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IMPACT OF OUTER SHELL DESIGN ON ENERGY PERFORMANCE OF UNIVERSITY LIBRARY BUILDINGS

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ABSTRACT

University environmental management aims to save energy, reduce emissions, reduce waste stream and monitoring water use. Libraries contribute to zero waste society to make environmental management by promoting knowledge creation, learning and leisure. Nowadays all nations become environmentally aware, so the library should be an environmental leader and is an important example of environmental care and practices and should also spread environmental education among all the people in which it considered as a place to discover new ideas and to discuss the concepts and to share information. The diagnosis was carried out in 36 university buildings (Renewable Energy Institute—REI) through survey and census; that in order to identify and to characterize current patterns of energy consumption and demand, as well as for generating specific strategies towards energy efficiency and saving, for instance the identification of systemic indicators and corrective proposals, and non-financial investment. Most of this loss can be reduced by setting energy efficiency principles in consideration. This can be done by providing correct orientation before designing a building, suitable usage of construction materials and low U value, the usage of heat absorption glasses, the usage of landscape around the building, shading of the building and the usage of opening in building design in university Library buildings. This paper will explore a number of current issues and challenges in energy efficiency in academic libraries and shows how they could solve them,

using a cases study analysis. Issues covered include sustainability concepts, operation of library buildings, energy efficiency in relation to library collections, and the reframing of the library organizational design and services. Therefore the importance of this research is raising energy efficiency in libraries by using principles of sustainability with applying retrofit measurements to the case study while noting the effect of energy efficiency (U-value, materials of glass, insulation systems and lighting) on the building. Afterwards, a comparative analysis will be held to determine efficiency of using materials treatments in increasing energy efficiency and decreasing energy consumption of the building by about 24%. The target is that "when applying energy efficiency analysis the energy consumption reduced to some extent.

KEYWORDS: Sustainability; Sustainability concepts; Environmental analysis; Energy efficiency; University library buildings.

1. INTRODUCTION

Countries need to use energy efficiently to be advantageous in the global competition and ensure the sustainable development.[1] Countries using the energy efficiently succeed economically and have leading the field in the competition.[2] All parties involved in designing the university library building should realize and understand the concept of efficient energy management before construction starts.[3,4] This is vital to energy usage which will give huge impact to the effect of high energy consumption in a building. The importance and understanding must be focused to design a building that meets the needs of efficient energy in a building and not just to view the cost of the building and its aesthetic values. This study helps to develop the understanding of all parties to increase the usage of energy efficiently to create the flow of energy usage intensity that is rising and to avoid wastage of energy usage.[5] The utilization of efficient energy in a building has a great role as one of the main divisions in the total usage of energy which comprises of 14% of national energy usage. So, this manual is required as the main reference to produce a building that meets the potential of a building which uses energy efficiently.[6] Educational buildings (schools and universities) consume 14.5% of commercial building" energy.[7,8,9]

It will focus on energy conservation that provides a comfortable environment for its occupants. To illustrate the function of building envelope as an important aspect to focus on building surface design achievement and then to evaluate how far the potential of the building

envelope that could fulfil the building criteria that is prescribed by the requirements in the guideline based on U-Value and Overall Thermal Transfer Value (OTTV) Value.[10]

The aim of this research is to raise energy efficiency in libraries by using principles of sustainability.

This requires achieving the following objectives:[11-16]

- Modifying energy efficiency to suite Egyptian university library buildings.
- Affirming the importance and benefits of using sustainability principles in library building.
- Within theoretical framework, understanding energy efficiency in university library building and its requirements.
- Highlighting the importance of choosing smart materials that assist designing university library building.
- Reconsideration of the various approaches to using energy efficiency in university library building.
- Studying the standards of energy efficiency principles and its approach in designing university campus.
- Studying the influence of using energy efficiency in library building and its influence on the ecological and environmental balance.
- Analysing the results of the case study and determining the total cooling by monitoring energy efficiency for university library buildings by using Design Builder program and determining modifications to reduce energy consumption and to increase energy saving.

Energy efficiency and environmental friendliness, as important principles of sustainability for university buildings, are here considered in the context of the experience, enabling an identification of the main aspects that are applicable when designing such buildings in Egypt. It is concluded that the use of alternative energy sources can cover at least 15-20% of the total energy consumption, and by optimizing the plan it is possible to increase the energy efficiency of a building by up to 14%.[17]

Egypt has been facing a vast power crisis in the past few years. A dilemma is projected to surge on the long run if not properly dealt with. The power sector is totally dependent on fuel, which is a primary source of energy in Egypt, and since the production of energy is not equivalent to the rising demand, so it becomes a major cause behind the power crisis.[18]

So to reach the objective of the research, the results of the case study will be analysed and determined the total cooling by monitoring energy efficiency for university library buildings by using Design Builder program and determining modifications to reduce energy consumption and to increase energy saving.[19-22]

2. METHODOLOGY

The main aim of this research is to produce strategies and proposals derived from a third level energy diagnosis, by characterizing consumption patterns, in order to help achieving greater energy efficiency levels within the REI.[23] The methodology is based on three different approaches: theoretical, comparative analysis of two libraries and applied approach. First, the theoretical study leads to analysis the influence efficient energy usage in Library buildings. This is followed by comparative analysis of the Library Building at UITM Perak and University Malaya (UM) Main Library Building to achieve sustainability principles to make sure that all future buildings meet the criteria that have been set by the guideline by emphasizing the aspects of design, construction materials, U-Value, building orientation and others that influence the rate of heat absorption into any building.[24-27] Third the concluded results are tested on one case study building in British University in Cairo, Egypt. This is done by applying retrofit measurements to the case study while noting the effect of energy efficiency (U-value, materials of glass, insulation systems and lighting) on the building. Afterwards, the analysis will be held to determine efficiency of using materials treatments in increasing energy efficiency and decreasing energy consumption of the building.

