to reduce the building's energy demands and are installed on the building's roof [9]. **Crédit Agricole Egypt New Head Office:** A 200 kW solar power station was installed on the roof to reduce energy consumption by 7% using photovoltaic panels[21].

EMEC Headquarters building: Renewable energy is generated through monocrystalline panels installed on the roof grid with a maximum capacity of 23 kW. These are connected via a single inverter that communicates with the building management system to provide instant power from solar energy, meeting 4.4% of the building's annual energy use [22]. **Mall Infinity Tower New Capital:** solar panels were used to provide electricity savings[17]. **Bank Egypt Global Service Centre (HSBC):** Take advantage of renewable energy sources to provide electricity for artificial lighting units[4].

6.2.3 Control systems:

Dar Al-Handasah: The industrial lighting system operates automatically in open office spaces, adjusted according to official working hours or using light sensors. This allows users in closed offices personal control over lighting, which is not possible in open offices. However, daylight sensors do not include dimmers to reduce light intensity throughout the workday, hence sensors are used only to determine the need for lighting system activation. Curtains in office spaces operate manually, while those in managerial offices are adjusted using light sensor.

Crédit Agricole Egypt New Head Office: Lighting units are connected to occupancy and daylight sensors, reducing input energy by at least 50% between 11 PM and 5 AM through automated devices. Additionally, 100% of space users have individual lighting controls allowing them to adjust according to their needs. Curtain control is also possible, adjusted via light sensors in managerial offices[21].

EMEC Headquarters: A fully automated control system is utilized, with the building's interior lighting system operating on a DALI system. This includes sensors to adjust light levels (LED lighting system responding automatically to daylight and user presence). The building also employs an advanced Building Management System (BMS) for communication, monitoring, and control of building performance[22].

Mall Infinity Tower New Capital: The building utilizes an automatic lighting control system in lighting units to provide adequate illumination in the absence of natural light while saving electricity.

Bank Egypt Global Service Centre (HSBC): use systems to control artificial lighting units to provide appropriate lighting for user comfort while saving electrical energy[4].

7. Concluding the relationship between global natural and artificial lighting strategies and the strategies used in modern Egyptian buildings

It is obvious from the previous analytical study that Egyptian buildings follow specific strategies for lighting their internal spaces, as follows:

7.1 Natural lighting strategies

7.1.1 Building envelope systems

Buildings rely on the design of their external envelope, which places significant importance on orienting the building in specific directions. This helps to avoid direct sunlight angles, achieve greater shading and reduce glare. The design of the building mass also depends on its relationship with surrounding buildings and the surrounding land area to benefit from solar reflections in the surrounding environment. In the design of the building envelope openings, the shapes of the external openings are varied between fully glass facades and small openings extending the full height of the space. This diversity aims to increase and deepen internal lighting, using glazing technology to manage incoming natural light, allowing for high transparency and maximizing natural light while providing shading and protection from heat gain. Buildings also use internal and external shading systems such as louvers and curtains, which vary in types and sizes according to the orientation of the openings, to provide visual comfort through shading and protection from glare (fig. 8).

7.1.2 Lighting enhancement systems in the internal spaces of buildings

Buildings have focused on partitioning internal spaces using transparent walls and light paint colors, as well as reflective materials on walls, ceilings, floors, and furniture. This design aims to increase light reflections and distribution within the spaces, enhancing natural lighting and reducing the need for artificial lighting (fig. 8).

7.1.3 Light assembling systems

Various types of courts have been utilized in buildings, ensuring adequate lighting for the interior spaces they adjoin. These courts enhance the distribution of natural light within the building, thereby reducing the need for artificial lighting and improving visual and environmental comfort. Additionally, some Egyptian buildings used mezzanine floor of buildings which have a double-height glass system for increased internal lighting, which has not been widely used in international buildings (fig. 9).



Figure 8:(a,b) Master plan-Perspective shows the building's form based on orientation and the surrounding environment; (c) shading the open office space in the administrative building; (d) Glass walls are used to separate internal spaces.



Figure 9: Utilizing an atrium with glass walls and a glass roof - Double-height glass to light up the internal spaces.

