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ENHANCING ENVIRONMENTAL PERFORMANCE IN EDUCATIONAL HALLS AT UNIVERSITY OF NAJAH

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ABSTRACT

Sustainable buildings seek to reduce their negative impact on the environment. In order to minimize energy consumption to raise systems efficiency such as heating, ventilation and cooling, and to improve the quality of the internal environment, a passive design and envelop formation of the building could improve the interior air quality and reduce energy consumptions. Based on climate consideration; designers could improve heating comfort and control heat gain and loss without consuming fuels. This study conducted to raise the environmental performance in educational halls at Najah University in Westbank by suggestion many design alternatives and measuring their ability to reduce energy consumption. The design variables are triple glazing, green roof, shading, triple glazing and green roof, triple glazing and shading, green roof and shading, and shading, triple glazing, and green roof. The Design Builder software is used to build building simulation to calculate heating capacities required to maintain the temperature set points in each zone and display the total heat gain by design options.

KEYWORDS: Environment, Educational, Performance, Heat, Shading, design Builder, Glazing, Loss/Gain.

رفع كفاءة الأداء البيئي في القاعات التعليمية في جامعة النجاح – نابلس- فلسطين

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الملخص

المباني المستدامة تهدف إلى تقليل العائد السلبي على البيئة المحيطة و إلى تقليل استهلاك الطاقة ورفع كفاءة النظم وتحسين جودة البيئة الداخلية، التصميم السالب و تصميم التشكيل المعماري لغلاف المبنى الخارجي يمكن أن يرفع جودة البيئة الداخلية و ينظم التهوية و يقلل من الاعتماد على الوقود الأحفوري، و يمكن للمصممين تحقيق الراحة الحرارية داخل المبنى دون استهلاك الوقود و بالاعتماد على وسائل الطاقة المتجددة، و قد أجريت هذ الدراسة لرفع كفاءة الأداء البيئي للقاعات التعليمية في جامعة النجاح في الضفة الغربية من خلال اقتراح العديد من البدائل التصميمة و قياس قدرة هذه البدائل على تحسين جودة الهواء الداخلي و خفض استهلاك الطاقة، و تتلخص هذه البدائل في التظليل و الزجاج الثلاثي و الأسقف الخضراء منفردة أو من خلال الجمع بينها، و ذلك من خلال إنشاء نموذج محاكاة للمبنى كلية الهندسة على برنامج .(Design builder)

1. INTRODUCTION

The most essential objective for sustainable architecture during building life cycle is Energy efficiency. Designers use many different techniques to minimize the energy needs of buildings to raise the quality of the interior environment [[1]-[2]].

It is very important for architects to achieve the efficiency of heating, ventilating, and air conditioning inside buildings. A more efficiency architecture means that it needs fewer fuels to achieve high air quality inside buildings. Passive designs allow buildings to utilize solar energy by using materials and envelope formation of buildings without using active mechanisms such as photovoltaic systems. Moreover, to achieve heat efficiency, a strong insulation for windows and roofs, shading technologies should be used [[3]-[4]-[5]-[6][7]-[8]].

University of Najah located in Nablus- Westbank. The climate of Nablus generally influenced by geographical aspects, territorial waters, highlands, lowlands, depressions air, and air masses. Climate regions divided into two regions; the regional climate of the Mediterranean Sea and the regional climate, which is hot, and dry [[9]].