3. THEORETICAL FRAMEWORK

3.1. Evaluation of energy efficiency in library building

Energy efficiency management is based on the guideline by producing the use of effective and continuous energy and also to evaluate the quality of energy usage by creating energy efficient environment that gives a better impact for the National Energy Sector in the future.[28]

3.2. Analysis that influence efficient energy usage in Library buildings

From the analysis, there are few factors that influence efficient energy usage in Library buildings which are:

1) Orientation.

2) Construction materials and U-Value.

3) Building design from the aspect of shading.

4) Surrounding landscape.[29-35]

Table 1: Description of the factors that influence efficient energy usage in library buildings.

Analysis	Description
Design criteria	For enclosed space building, building envelope is usually used for the need of Overall Thermal Transfer Value (OTTV)only for air-conditioning building, targeted to enclose design space building to reduce the absorption of external heat and ultimately reduce the cooling load of air-conditioning system. It is verified that this criterion is known as (OTTV). The goal of OTTV is achieving the design of enclosed space structure to minimize the absorption of external heat and also to reduce the cooling load of air-conditioning system. $OTTV = \frac{\mathbf{Ao1\ x\ OTTV1\ + Ao2\ x\ OTTV2 \ldots\ldots + Aon\ x\ OTTVn}}{\mathbf{Ao1\ + Ao2\ + \ldots\ldots\ldots Aon}}$ OTTVi = 19.1α (1 – WWR) Uw + (194 x CF x WWR x SC) Where : Aoiis the Gross exterior wall area for orientation OTTViis the OTTV value for orientation For a fenestration at given orientation Where : WWR is the Window-to-gross exterior wall area ratio for the orientation under consideration α = Solar absorptive of opaque wall Uw is the Thermal transmittance of opaque wall (W/m² K) CF is the Solar correction factor for the orientation of fenestration under consideration assume nearest predominant orientation SC is the Shading Coefficient
Construction materials and U-value	A good wall needed in the building is a wall that can prevent the entry of excess heat into the building. Used materials needed to build the wall also influence the heat entry rate into a building. Construction materials and U-value are two main matters which are closely related, a thicker material will yield a lower U-value of a certain material. The lower the U-value of certain construction materials, the better the value of insulation and its quality of preventing heat absorption.
Orientation	Correct orientation application is the main factor in the reduction of OTTV value without the need to comply with other factors. Without the preparation of insulation material at wall building, it may increase the U-value quite a lot. Maximum wastage through design, location and building arrangement taking into consideration the building orientation factor enables the reduction of energy consumption for the purpose of building cooling and direct lighting of sun heat into a building. The usage of air-conditioning in a building certainly will reduce the effect of heat and the production of comfortable dry air. The rate of direct sun light penetration can be reduced through good orientation effect. Heat production effect from sun energy will affect the rate of energy consumption in the building. The ray heat effect a wall building and no wind movement will drive the heat to accumulate in the building. The revolving of the sun and wind has a regular path. It has been considered from the level of planning. Design features are like an arrangement and building

	orientation needs the reduction of sun heat exposure. The guideline requires buildings in hot and humid tropical climate like our country to build a longer facade towards south north is applicable especially for skyscrapers.
Shading design aspect	There are few aspects of design that should be controlled by designers including from the aspect of shading. Shading is very important to prevent direct light from entering a building. It is one of the ways to reduce cooling load which will eventually reduce the usage of energy by the air-conditioning. So, to prevent hot light from entering the building interior, the need of shading tools should be arranged. In addition, the design of the accurate shading tools is intended to produce shadow effect in the building. The presence of high humidity of air and windy rain require an effective shading design building. The projection on the window not only to block rain but also to obstruct sun heat from its direct ray from entering the interior of a building that will increase the internal temperature.
Landscape usage	The environment of a building can boost to create thermal comfortless that is much needed by a building to support the usage of air-conditioning system. Quality landscape design will prevent heat from sunlight and heat rebound that is produced from earth surface. It is found that the wall of the east and west sides accept sunlight ray directly and expand on wall building.

Note: Adapted from researcher.

4. Comparative table for analysis model

Malaysia buildings consider energy efficiency, indoor environment quality, materials and resources, sustainable planning and management, water efficiency, and innovation, So we chooses 2 library buildings to apply comparative analysis on both of them. The Library Building at UITM Perak and University Malaya(UM) Main Library Building study one of the aspects of efficient energy that is Building Envelope and to assess how far the needs of the buildings meet the minimum standard of efficient energy in educational buildings. The factors of high energy consumption and also the rising cost are on apart with the increase of electrical appliances like air-conditioning, lamps, visual equipment and others. UITM Perak is now upgrading its structure and infrastructure which will drive towards higher energy consumption if energy usage is not managed efficiently. Thus, the efficient usage of energy in educational buildings is very vital to look at the potential of a building whether the construction meets the guideline that has been regulated.[15] As the two libraries are located at Malaysia in Seri Iskandar and LembahPantai where they are situated at a hot and humidity, the effect of ray into buildings is greatly influenced by building orientation. Malaysia's latitude and longitude is 2° 30' N and 112° 30' E.[36-40]

