ISSN: 0974-5823 Vol. 7 No. 5 May, 2022

International Journal of Mechanical Engineering

Towards environmental sustainability of existing buildings in Egypt

"Case study of the building of the Faculty of Engineering - Department of Architecture – Al-Azhar University – Cairo"

Prof. Mohamed Saad Attwa
Professor in Architecture- Dep. Faculty of Engineering, Al-Azhar University

Assoc. Prof. Magdy Mohamed Qasem
Associate Professor in Architecture- Dep. Faculty of Engineering, Al-Azhar University

Eng. Haitham Emad el- din Morsy
Assistant Lecturer – Department of Architecture, Faculty of Engineering, El-Gazera academy

Abstract:

Existing buildings have significant negative impacts on the environment. We see this by consuming large amounts of energy in these buildings. Modern building technology has witnessed a great development in the development of building materials aimed at reducing negative impacts on the environment. These developments emphasize the sustainable use of buildings; these developments were at the local level (Egypt). The Egyptian state is taking serious and real steps to direct the construction industry towards sustainability. In fact, we see many studies dealing with the importance of sustainability in the field of building and construction, but few of these studies address the role of locally available building materials in sustainability. There are also few studies on the role of locally used building materials in saving energy consumption. The research problem came from this point, which deals with the inability of the existing architectural facilities in Egypt to play their role in achieving the concepts of sustainability. In fact, existing buildings in Egypt do not benefit from the environmental potential for sustainability.

This research aims to try to reach the effectiveness of achieving sustainability for existing buildings in reducing energy consumption, and increasing their compatibility with environmental specifications according to the concepts of sustainability.

Keywords: sustainability, existing buildings, sustainable building materials.

1- Introduction:

The relationship between man and the environment was characterized by harmony and compatibility before entering the industrial era and scientific progress. This compatibility was due to the weakness and slowness of human activities before this age. Before the modern industrial era human activities were very limited. The industrial and progress era led to many changes in human behavior, and these rapidly changes affected the environment. Ecosystems are often unable to restore their natural balance. In this regard, the architectural industries had the largest share of these negative impacts on the ecosystem. Modern architecture relies on reinforced concrete, iron and other building materials, which have had a significant negative impact on the ecosystem. This research attempts to find solutions to the environmental problems of existing buildings and approximate them to be compatible with the concept of sustainability and green architecture.

According to Egypt's Vision 2030, the population of Egypt is expected to reach 140 million. This large number will need more buildings. These buildings will consume more energy. For these reasons we shall develop existing buildings in order to reduce energy consumption and provide local materials compatible with sustainability. We need to allow existing buildings to play their part in reducing energy consumption as well as preserving the environment.

2- Research problem:

The research problem revolves around the negative impacts on the environment due to the consumption energy of existing buildings. These negative effects are expected to increase due to the expected increase in the population. These negative influences affect society in many ways, the most important of which are:

- The current society suffers from environmental problems, and this has led to an increase in the need to implement environmental standards.

- Existing buildings consume large amounts of energy, especially educational buildings.
- Existing buildings are unable to perform their role according to the concepts of sustainability.

The emergence of these environmental problems made architects think about creating buildings that comply with the concept of sustainability. From this perspective, the following research question emerged:

- How can existing buildings be compatible with sustainability in Egypt, according to local conditions?

3- Sustainability and Development

Environmental sustainability means preserving the natural materials and ecosystems of the environment in order to preserve the rights of future generations. The term environment includes everything that surrounds humans and affects or is affected by the human race. Human society lives in an integrated ecological system. As we can see in Figure (1); the ecosystem is divided into three components as follows [(1)]:

1. **The natural system**: The natural system is the biosphere or the space in which life exists, or the place of life.
2. **The Man-Made System**: manufactured systems or Man-made system means man-made activities. The manufactured system includes buildings, cities, all human activities such as industry, agriculture, transportation networks, water, sewage, energy, and others. That is, the manufactured system means all human interventions made by man to provide goods and services to satisfy the needs of society.
3. **Social System**: The social system includes all the administrative institutions that link the ecological systems (natural and man-made) and the relationships between individuals in society.

There are multidirectional interactions between these three components that represent the community life. Environmental problems usually arise due to a defect or deterioration in some of the interactions that take place between the components of the ecosystem. An example of this defect is that the human being, through the made system, performs practices that lead to the pollution of the vital system. Environmental problems occur due to pollution resulting from human activity that pollutes the environment.

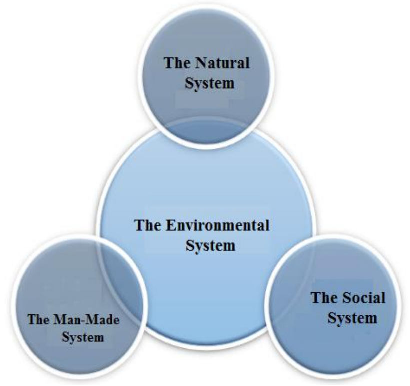


Fig. (1): The main components of an Environmental system.

Source: Ihab Mahmoud Oqba, 2006

(Formatted by researcher).

4- University buildings

University buildings are buildings designated for university students. Students spend most of their time inside these buildings for various activities. The most important student activities are learning, scientific research, and preparing experiments in university laboratories. UNESCO defined the university as an educational institution that gives students education and training over a period of (4:7) years. The university consists of professors, students, and staff gathered in one place with the aim of imparting and absorbing knowledge of all kinds.

University buildings consist of a group of architectural buildings such as colleges, conference centers and administrative buildings. The administrative buildings are responsible for managing all university activities. Many scholars and researchers consider the universities are small cities because of its large size and the number of people inside it. The university includes many intersecting, interactive and complex activities.

5- A strategy to achieve sustainability in university buildings:

The strategy to achieve sustainability in university buildings depends on reconciling the university buildings with the principles of sustainability. The reconciliation process includes rationalizing energy consumption, supporting the use of sustainable energy, conserving & reprocessing water, supporting an increase in green space, recycling & benefiting from waste, reducing the use of transportation that pollutes the environment, encouraging pedestrian movement, and reducing the movement of traditional cars within the university. What is more, is to use the university as an educational tool for sustainability. Without a doubt, universities are specialized in scientific research. We can use this function to support scientific research aimed at achieving sustainability through several strategies, as follows[2]:

Fig No. (2): Interest of employing alternative means of transportation and pedestrian paths.