7.2 Artificial lighting strategies

7.2.1 Energy efficient lighting units

All buildings used energy-efficient LED lighting units, which vary in numbers and shapes depending on the type of administrative space. These units are characterized by their high energy efficiency,

reducing electricity consumption and associated costs. Additionally, LED lighting units provide balanced and high-quality lighting, enhancing user comfort and increasing work efficiency in administrative spaces (**fig. 10**).

7.2.2 Systems for producing Renewable energy

The buildings using photovoltaic panels to generate electrical energy from the sun. These panels help to reduce and lower the cost of electricity used for lighting, making the buildings more energy-efficient and less reliant on conventional energy sources. Additionally, photovoltaic panels are a sustainable and environmentally friendly option, enhancing the buildings' sustainability and reducing their carbon footprint (**fig. 8**).



Figure 10: The design of lighting units varies depending on the function of the space.

7.2.3. Control systems

The buildings employ automated control systems for their lighting units, integrating sensors to regulate light levels within the space. These sensors ensure adequate lighting when natural light is insufficient, improving energy efficiency and lowering electricity usage. Moreover, the systems provide manual control options, offering users enhanced personal comfort and the ability to adjust lighting based on individual preferences.

Thus, we find that the natural and artificial lighting strategies used in Egyptian administrative buildings encompass various lighting treatment systems that align with sustainable lighting strategies in observed global administrative buildings.

8. Deducing the efficiency of using the global sustainable strategies in the Administrative Buildings in Egypt

This part of the research aims to measure how well the sustainable lighting strategies used in Egyptian administrative buildings achieve visual comfort within the space and the building's sustainability. This is determined through a questionnaire formed of a set of questions posted to the building's users of the top three administrative buildings in Egypt, based on LEED and GPRS evaluation, which are: Dar Al-Handasah set for case no (1), Crédit Agricole Egypt New Head Office set for case no (2), and EMEC Headquarters. Set for case no (1), the results of the questionnaire measures the level of the user's satisfaction. The questionnaire included questions measuring the role of the building envelope design systems, light enhancement systems within spaces, light polarization systems, appropriate artificial lighting systems, and lighting unit control in the sustainability of lighting within the building spaces.

Table 2. A survey to assess user satisfaction with the effectiveness of lighting systems in achieving visual comfort in interior spaces.