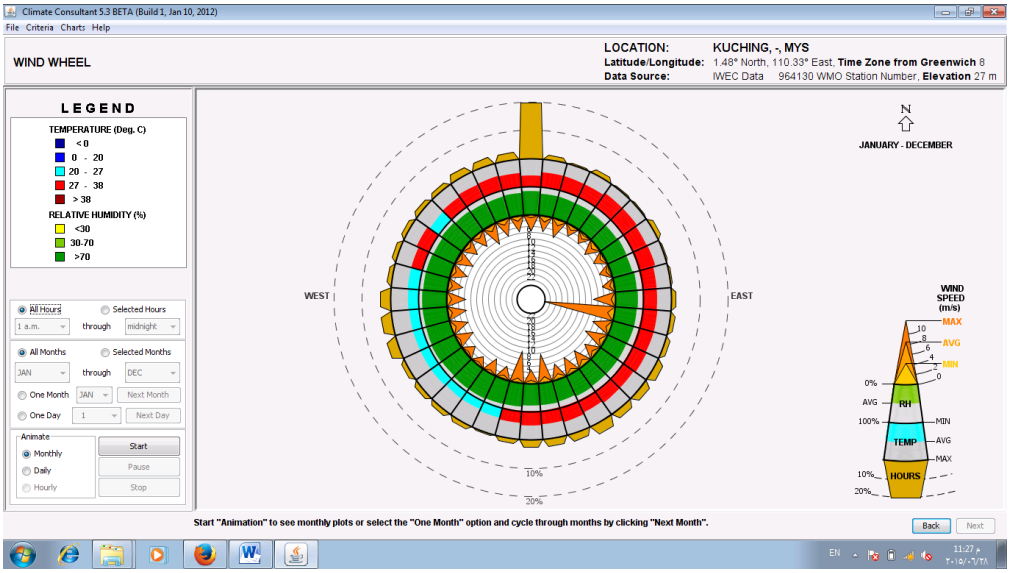
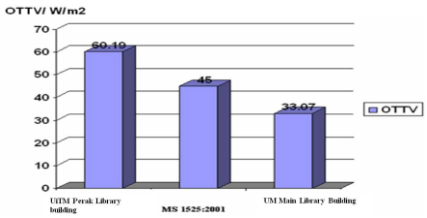
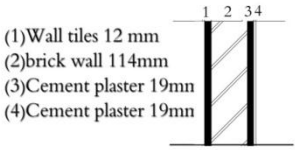
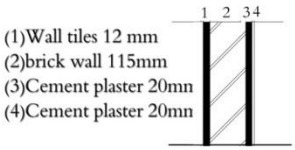


Figure 1: Malaysia Wind rose.

Table 2: Energy efficiency analysis in UITM Perak Library and UM Library Building.

	UITM Perak Library	**University Malaya(UM) Main Library Building**	**Conclusion**
Design criteria	Overall OTTV of UITM Perak Library Buildingis 60.19 W / m² and this is higher than the value set by the guideline in MS 1525:2007. This shows that efficient energy usage in the assessment of building envelope aspect of UITM Perak Library Building is inefficient because the value of OTTV of the building exceeds the set value which is 50 W / m². The construction materials that are used by UITM Perak library building are the usage of conventional building materials like concrete, plaster, brick wall and also wall tiles as wall foundation. Especially in the UITM Perak Library building we are looking at the short term effect of the cost, with the usage of conventional construction materials it has contributed to high rate of heat intensity inside a building.	Overall OTTV of University Malaya Main Library Building= 33.07 W / m² The main library building of university Malaya, the OTTV value is 33.07 W /m² and this value is lower than the value set by the guideline. The construction materials that are used by UM Main library and are the usage of conventional building materials like concrete, plaster, brick wall and also wall tiles as wall foundation. At UM Main library building, the construction materials are not influenced by the low value of OTTV of the building. Looking deeper, the thickness of the construction materials in the building of UM main library building may cause the reduction of the U-Value of the building.	• The conclusion reveals that the usage of energy in university Malaya main library building from the aspect of building envelope is more efficient than UITM Perak library building as the value is less than 50 W / m². The difference can be seen in Chart.  Figure 2. The Difference Between UITM Perak library building and UM Main library building with the guideline. The conclusion is: • This construction may reduce the cost of construction materials of a building without considering the factor of efficient energy usage. • When we look at the usage of concrete, it absorbs heat at a high rate during the day and releasing high heat at night. So the heat that absorbs through building wall element will give impact to the temperature in the

			building.
Construction materials and U-value	Consequently, the energy capacity that will be used increases together with increases usage of air-conditioning in the building.  Figure 3. Brick wall of UITM Perak Library Building U-Value = 2.59 W/ m² K	 Figure 4. Malaysia Brickwall of UM Main Library Building U-Value = 2.55 W/ m² K There is no usage of heat insulation in UM Main library building, the value of OTTV of the building is still low.	• Conventional usage of concrete will affect the rising usage of energy in the building. This is the source of increase internal temperature which led to the importance of choice the building color component. External wall that is painted with white color will help to reduce the heat absorption that will be stored and channeled to the space in the building. • The U-value of the construction materials of UM Main library is lower than the U-value of UITM Perak library building although the difference is not very obvious. • If we look at the value of the U-value where the maximum value is 2.0W/m², it can be said that the level of insulation is good. • U-value will be achieved by providing enough insulation at the wall building. However, both libraries, at UM and UITM Perak are not using insulation materials in their walls. The U-value for the wall building has exceeded the maximum value that has been set. • Wall insulation is very important to reduce U-value. The lower the U-Value of certain materials and constructions, the better the insulation value and the quality of the heat entry prevention will also be improving. Generally, UITM Perak Library and UM Main library buildings are using conventional method.