Source:(https://www.independent.com/201/10/08/ucsb-bikes/,2010)

- **Sustainable location and transportation:**

The architect always thinks of the connection between the site and the building. The monumental buildings have remained until now due to the architects' respect for the site, environmental, climatic studies, topography and all the characteristics of the environment. For these reasons, the first principle for achieving sustainability is site selection. The site should help realize the principles of sustainability. Site selection means taking advantage of all environmental conditions. Site selection of the university should be based on studying the environment and how to benefit from it before starting to construct the buildings. After that, the architects shall be careful to reduce the use of transportation that pollutes the environment as shown in Figure(2), activate the pedestrian movement and reduce the movement of traditional cars inside the university[3].

- **Sustainable formation and renewable energy:**

The efficiency of the high-quality architectural design of the university's buildings is highly efficient when it meets the requirements of the users and is consistent with the principles of sustainability. Sustainable architectural design includes the use of elements and forms that provide natural light and ventilation on the one hand. On the other hand, sustainable buildings use renewable energy sources to obtain energy. Renewable energy sources can be through the use of photocells because they are characterized by the right size and color; In addition, these cells are able to produce energy not only from direct sunlight but also from daylight in General [2].

- **Environmentally friendly building materials**

Using environmentally friendly building materials means using materials that are reusable or recyclable. These materials shall be made of natural materials such as clay, wood, and others. These materials shall not harm the environment in any way after use. It is also necessary to take advantage of the elements of nature, such as taking advantage of the shade of trees and improving the university environment in general, as in Figure (3) [3].

Fig No. (3): Lucien Cornell housing project for university students in Marseille.

Source:(https://ara.architecturaldesignschool.com/lucien-cornil-studentresidence,2021)

- **Waste recycling**

The waste of educational environments is not included in the waste harmful to the environment. That's why students can take advantage of it by separating it, sorting it and putting a wastebasket for each type. We see in Figure (4) that most of the waste of the educational environment is paper, then glass, then metal, and then food waste. We can easily recycle this waste and use food waste as agricultural fertilizer, in addition to reducing waste fundamentally [4],[5].

Fig (4): Alexandria University initiative to separate and recycle waste.

Source :(https://alexu.edu.eg/index.php/ar/-08-18-11-2015/staff-search-ar-21/2-arabic/5887,2021.

6- Case study of the College of Engineering

6-1) Analyzing the building (case study) according to the current situation and according to sustainability criteria.

1. **Location considerations**:

Advantages:

- The building is located near the main gates of the university and close to transportation, so it is easy to reach the building.
- The building consists of two parts. The first part is located in the northwest direction and the second part is located in the southeast direction, where the sun's rays are strong; we see this in Figure (6, 7).
- The building is close to the University City of students, figure (8).

Disadvantages:

- The building is free from shaded pedestrian walkways in the outdoor areas.
- The building includes many heat islands. These heat islands increase the temperature of the building and facilitate heat transfer to the building.
- The building is far from sources of light pollution.

Fig. (5): The figure shows the ease of access to the site because it is located between four main roads inside downtown Cairo.

Fig. (6): The Faculty of Engineering Building- Department of Architectural Engineering, Al-Azhar University. (Northwest side) (prepared by the researcher)

Fig. (7): The Faculty of Engineering Building- Department of Architectural Engineering, Al-Azhar University. (Southwestern side) (prepared by the researcher)

Fig (8): The figure shows the building of the College of Engineering and its nearness to the university city of students (prepared by the researcher)

The researcher determined all the elements and factors of the general site, and measured the heat load using the simulation program (REVIT) for the general site (Fig.9), with values that exceeded (1500kw/h/m^2).

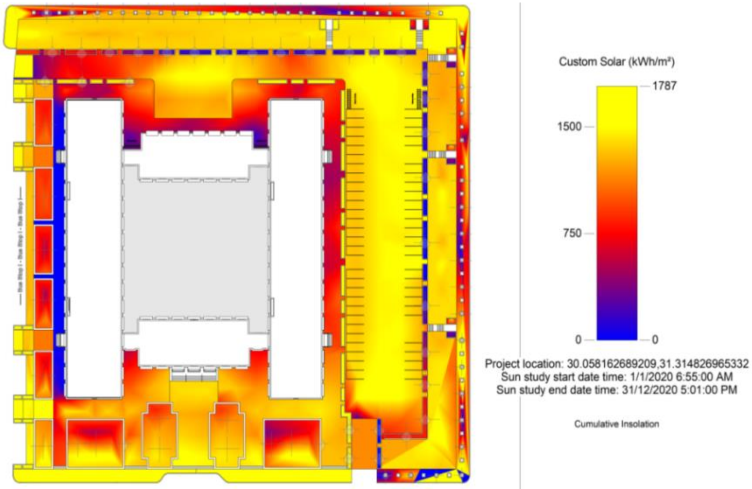


Fig (9): The heat load of the general site on the existing situation with values higher than (1500 kw/h/m^2)

2. Water efficiency

Advantages:

- The sewage network is completely separate from the sources of pure water, so that the pure water is fresh and not polluted.

Disadvantages:

- The building is devoid of any water recycling facilities, especially drinking water.
- The plants are irrigated by clean water.

3. Energy Efficiency

The design elements are not integrated with natural energy sources, and there is no use of ecological solutions; we see that in the following:

- The building materials used are not characterized by low thermal conductivity, and the thickness of the walls is not large. These specifications do not reduce the effect of solar radiation within the educational spaces.
- Ventilation methods did not use natural ventilation methods such as air hooks and others.
- The building is free from methods that using renewable energy in order to reduce energy consumption in the building; Fig (10).
- There are a large number of openings in the external facades, especially on the south side; this leads to an increase in the heat load on the building.
- The refrigerants in the building use Chlorofluorocarbons, are consuming about 35% of the total energy consumption in the building; Fig (11).