	Questions	Method of utilizing the system	Case studies			
			1	2	3	
Natural lighting systems	Building envelope systems	Q1. How does the design of the building envelope to utilize natural lighting inside the building?	The building orientation to avoid direct solar radiation angles	✓	✓	✓
		The multiple slopes of the building's external envelope facilitate deep penetration of natural light into the building spaces.	✓	✓	✓	
		Using the reflected light from the surrounding natural and built environment	✓	✓	✓	
		Q2. How does the shape of the openings used in the building envelope affect the natural light that penetrating the building?	Full-building glazing to maximize the amount of natural light entering and reducing glare Small openings allow for controlled amounts of natural light and provide even light Skylights openings allow ample natural light to enter distribution for minimizing shadows and glare.	✓	✓	✓
		Q3. How does the use of technological glass affect lighting inside the space?	visual comfort inside the space	✓	✓	✓
		Shading from sunlight	✓	✓	✓	
		protection from external heat	✓	✓	✓	
		Q4. What role does the shading system play in influencing natural lighting within the space?	Shading provides protection from sunlight	✓	✓	✓
		Ensures visual comfort for the users	✓	✓	✓	
		Q5. How does using more than one of external shading system affect the natural lighting of the space?	Increasing shading from external sunlight and enhancing enhancing visual comfort within the space	✓	✓	✓
	There is no more than one type of shading system	✓	✓	✓		
	Q6. Does the shading system for use the automated control?	Yes, in the internal shading system	✓	✓	✓	
	Yes, in external shading system	✓	✓	✓		
	Q7. What role does automated control play in the internal shading system of the space?	Shading and visual comfort for users	✓	✓	✓	
	Personal comfort for users	✓	✓	✓		
	Energy savings from reduced electrical usage in building lighting	✓	✓	✓		
	The achievement ratio of the building's system			84%	79%	79%
	Lighting enhancement systems in the internal spaces of buildings	Q8. What is the purpose of using transparent materials in the interior walls of buildings?	Partition between internal spaces in the building	✓	✓	✓
		Distribution and spread of lighting between interior spaces	✓	✓	✓	
		Communication between users and prevention of boredom	✓	✓	✓	
Q9. How do painting colors and reflective materials used in the ceilings, walls, and floors of internal spaces improve lighting?		Reflection and diffusion of light within the space glare protection	✓	✓	✓	
The achievement ratio of the building's system			100%	100%	100%	
Light assembling systems	Q10. How do light assembling systems help to improve the lighting of internal spaces in building?	provides additional natural light to surrounding spaces Court	✓	✓	✓	
	Courtyard enhances light distribution to surrounding spaces.	✓	✓	✓		
	Atrium allows a significant natural light to penetrate deep into the building	✓	✓	✓		
	Sunlight collecting devices	✓	✓	✓		
	Double-height glass (mezzanine) for increased internal lighting	✓	✓	✓		
Q11. Does the building need to increase the size of the assembling systems used?	Yes, it needs to	✓	✓	✓		
No, it doesn't need to	✓	✓	✓			
Q13. Does the building need to use more assembling systems to achieve the visual comfort?	Yes, it needs to	✓	✓	✓		
No, it doesn't need to	✓	✓	✓			
The achievement ratio of the building's system			75%	85%	70%	
Artificial lighting systems	Energy efficient lighting	Q14. Do artificial lighting units provide the appropriate light for visual comfort of space users?	Yes, they do	✓	✓	✓
		No, they don't	✓	✓	✓	
	producing Renewable lighting	Q15. Can renewable energy systems help lower the amount of electrical energy for lighting?	Yes, they do	✓	✓	✓
		No, they don't	✓	✓	✓	
	Control systems	Q16. What role does automate control play in artificial lighting units within a building?	Providing visual comfort for space users throughout the work period	✓	✓	✓
		Providing visual comfort for space users at specific times during the workperiod	✓	✓	✓	
		Saving on electrical energy used for lighting	✓	✓	✓	
		Q17. What role does manual control play in artificial lighting units within a building?	Providing visual comfort for space users	✓	✓	✓
		Providing personal comfort for space users	✓	✓	✓	
		Saving on electrical energy used for lighting	✓	✓	✓	
Q18. How many sensors used for the artificial lighting units?	Only one	✓	✓	✓		
More than one	✓	✓	✓			
Q19. What role do the sensors connected to artificial lighting units play?	Providing appropriate industrial lighting when natural light is insufficient	✓	✓	✓		
Saving on electrical energy used for lighting	✓	✓	✓			
The achievement ratio of the building's system			83%	92%	92%	

9. Results & Conclusion

In this research, the focus was on evaluating the implementation of global sustainable strategies for

natural and artificial lighting in Egyptian administrative buildings and determining the efficiency of these strategies through an analytical study of a group of modern administrative buildings in Egypt that have received or are seeking LEED or GPRS certification, which use advanced lighting technologies. The study concluded the following:

- Alignment with Global Sustainable Lighting Strategies. These strategies employ a variety of methods to achieve sustainability and enhance visual comfort for users. The systems include building envelope systems to improve natural light entry, internal lighting enhancement systems for even light distribution and glare protection, light collection systems to ensure significant amounts of natural light penetrate deeply into the building, energy-efficient lighting units that combine automated and manual controls to provide adequate lighting when natural light is insufficient and reduce energy consumption, and renewable energy systems to improve overall energy efficiency in the buildings.
- Effectiveness of the Strategies in Achieving Visual Comfort as survey results indicated that users of the building spaces confirmed the significant effectiveness of these strategies in achieving visual comfort.

Thus, it is essential for designers of Egyptian administrative buildings to conduct a comprehensive evaluation of the current lighting systems and update them to align with global sustainability strategies. They should also work on developing lighting systems that are suitable for local conditions and integrate artificial intelligence technologies with lighting systems to achieve advanced energy management and enhance performance.

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