Orientation	UITM Perak Library building has vast surface that is facing the west side compare to the north and south side. The design of the building has breached the principle of building orientation to reduce the heat volume that hit the wall building. This method will also reduce the total cooling load of the air-conditioning system in the building.	UM Main library building has applied the right orientation where a long facade is directed towards north and south while the short facade is directed towards east and west. Excess heat from east and west with the short facade will enable only low entry of heat into the building because only a small part of the facade is exposed to sunlight heat. UM Main library building is equipped with glass window at the east side only meanwhile the west is covered completely with brick wall. So, only the east side will absorb energy without fail. No window facing the west side because it is covered by brick wall and only the east side is using glass window and the heat effect can only be felt in the morning because the sun rises from the east.	e conclusion is: • The designer of the library building should lengthen the main core towards east and west as significant wall exposure can be directed towards south and north. Using this method, the total rate of wall surface that is exposed to sun heat can be reduced. • The objective to efficient energy saving into the building can be suited with the building orientation effect with the total heat rate that goes into the building through sun passageway.
Shading design aspect	As depicted in Fig.(4-18), there is no shading tool at the window of UITM Perak library building. This enables heat to directly entering the building through the window of the building.  Figure 5. There is no Shading Tool at the Window of UITM Perak library building	UM Main library building is a good shading tool because most of the windows of the building have a shading tool with the shape of a panel that is made of concrete or also known as Vertical Shading Tool (VST) that prevent the heat and light from entering directly into the building. UM Main library building also has a shading tool called “Hung Louvers” at the west side of the building like what is shown in Fig (4-19)below. The intense heat from the sun in the afternoon is facing the west to suit the usage of the	e conclusion is: • The best shading has the capability to protect the entire wall to prevent from rising wall heat and reduce the climate negative effect such as obsolete and decay element or wall finishing. • As for UM Main library building, there is a good shading tool because most of the windows of the building have a shading tool with the shape of a panel that is made of concrete or also known as VST that prevent the heat and light from entering directly into the building.

		shading tool at the research building. The shading tools are important because the fierce sun ray takes place on the east and west sides.  Figure 6. Hung Louvers a shading tool at the west side of UM Main library building	
Landscape usage	UITM Perak library building, it can be seen that there is a lot of heat absorption at the southwest and northwest. In the morning, sunlight hits the wall at the southwest and northeast while in the afternoon, the density of sunlight is more towards the northwest and southwest of the wall building. Looking at the landscape at the southwest side as shown in fig (4-20) we could see unorganized arrangement and the usage of tree is not protecting the wall building where the effectiveness of the plants to be the natural shading is limited to the maturity height. This can be seen as there are no small plants that is being used as effective natural shading to the wall building. So the rate of sunlight ray penetration is direct towards the wall building.  Figure 7. Landscape at the Southwest of UITM Perak Library Building	At UM Main library building, the landscape usage has been adapted effectively at every part whether the north, south, east and west. Figure (4-21)below shows the usage of landscape at UM Main library building. The type of trees is also suitable with the building height. With the presence of big size trees, this enables the prevention of direct and excess heat into the building because there are obstacles for the heat to enter.  Figure 8. Landscape at the entire view of UM Main Library Building.	e conclusion is: • UM Main library building chooses of types of trees and their arrangements give effective natural shading to the building and consequently have solved part of the problems of rising heat in the building. • The planting of unsuitable trees and disorganize plantation have caused the presence of landscape not giving positive impact to the landscape protection of the building. So the function of existing landscape does not contribute to the reduction of heat entry rate into the building.

From the before mentioned analysis, one can conclude

- Overall Thermal Transfer Value (OTTV) value of UITM Perak Library Building is 60.19 W / m² and this is higher than the value set in MS 1525:2007 guidelines. For University Malaya Main Library Building the OTTV value is 33.07 W / m² and this value is lower than the value set by the guideline. This finding shows that the usage of energy in University Malaya Main Library Building from the aspect of building envelope is more efficient than UITM Perak Library Building because the value is less than 50 W / m².
- Moreover, the UITM Perak Library Building does not reach the requirement of the above factors and this is why the OTTV value of the building exceeds the value set by the guideline.
- University Malaya Main Library Building is applying the efficiently factors. So building envelope is an important aspect that needs to be considered by any building designer to gain efficient energy usage of a building before looking at other aspects.
- The choices of building envelope and the achievement of good usage of building envelope will lead to positive impact on the aspect of air-conditioning choices. The operation in the building and finally continuous maintenance will create efficient energy usage in a building. So some factors have to be done to make sure that all future buildings meet the criteria that have been set by the guideline by emphasizing the aspects of design, construction materials, U-Value, building orientation and others that influence the rate of heat absorption into any building.[42-47]

5. Applied approach (Analytical study for the British University Library)

The main sustainability concept is reaching energy efficiency; so to monitor thermal comfortless to reach energy efficiency in the university library building the following items must be taken into account[30,34]:

- Correct orientation before designing a building
- Suitable usage of construction materials and low U value
- The usage of heat absorption glasses
- The usage of landscape around the building.
- Shading of the building.
- The usage of opening in building design.

Choosing the British University library, El Shorouk city as the case study is based on a number of points, the location in a new city and especially in the Shorouk city is definitely

concerned with that the Shorouk city is considered a new city and a business education center and modifying the design of some of its buildings will raise the energy efficiency of them. In addition to setting a prototype to library buildings at this location which will facilitate the energy saving out of them and the decrease of energy consumption as to help and save the environment. Now the government focuses on this area to increase energy efficiency of the buildings to avoid high population of downtown and to achieve green architecture.

5.1. Location Information

The building is located on the following coordinates, 30°01'02.30" East, "49.67'58°63 North. The university is located in a vital space at Shorouk city at the center of the main road of gate1 in Shorouk city connecting Suez ring road and Ismalia ring road as shown in Figure 9. The main new library is located in the centre of the University between the ICS Building and the Pharmacy Building as shown in Figure 10.