Fig. (10) Shows the non-exploitation of roofs to generate renewable energy for the building (Case study) - (Prepared by the researcher).

Fig. (11) Shows the use of fluorocarbons on the southern facades (Case study) - (prepared by the researcher).

4. Materials and resources

- The used materials in construction are characterized by high thermal conductivity, and this negatively affects the heat transfer of the building significantly.
- Purchases of educational papers and tools are from outside of local environment.
- The used materials in the maintenance are not subject to the principles of sustainability.

- Dilapidated furniture materials are not recycled; this leads to an increase in the amount of waste and a negative impact on the environment, figure (13, 12).
- The college does not have a clear and correct plan for waste management from its collection and separation to its recycling.

Fig. (12): shows the disposal of worn-out furniture materials that are not recycled; Dispose of them in way harms the environment.

Fig. (13): shows many resources such as art boards that are not reused.

5. Environmental quality

- The college does not use means to achieve the quality of ventilation and to improve the movement of air within the educational spaces.
- Thermal comfort does not exist because the building's facade is to the south, and this facilitates the passage of heat into the building.
- Natural light enters through many openings in the building, but there is no method to control the degree of penetration of the rays.
- Acoustic comfort is available by separating educational spaces from other functional spaces, such as administrative spaces.
- Finishing materials are made of materials that contain harmful carbon emissions.
- Pest control is by using materials containing organic compounds.
- Cleaning tools do not require power like manual brooms.

The researcher took three samples from the several spaces. The researcher used simulation program to select and analyze samples. The selection of samples was based on different directions and positions. The samples were from the northern, southern and eastern sides, and from spaces with different functions such as an educational space Fig. (14), a studio Fig (15), an administrative space Fig. (16).

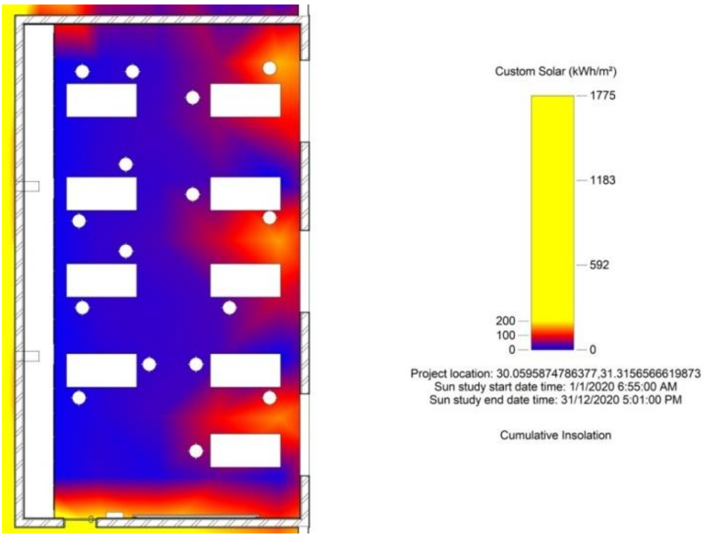


Fig. (14) Shows the heat load of the classroom, which reaches the highest value (160 kw/h/m^2).

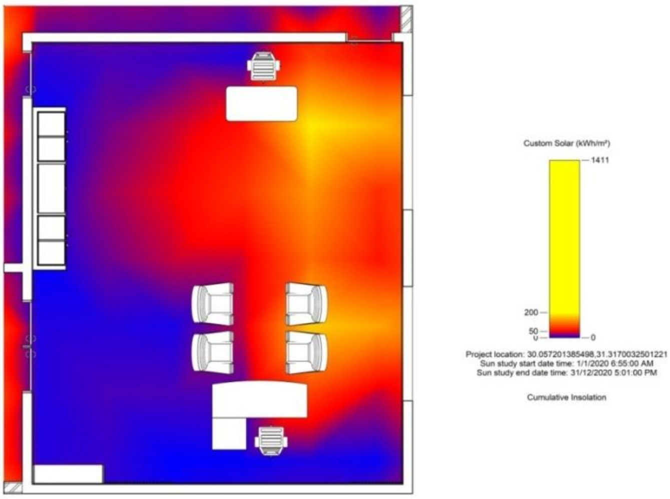


Fig. (15) Shows the heat load of the administrative space, which reaches the highest value (250 kw/h/m2).

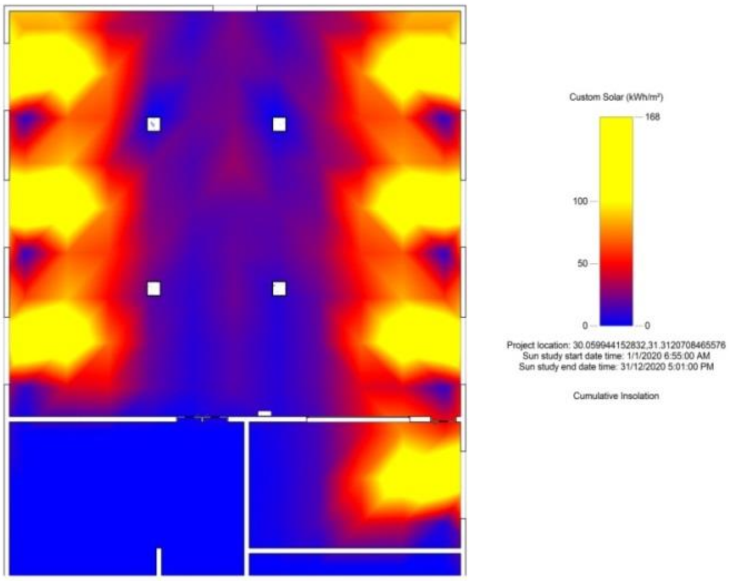


Fig. (16) Shows the heat load of the classroom, which reaches the highest value (170 kw/h/m^2).

6) The process of applying environmental treatments at the building level:

1- Location considerations

- The college building is close to the main roads, this location helped in providing transportation to move from one place to another, Fig (17)
- There are places for waiting for bicycles in order to encourage students to use them, Fig (18).
- There are car parking spaces with the addition of solar cells.
- The application has added Sun-breakers for the interface. This helped reduce a glare and light pollution Fig. (19)
- The application reduces heat islands around the building by increasing afforestation and increasing the percentage of shaded areas. This led to the provision of shaded places to sit, such as wooden pergolas. These pergolas are made from old materials (recycled) Fig (20).

The researcher measured the heat load after adding the previous modifications Fig. (21); In order to know the efficiency of the modifications in reducing the energy consumption of the building in general. The heat load before adding the modifications recorded a higher level from (1500kw/h/m^2) to (820kw/h/m^2). This value confirms the efficiency of the modifications. These modifications reduced power consumption by approximately 45% compared to the previous situation.

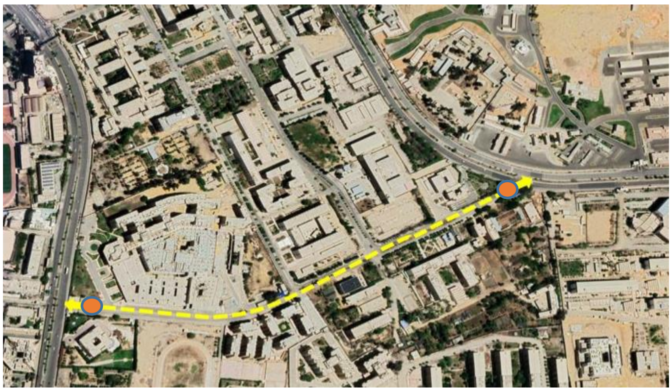


Fig. (17) shows the main entrances of university, which providing to public transportation, and its proximity to the College of Engineering building.

Fig. (18) Bicycle parking

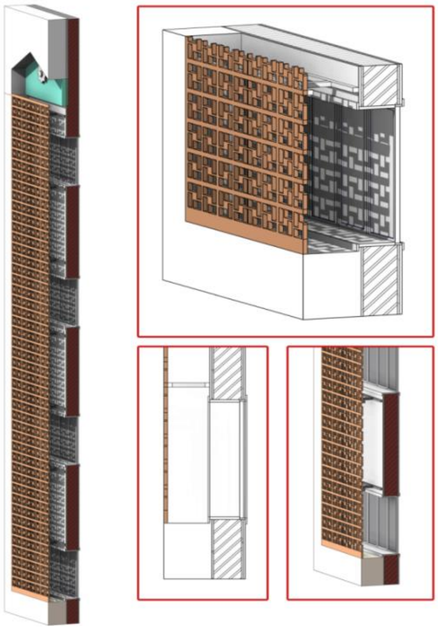


Figure (19): Sun-breakers on the facade to help reduce glare and light pollution.

Fig. (20): Shows the presence of wooden pergolas to reduce heat islands and increase the shaded area.

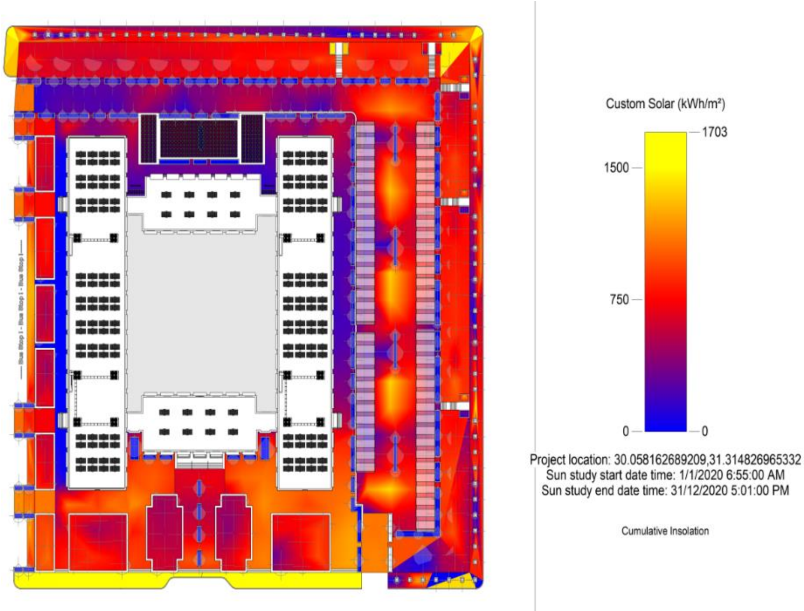


Fig. (21): shows the heat load of the general site after using environmental treatments with values less than (850kw/h/m^2).

2- Energy Efficiency

- **Use of renewable energy means**

During application; We put solar cells on rooftops, in parking lots, on horizontal sun deflectors; And that was in the places facing the south side with the aim of generating power. We used RETScreen, this program specializes in the generation and management of clean energy, Fig (25, 24, 23, 22). This program analyzes the feasibility of the energy project and the efficiency of renewable energy in addition to the analysis of continuous energy consumption.

- **Using tools to treat and reduce heat intensity on the building**

We did this by placing solar cells to produce electrical energy on top of the diffusers; We leave space between cells and walls or ceilings to prevent heat transfer to the building.

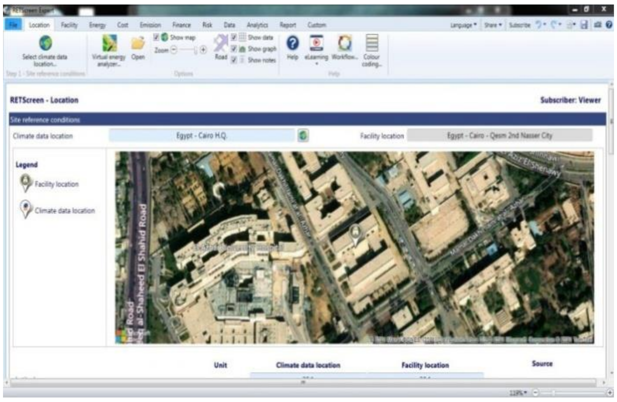
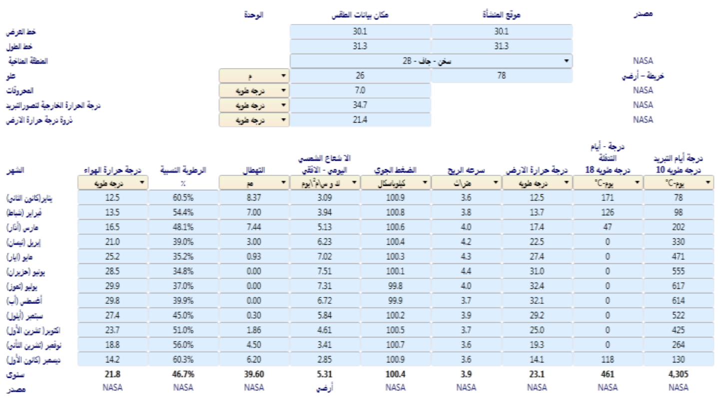