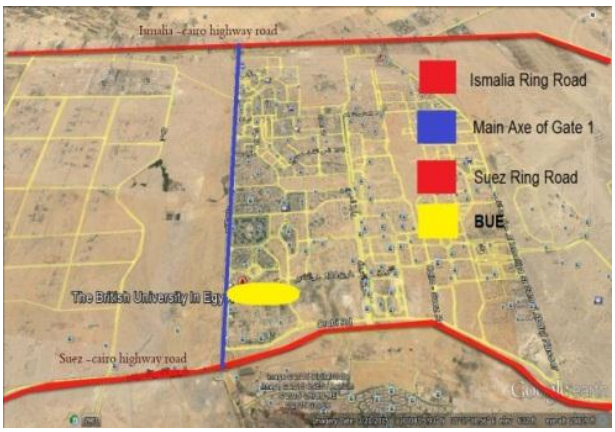


Figure 9: BUE-New Cairo- Layout.

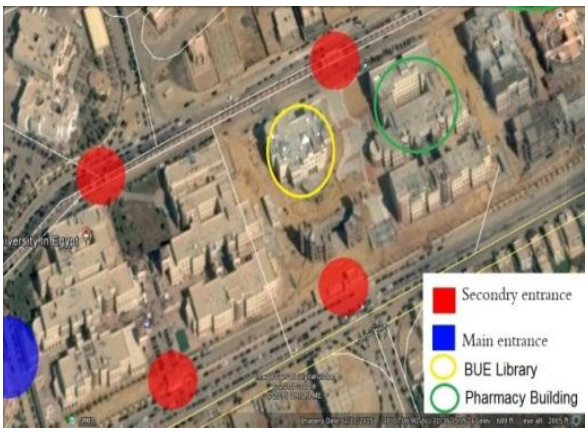


Figure 10. BUE library building site location- Layout.

5.2. Climatic analysis of Cairo

Cairo is the capital of Egypt; it lies at a longitude of 31° 21 E and latitude of 30° 2N. It is classified by the Koppen classification as hot arid region.[58] According to Egyptian Organization for Energy Conservation and Planning (EOECP) Cairo is classified as a Semi Desert zone within the seven climate classification zones of Egypt.[59]

The Semi desert zone has an average annual temperature of 22.2 C°, with a maximum monthly average temperature of 34.2 C° in August and minimum monthly average temperature of 10.2 C° in January. Extreme temperature in Cairo may reach a maximum 44 C° and an extreme minimum of 3 C°. As for diurnal ranges, it has a monthly mean difference of 12- 17 C° with a mean of 14 C° in summer and 13 C° in winter.[60]

5.3. British university library in Egypt architecture

The "British University (BUE) Library" Building is one of the main important university library buildings in Egypt; it accommodates around 1200studentand 50 employees entering the library building, as well as accommodating an administration branch of the library dealing with students of the library, in addition to facility as it opened 6 days in the week for 7 hours.

Type of Building: University Library Building.

Designer: DrAmr el Halafawy

Supervisor Consultant: Administration Engineering of BUE.

General Contractor: SINCO Company.

Owner: BUE.

Location: El Shorouk city, New Cairo, Gate1.

Figure 11: BUE library building.

The building consists of 4 floors (Basement, Ground floor and 2 typical floors) as shown in Figure 11.

The main idea of the building is designed after the open plan space planning concept which is dividable through having a module to have flexibility to adapt to the reading requirements. The building has curtain wall façade and skylight to allow the maximum use of natural lighting through the transparent façade, and solid walls at the areas of services and control rooms.

5.4. BUE Library in Egypt due to environmental analysis

The main new library is located in the center of the university.

The library is near the secondary gate between the ICS building and the Pharmacy building.

The library has accessibility to service road.

The library has a public access in 1st floor and service access in the basement.

Glazing is placed in a North/South orientation to reduce direct solar gain.

Reading area took north orientation as shown in Figure 12.

Court in the center of library is covered by skylight to provide natural lighting.

Computer labs took south orientation.

The architecture use plans to be path for pedestrian and interlocks.

The architecture used LED lighting.

Ceilings were finished using two types of suspended ceilings: Gypsum boards for reading area and linear ceiling for bathrooms.

The majority of the reading space was covered using curtain wall glass to achieve maximum use of the natural lighting.

The architecture used atrium covered by skylight to maximize natural lighting entering the reading space as shown in Figure 13.

The architecture depends mainly on artificial ventilation (Fan coil unit) through a central air conditioning unit inside the building regardless to the natural ventilation for reaching thermal comfort inside the building.

The architecture use HVAC for office spaces.

Gypsum boards are solid, light weighted and its back was covered with pet for protection against humidity and water.

The architecture used sound insulation in 2nd floor for small lecture hall.

The architecture used carpets on the floor for sound insulation.

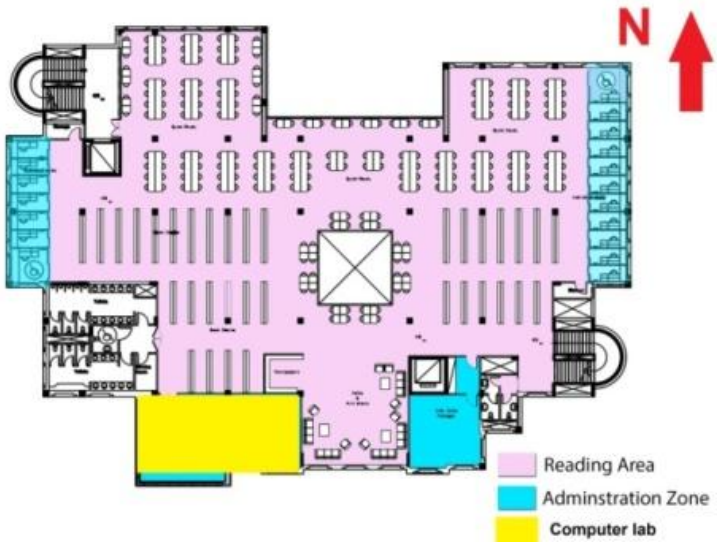


Figure 12: BUE library building- 1st floor plan took north orientation, source: Engineering administration.