Fig (23) shows the determination of the site through the program as a prerequisite for determining the necessary climatic data.



	الوحدة	مكان بيانات الطقس	موقع المنشأة	مصدر
خط العرض		30.1	30.1	
خط الطول		31.3	31.3	
المنطقة المناخية		سخن - جاف - 2B		NASA
علو	م	26	78	خريطة – أرضي
المحروقات	درجة مئوية	7.0		NASA
درجة الحرارة الخارجية لتصور التبريد	درجة مئوية	34.7		NASA
ذروة درجة حرارة الارض	درجة مئوية	21.4		NASA

الشهر	درجة حرارة الهواء	الرطوبة النسبية	التهطال	الا شعاع الشمسي اليومي - الافقي	الضغط الجوي	سرعه الريح	درجة حرارة الارض	درجة - أيام التدفئة درجة مئوية 18	درجة أيام التبريد درجة مئوية 10
	درجة مئوية	%	مم	ك و س\م²\يوم	كيلوباسكال	م\ث	درجة مئوية	يوم-°C	يوم-°C
يناير(كانون الثاني)	12.5	60.5%	8.37	3.09	100.9	3.6	12.5	171	78
فبراير (شباط)	13.5	54.4%	7.00	3.94	100.8	3.8	13.7	126	98
مارس (آذار)	16.5	48.1%	7.44	5.13	100.6	4.0	17.4	47	202
إبريل (نيسان)	21.0	39.0%	3.00	6.23	100.4	4.2	22.5	0	330
مايو (أيار)	25.2	35.2%	0.93	7.02	100.3	4.3	27.4	0	471
يونيو (حزيران)	28.5	34.8%	0.00	7.51	100.1	4.4	31.0	0	555
يوليو (تموز)	29.9	37.0%	0.00	7.31	99.8	4.0	32.4	0	617
أغسطس (آب)	29.8	39.9%	0.00	6.72	99.9	3.7	32.1	0	614
سبتمبر (أيلول)	27.4	45.0%	0.30	5.84	100.2	3.9	29.2	0	522
اكتوبر(تشرين الأول)	23.7	51.0%	1.86	4.61	100.5	3.7	25.0	0	425
نوفمبر (تشرين الثاني)	18.8	56.0%	4.50	3.41	100.7	3.6	19.3	0	264
ديسمبر (كانون الأول)	14.2	60.3%	6.20	2.85	100.9	3.6	14.1	118	130
سنوي	**21.8**	**46.7%**	**39.60**	**5.31**	**100.4**	**3.9**	**23.1**	**461**	**4,305**
مصدر	NASA	NASA	NASA	أرضي	NASA	NASA	NASA	NASA	NASA

Fig (24) shows the climatic data issued by the program after determining the area of the study case.

Fig (25) shows the general data page of the project and the proposed system.

The proposed project depends on designing a program works in a matrix manner on the proposed surface. These matrices operate in an open grouping and static orientation with perfect slope [6], Fig. (27,26). This system helps in allowing sunlight to reach the roofs of buildings for most day. This facilitates the optimization of the roof of the building in addition to the presence of a horizontal surface for installation. The horizontal surface saves the costs of creating structures to bear arrays on a false surface.

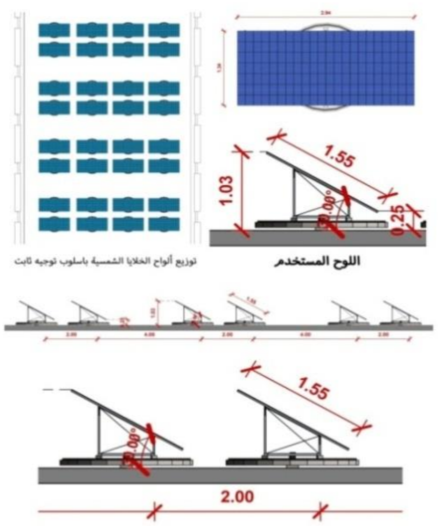


Fig. (26) shows distribution of photovoltaic matrices in a static routing fashion and open aggregation (proposed program).

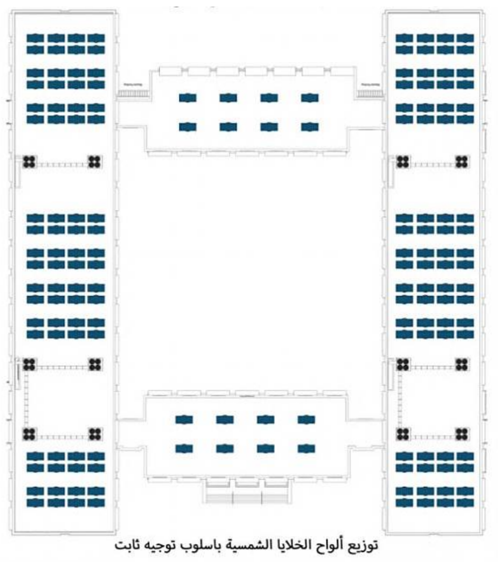


Fig. (27) shows distribution of photovoltaic matrices in a static routing fashion and open aggregation (proposed program).

Calculate the amount of produced energy by the system

The program (RET Screen Expert) displays the expected amount of generated energy by the system through knowing the data entered. With the help of this program we were able to summarize the input data (input), and the output data (output). We compare these results with the results of the mathematical equations as in Table (1).

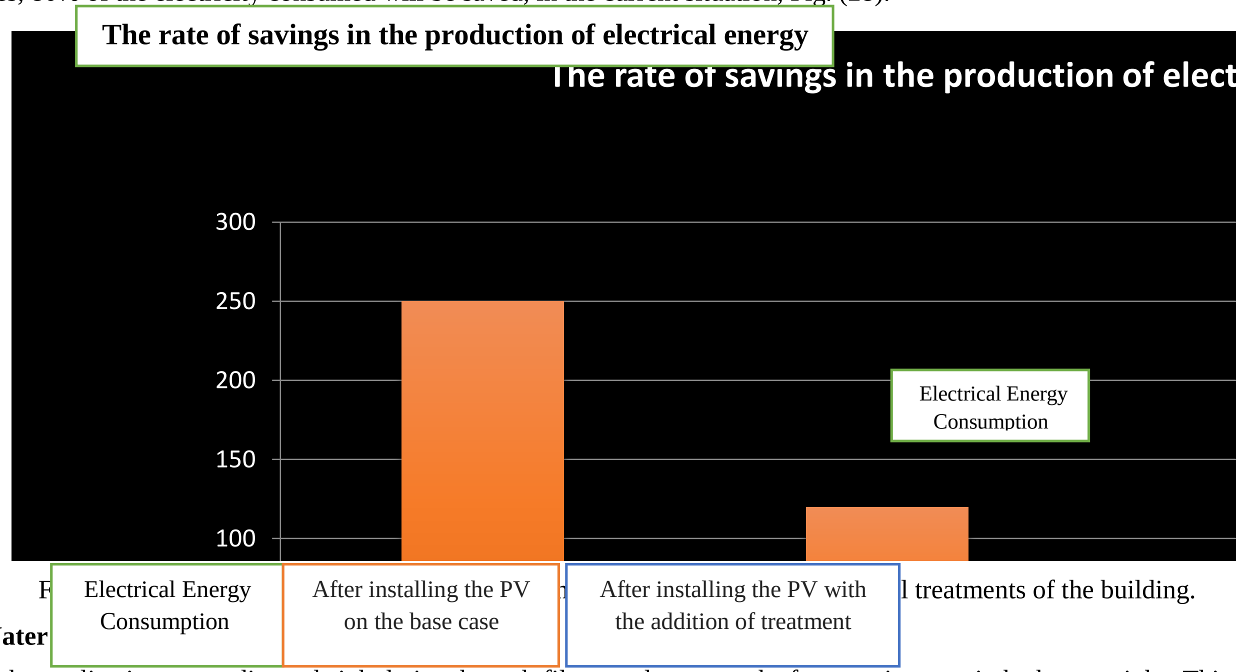
Table (1): It presents the calculation of the amount of electrical generated energy by the photovoltaic system in the different design cases of the system using the RET Screen Exepert program and its comparison with the mathematical equations (prepared by the researcher).

		Case statement
Output (The amount of electrical energy produced (M.W.h))	Climatic data	Cairo city data
	The used board	(Mono Si Hip 205BA3) Sanyo company.
	Direction style	Fixed
	320	Number of boards
	January	9.815
	February	8.541
	March	10.655
	April	10.994
	June	9.123
	July	11.685
	August	10.985
	September	10.136
	October	9.874
	November	9.651
	December	8.951
The annual total (M.W.H/ Year)		119.36

From the above table; we note several points, the most important of which are; the largest amount of energy is 119.36 M. W. H/year. This result is under standard conditions and according to the solar cell manufacturer's recommendations and instructions. The manufacturer recommended that regular maintenance be done every three months. The building is depreciated annually according to the years 2018/2019, 2020/2021 AD, about 250 M. W. H / Year [7]. This means that the production of solar energy saves 50% of the electrical energy consumption, according to the current consumption.

Traditional lighting methods consume 60% of the total energy consumption, while when using energy-saving bulbs (LED). These bulbs are made from 35% recycled materials. In the recycling process, we will not use Chromium. We will also use 100% recycled materials for packaging[8].

We will replace the treatment systems and air conditioning units that consume 30% of the electricity in the building. After all these measures, 80% of the electricity consumed will be saved, in the current situation, Fig. (28).



F … l treatments of the building.

- **Water**

During the application, we redirected sink drains through filters and water tanks for one-time use in bathroom sinks. This process saved nearly 97% of the total per person consumption of clean water. This is because the average person consumption of water per day is about 300 L/person/day. This consumption is during the average number of hours spent studying or working for 8th hours per day, about 100 liters / person / day. We calculated the per person consumption by calculating its average per person consumption from the average discharge of wastewater (gray water and black water) with the help of the following equation:

$$\mathbf{Q_{AV\ (SEWERAGE)} = (0.8\text{-}0.9)\ Q_{AV\ (WATER)}}$$

Thus, per person consumption of gray water and black water becomes:

$$Q_{AV\ (SEWERAGE)} = (0.8\text{-}0.9) * 100$$

$$Q_{AV\ (SEWERAGE)} = 85\ L/P/D$$

We see through these equations that the person consumption of gray water (basin wastewater) is about 35% of the average wastewater (gray and black water combined). This means that the person consumption of gray water is approximately 30 liters/person/day. We also know that the person uses the toilet around 4 times a day at a rate of once every 6 hours. Toilet flushing bin needs 7.5 to 10 liters each time. That is person who uses the toilet within 8 hours consumes approximately 12 liters of water per day.

When we direct the gray water after treatment and redirect it to the parcel boxes, that is, to use it again. This means saving 100% of gray water and using it to fill package boxes. This means that no clean water will be used for flushing boxes of toilet (Fig. 29). We will use the remaining water of 18 liters / person / day to irrigate the gardens [9].