Figure 13: BUE library building- Atrium covered by skylight to maximize natural lighting entering the reading space.

5.5. BUE library in Egypt modeling process

The building's modelling process started with assigning the building's location and loading the weather file of that location to the Designbuilder program version 2.4(12-5-2015)and setting the right orientation.

We start modeling different floors of the buildings, and then start putting them on each other to reach the whole building model by the data that we have collected before to the building as shown in Figure 14.

The result for energy consumption represents total cooling of building and it is 378700 K.w/h, the annual CO2 production is 243155 kg. From the above results we notice that general HVAC causes increasing of energy consumption.

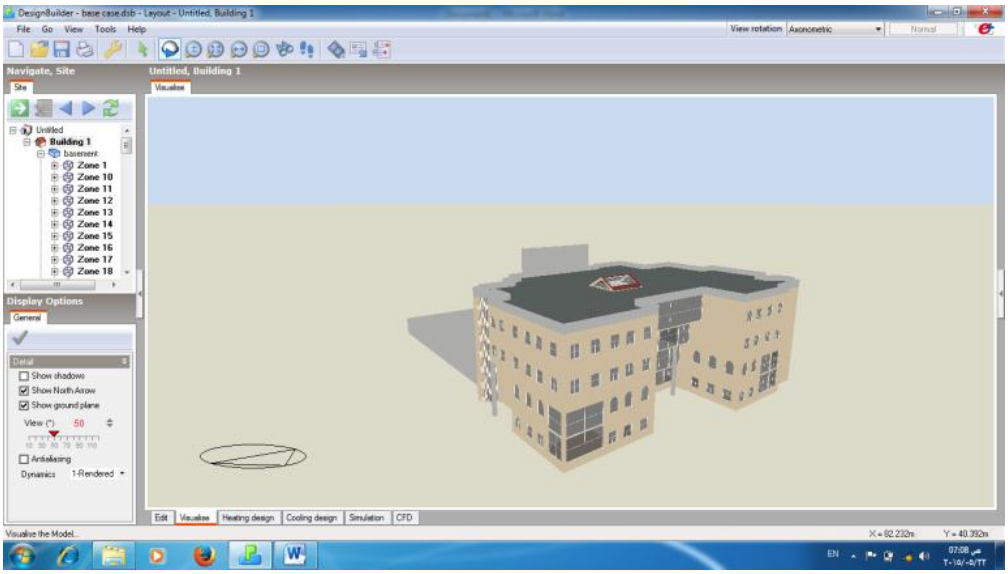


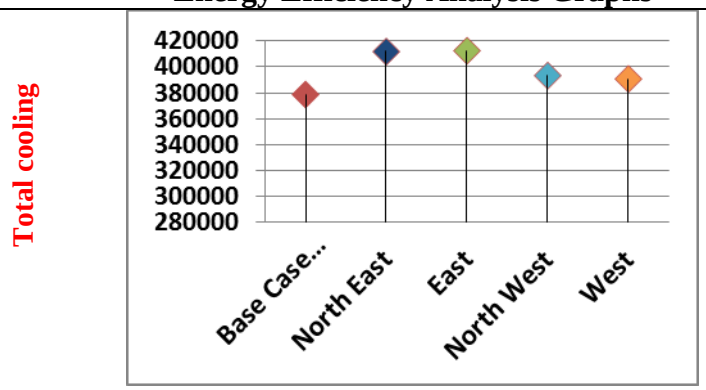
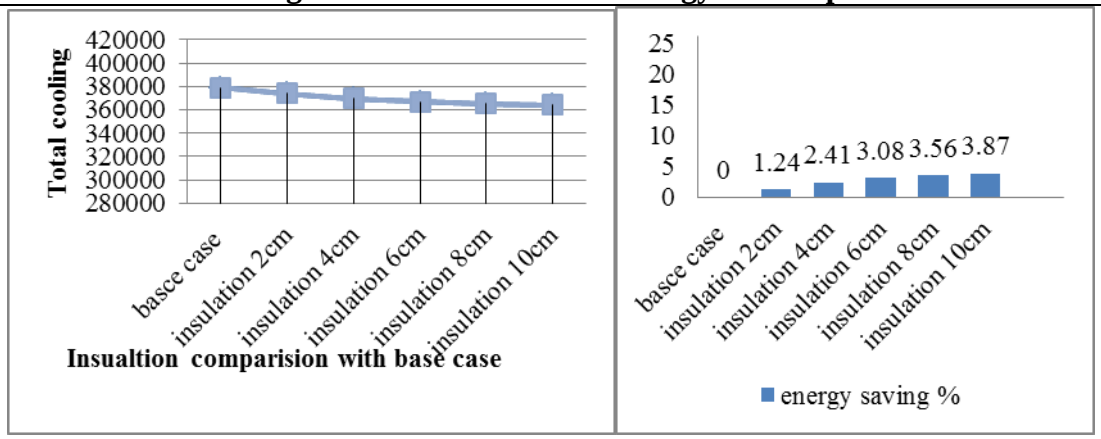
Figure 14: BUE library model.

5.6. Applying the modification on the BUE library

We will modify the building with DblLoE Spec Tint 6mm-13mm Air-all, expanded polystyrene insulation with thickness 8 cm for wall and using shading device. The annual CO2 production was decreased from 243155 kg to 208174 Kgby about 14%.It's obvious that integrating the systems together is the most efficient strategy as it reduced the energy consumption and energy saving became24%.