- On the other hand, the application provides a design for collecting rainwater Fig. (30) from the roofs of buildings, collecting it, then purifying it and using it to irrigate outdoor gardens. According to official data, annual precipitation falls at a rate of 160 mm/year/m2. From this point, we conclude that the amount of rainwater that will be available [10]:

Average rainwater = building area x fence height x average annual rainfall

Average rain water = 4210 x 160

This means that the average amount of rainwater collected annually = approximately 673600 mm/year. We will direct this water to irrigate the gardens.

3- Materials and resources

A. Materials:

- According to the proposed program, we will use recycled materials. These materials are heat insulating and free of organic matter. This means that it will contribute to reducing energy consumption in the building.
- We will place sun breakers (solar panels) in a horizontal position in proportion to the architectural character of the building. We will leave a space between the ceilings and the rays to create an air distribution area to cool and reduce heat reaching the building through the walls Fig. (31).
- Reuse of materials: This will be through the use of used and usable products again, such as modified storage places to suit a larger number of users, as well as the exploitation of columns and front space. We will manufacture leftover timber shelves for a variety of uses Fig. (32). We will renew the drawing tables without the need to purchase new materials, by adding architectural drawing boards to the same tables Fig. (33).

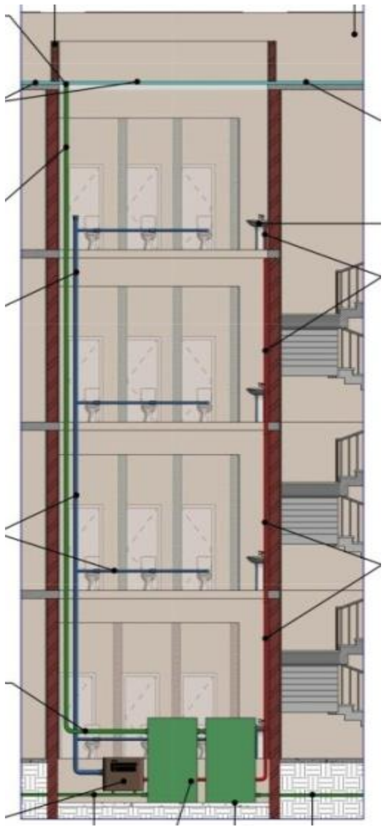


Fig (30): a vertical section of the building is passing through the bathrooms, showing the paths: collecting rainwater and draining rain (In green color) and the path for collecting basin wastewater (In red color) and directing it to the expulsion boxes in the bathrooms (In blue color).

Fig. (31): Wall curtains from reused and recycled materials to control the amount of natural light inside the spaces while maintaining air entry.

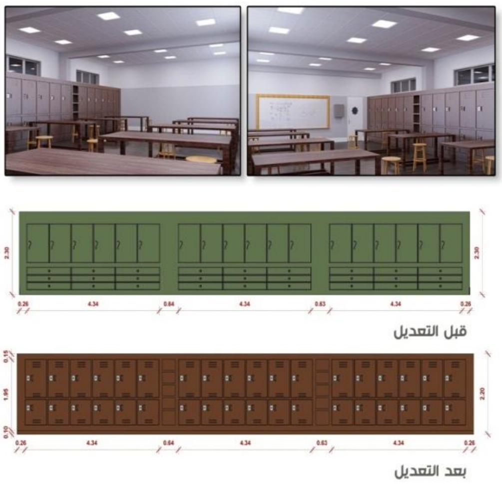


Fig. (32): Reusing cupboards and drawers and modifying them by making safes with a larger number commensurate with the number of students using the hall.

Fig. (33): Recycling and developing wooden drawing tables to be used instead of purchases.

- **Waste management**: We will equip the floors with tools to collect garbage inside and outside the building Fig. (34), during the garbage collection process, we will separate it in preparation for an agreement with the recently built garbage recycling factories in Egypt. We will immediately begin to agree with those factories that garbage from some universities will be collected and replaced with recycled products from those factories.

Fig. (34): Separation of garbage inside and outside the building for reassembly and recycling.

4- Indoor environment quality:

The application will - in this part - achieve the best quality of the ventilation process and improve the way the air moves inside the building. This will provide the highest degree of thermal, visual and acoustic comfort in the building. This is in addition to the use of sustainable finishing materials such as:

- Using HARMONY paints: These paints are free of any carbon or organic materials, Fig. (35).
- We will keep the window openers. This operation will help in improving air movement while adding hinged blinds. These blinds will help control the window openings free movement with the ability to open and close to control the amount of natural light entering the building. These blinds are made of eco-friendly materials.
- Suspended ceilings will help provide acoustic and thermal comfort, made of 70% recycled glass. These ceilings are sound-absorbing and heat-resistant, (Fig (36).
- Wooden floors made of recycled wood will help absorb sound, Fig. (37).
- We will put up many signs emphasizing the prohibition of smoking inside the building, Fig. (38).
- The lighting in the building will be in an appropriate and comfortable way for the eye and save electrical energy (compared to similar ones). The building will include smart explanation boards. These panels will help in the comfort of the eye in all the educational space, Fig. (36).
- The building will rely on natural ventilation, Fig. (40). There will be a machine that draws air from the outside and distributes it to all the spaces inside, Fig. (39), this will help dispense with environmentally harmful refrigerants.

Fig. (35): Renewal of paint works using organic-free finishing materials

Fig. (36): Using suspended ceilings from recycled materials, which are sound-absorbing and heat-insulating.

Fig. (37): The use of heat insulating wooden floors, which were made from recycled wood.

Fig (38): The use of heat insulating wooden floors, which were made from recycled wood.

Fig. (39): Air ducts exiting the service skylight and distributing them to the right and left of the classrooms and administrative spaces.

Apply manipulations to multiple spaces

- **An example of an educational space**:

The researcher, after clarifying the method of applying environmental treatments to all parts of the building separately, applied these treatments to the different spaces of the building. This step is to determine the extent to which these treatments can be applied together. At the end of this step, the researcher measured the thermal loads of these voids, Fig. (40, 41) . This is in order to know the effectiveness of applying these treatments to the building.

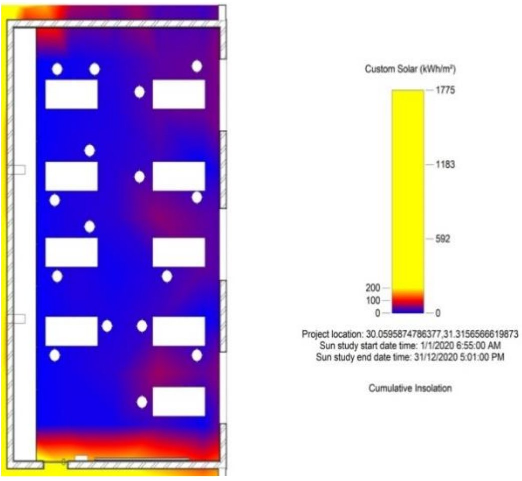


Fig. (40): The heat load of the educational space after using environmental treatments with values less than (45 kw/h/m2)

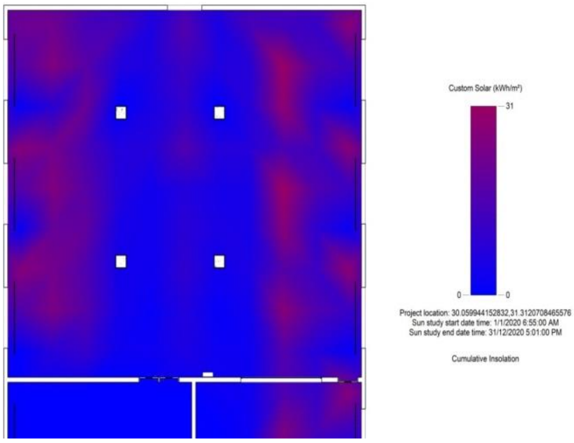


Fig. (41): The heat load of the educational space after using environmental treatments with values less than (15kw/h/m2).

- **An administrative of vacuum model**

The application of the treatments was in an administrative vacuum: the application was in the room of the head of the architecture department. This was due to the variety of spaces and their versatility. At the end of this step, the researcher measured the thermal loads of these vacuums, Fig. (42). the objective of the measurement process is to know the effectiveness of applying these treatments to the building.

Analytical comparison of the case of the study before and after the use of treatments:

The researcher measured the energy consumption and thermal loads on the existing situation and after adding the environmental treatments to the building of the case of the study. Through these measurements, we can know the values and the amount of savings in consumption as follows:

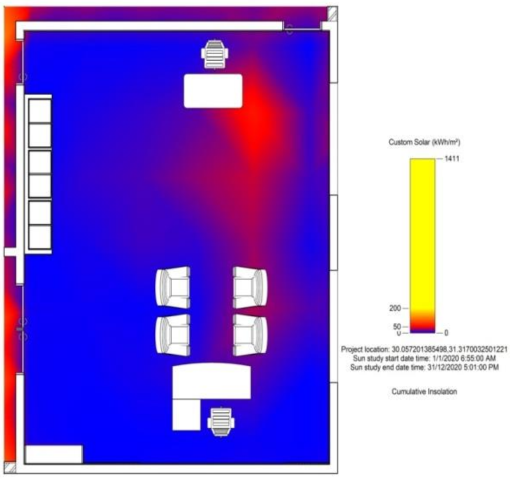


Fig. (42): The heat load of the administrative space after using environmental treatments with values less than (55 kw/h/m2)

Table 2: includes Analytical comparison of the case of the study before and after the additions of environmental treatments (prepared by the researcher).

Sustainability Principles	Energy consumption ($Kw/h/m^2$)		The saving rate %	Notes
	Before	After		
The site	1500	850	44%	
Water efficiency	30 L/p/d	0	100%	
Energy efficiency	35	25	80%	
Materials and resources	Furniture has been exploited, restored, used and even developed to suit the requirements of the user (the student).			
Indoor environment quality	160	45	71%	
	25	15	95%	
	170	55	67%	

7- **Results**:

The research found that applying the proposal to a case study of the building model of the Faculty of Engineering - Department of Architecture and Urban Planning, Al-Azhar University - Cairo, has reduced nearly 75% of energy consumption. The research also found that environmental treatments are technically valid for application to the chosen model. This means that the experiment is generalizable.

8- **Recommendation:**

Through this paper, we see the need to apply sustainability standards to existing buildings. This is because sustainability increases our efficiency. At the same time, we believe that there is a strong need for more scientific research to reach the best results. This is in order to reach an existing sustainable building with the highest efficiency and lowest cost.

9- **References**

1- Issam El Hennawy, 2011, "Environmental and Development Issues in Egypt", Dar El-Shorouk, Cairo.

2- Brian w. Edwards and Emmanuelle, 2013 "Green Buildings Pay", by Rutledge in USA and Canada.

3- Asmaa El-Sayed Ali Ismail, 2012, "Towards a strategy for evaluating a sustainable campus at the beginning of the third millennium", Master's thesis, Faculty of Engineering, Cairo University.

4- Eman Muhammad Eid Attia, Muhammad Ibrahim Muhammad Ibrahim, 2010, "Sustainability Architecture towards a Safer Future", Conference on Technology and Sustainability in Urbanism, College of Architecture and Planning - King Saud University, Saudi Arabia.

5- Samar Youssef Ismail, 2011, "Strategies for Achieving Sustainability in the Urban Design of Schools", Master's Thesis, Faculty of Engineering, The Islamic University - Gaza.

6- Haitham Emad El-Din Morsi Ismail, 2018, "Towards an integrated system to take advantage of modern systems as an entrance to achieving sustainable architecture in Egypt", Master's thesis, Department of Architecture, Al-Azhar University.

7- Ministry of Electricity and New and Renewable Energy, 2021, North Cairo Electricity Distribution Company.

8- https://www.ecophon.com/exp/ecophon/lighting/ecophon-lightingAccessDate25/11/2021.

9- Egyptian Code, 2018.

10- https://www.meteoblue.com/ar/weather/historyclimate/climatemodelled. /%D8%A7%D9%84%D9%82%D8%A7%D9%87%D8%B1%D8%A9_%D9%85%D8%B5%D8%B1_360630,Access date:6/12/2021.