6. RESULTS

Table 2: ***Impact of energy efficiency analysis on the BUE library building.***

	Energy Efficiency Analysis Graphs
Orientation	 **Figure 15. The architecture used best orientation which is North orientation for reading zones which has lower energy consumption.**
Construction materials and low U value	 **Figure 16: The energy consumption decreases when the thickness of wall insulation increase but after the wall insulation thickness become 8cm the increase of energy saving became weak by taking into account the cost and area of building so the result is that, the wall insulation 8cm is the most efficient.**

Heat absorption glass

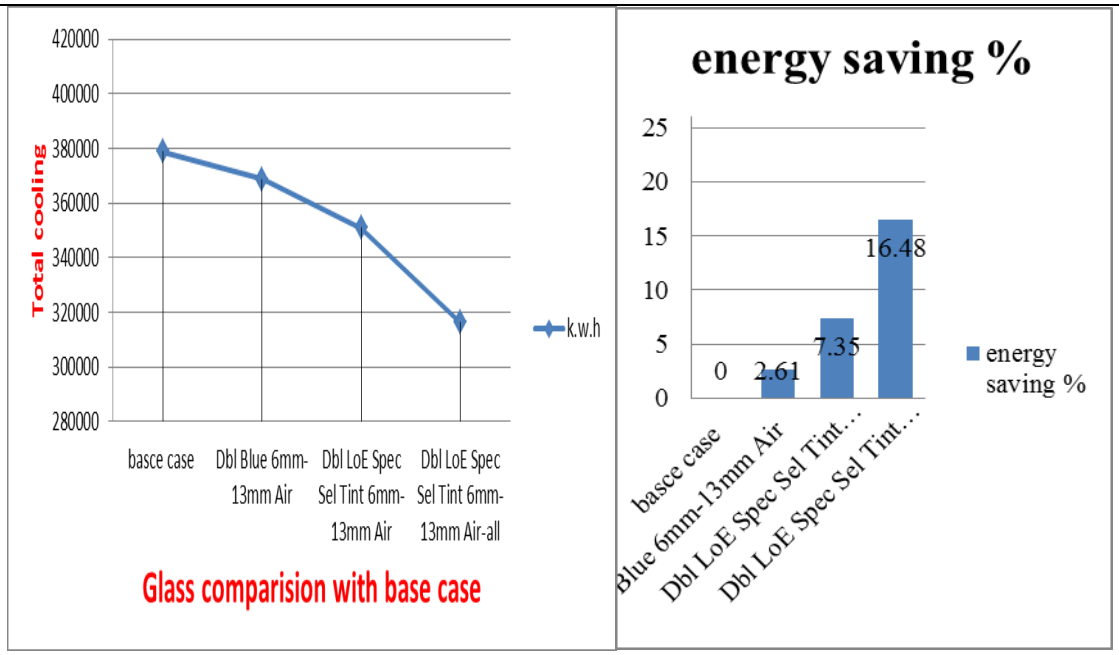


Figure 17. DblLoE Spec Tint 6mm-13mm Air-all has the lowest energy consumption and the highest energy saving.

Shading of the building

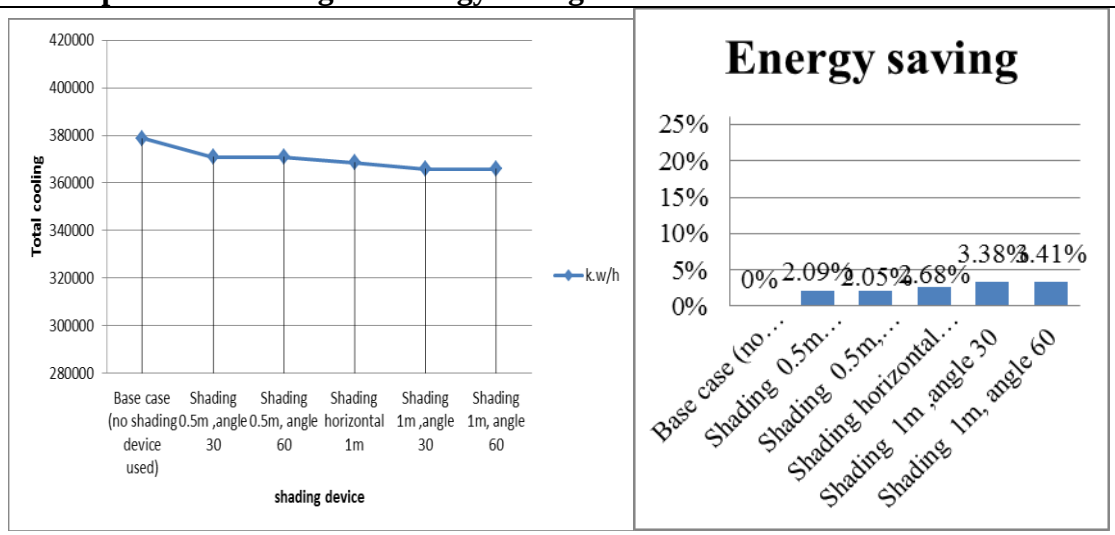


Figure 18. Shading 0.5m with angle 30 is more efficient by the comparison of cost.

Opening in building design

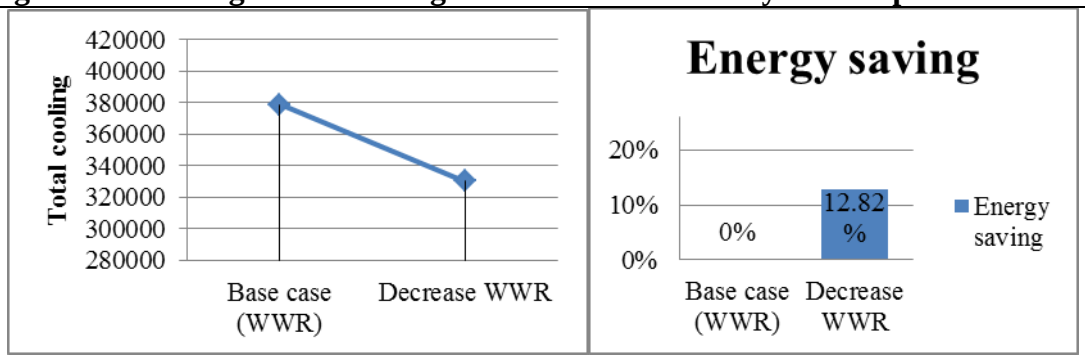


Figure 19. Decreasing WWR to 5% decrease energy consumption to 22.8%.

DblLoE Spec Tint 6mm-13mm Air-all, expanded polystyrene insulation with thickness 8 cm for wall and shading device

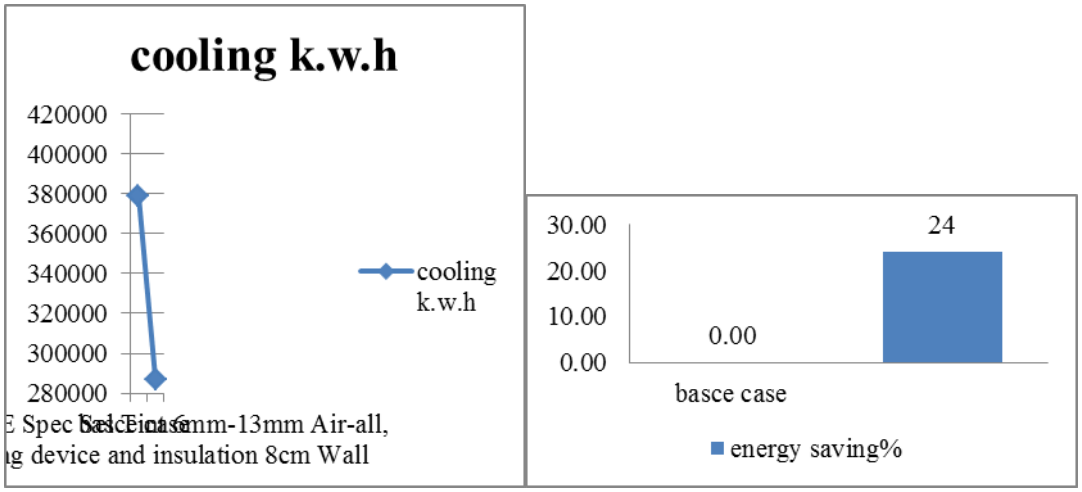


Figure 20. Comparison between the base case and modifying the building with DblLoE Spec Tint 6mm-13mm Air-all, expanded polystyrene insulation with thickness 8 cm for wall and using shading device. It's obvious that integrating three systems together is the most efficient strategy as it reduced the energy consumption and energy saving became24%.

From applying the modification on the BUE library building to integrate energy efficiency by:

- Using insulation with different thickness reduced energy consumption by 3.56 %.
- Using glazing with high efficiency reduced energy consumption by 16.48 %.
- Using shading device on south elevation reduced energy consumption by 2.09 %.
- Decreasing WWR reduced energy consumption by 12.8 %.

So the integration between the systems DblLoE Spec Tint 6mm-13mm Air-all, shading device and expanded polystyrene insulation with thickness 8 cm for wall increase energy saving to24%.The annual CO2 production was decreased from 243155 kg to 208174 Kg by about 14%. So the conclusion is using energy efficiency analysis on the buildings decrease energy consumption by 24%.

7. CONCLUSIONS

- Eco-design has a big effect on environment, human health and needs. As well as Eco-design concepts can be achieved in university library buildings not only the product.

-Using sustainable building materials and construction systems, clean renewable energy and improving the energy efficiency in the library building are very essential to specify the ways of reducing energy consumption from the aspect of how much university library buildings doesn't concern energy efficiency.

-Eco-systems proved great effect in reducing energy consumption. As HVAC is the largest energy consuming. Taking the type of glazing and insulation system as the scope of work is important to have a big impact on decreasing energy consumption to improve energy efficiency from university library building by about 24%.

- There is a lot of level in using eco systems. It varies from just putting different type of glazing which has high efficiency and low SHGC and using insulation in the wall to decrease U-value for achieving thermal, visual and acoustical comfort.

-Using glazing to integrate energy efficiency reduced energy consumption by 16.48 %. Using insulation with different thickness reduced energy consumption by 3.56 % and using shading device reduced energy consumption by 2.09 %.

-The integration between the systems DblLoE Spec Tint 6mm-13mm Air-all, shading device and expanded polystyrene insulation with thickness 8 cm for wall increase energy saving to24%. The annual CO2 production was decreased from 243155 kg to 208174 Kg by about 14%.

7.1. Limitations and future research

-We need to add university buildings to the Egyptian energy code.

-Ministry of higher education set an appropriate budget and special programs to convert the university libraries to eco university libraries. And to have attention to the type of materials used in sites.

-Level academic education is to train students in vacations in companies specializing in software programs that test building to achieve best solutions to reach comfort and high energy efficiency and the work of lectures and seminars under the joint management between the departments of architecture and those companies. .

-It is recommended for further studies that we should test the university library buildings concerning ventilation, lighting, materials etc… by using environmental software's before construction to detect eco systems to improve energy efficiency of the building.

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