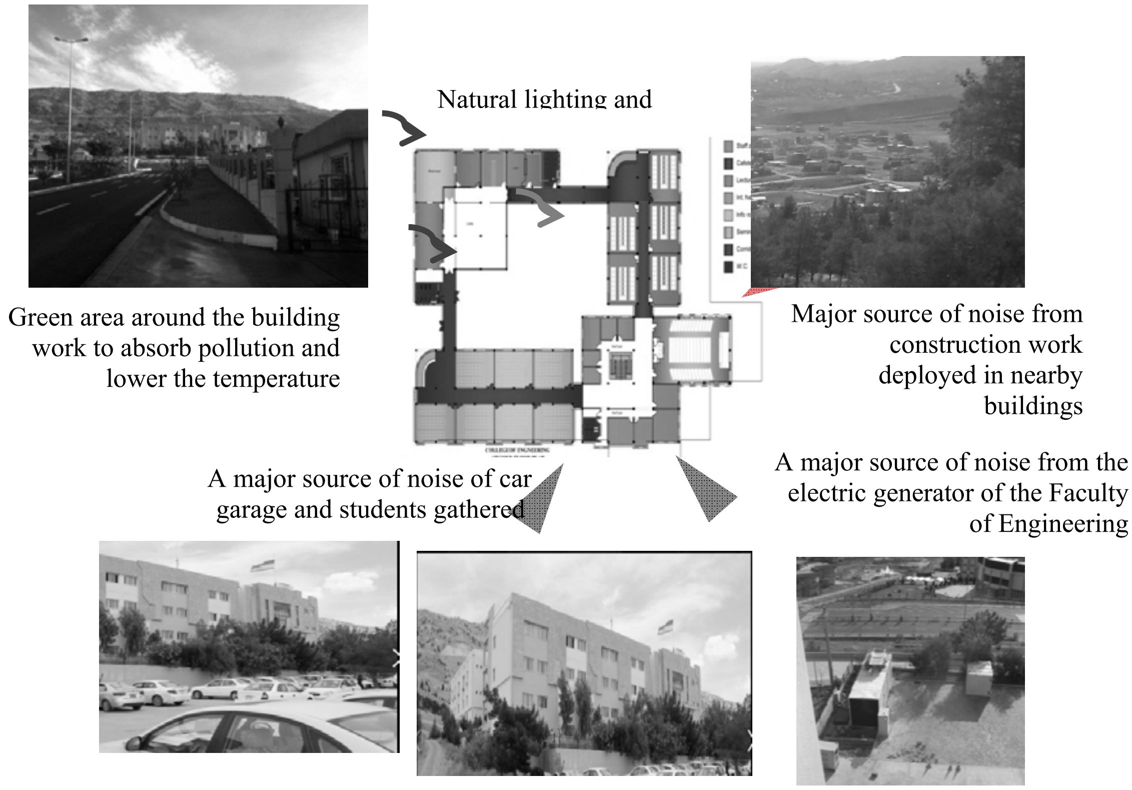


Fig. 1. Najah engineering college plan and surrounding analysis

2. LITERATURE REVIEWS

J.L. Hadden identified in his study the features existing in Georgia's schools determine the trends in school design. Two main areas were selected inclusive of the schools' physical environment and the schools' functional environment. The research following: categories were analyzed: Energy Efficient, Flexible, and Sustained Designs; Aesthetics; Safety; Collaboration; Classroom Space and Furnishings; Technology [[10]]
Rasmy‘M. Discussed The topic of sustainable educational buildings since it is considered the new approach for university design. the research reach that the good design for education building is fit for purpose, soundly built and attractive to the students. It is about more than iconic, big budget projects in the same way that sustainability is about more than the mechanics of carbon reduction [[12]].
In Energy Star report, (2007) conclude the Achieving energy efficiency in schools will improve students’ health, productivity, and performance. Energy conservation is an important issue to take into consideration in educational buildings which includes improving indoor air quality (IAQ) depending on renewable energy resources or using passive designs [[13]].
DERA, (1998) explained the design process for educational buildings should concern with ventilation; daylight; sunlight; flexibility; educational needs; heating; domestic hot water; solar gains; and existing premises. Energy consumption should make use of the site features

by designing shelters to organize heat loss and gain and take into consideration the orientation of the building to make use of renewable energy resources. Aims of design should focus on maximizing the use of daylight by design features [[15]].
Sharma R. L., Amar S. (2019) identified that the buildings that are not "connected" are the same they were decades ago and have retained fundamentally the same purpose i.e. to provide shelter, temperature control, and safety at the same efficiency level. This research provides a contemporary look at the potential of smart architectures and evolving smart energy technologies to reduce energy consumption and carbon footprint in built environments. The scope of this research is limited to the brief overview of these technologies and their applications [[16]].
Omair A., Bassam A. identified in their study that the amount of solar heat gain and thermal transmittance of the glazing and its setback properties are the main factors that can be calculated. External Shading devices contribute a lot in solar radiation penetration and reflectance. The study reached that it is possible to reduce 10% of houses' cooling bills in the UAE by adopting simple and passive design strategies, which are applicable for existing and newly designed projects. The present study shows that around 6% reduction in the houses annual energy consumption could be achieved. Therefore, and based on a simple calculation, 2.7% reduction in the annual energy consumption of UAE thus, carbon dioxide emissions' reduction by around the same percentage [[17]].
Mohammed K., Touraj A., Cem D. study the façade and shading systems at school building to reduce energy consumption and enhance the effectiveness of the building performance. The different glazing types and shading systems alternatives will show the most efficient one to be used as some optimized alternatives for the systems. Findings indicate that proper glazing and shading systems can reduce the needed energy for heating, lightening, and thus total energy consumption of a school building significantly [[18]].

3. DATA COLLECTION AND METHODOLOGY

3.1 THE METHODOLOGY

The main goal of the work is to reduce the negative impact on the environment, to minimize energy consumption in educational halls at university of NAJAH using three design alternatives (passive design). The alternatives are shading, triple glazing layers, and green roof which will be used individuals or as a group. To achieve this result, the following steps have been applied to conduct to measure the energy efficiency of design alternatives as follows:
Finding data:
Data were collected following an extensive literature review. In particular, data concerning NAGAH University case study were collected by:

1) Having measures of humidity, light, temperature, and sound for two days; 9 and 10 of February, four times per day (9:00, 12:00, 15:00, and 17:30) one time with open windows and the other with closed windows. And one time with the occupancy and the other empty building.
2) Building a simulation model for engineering College of Najah University using the design builder software.

- Data analysis

1) Then analyzing the base case which includes the total energy consumption in the building in kWh, and the level of carbon dioxide.
2) Adding design alternatives to the simulation model to test the energy consumption reduction and the alternatives efficiency.

3.2 DATA COLLECTION

Many tools used to collect data and measurements these are:

1) LM-8102 5 in 1: Anemometer, Humidity meter, Light Meter, Thermo meter, Sound level meter to measure data related to indoor environmental aspects.

2) The Design Builder Software: it is used to check building energy, carbon, lighting, and comfort performance by using a building simulation to compare the performance of design alternatives.

3.3 DEFINE THE CASE STUDY

The college consists of three floors as shown in Figure 2 which represents a basement that contains the services of the building and is distinguished by its distinctive design. The façades are distinct so that the colors overlap, and its design is an internal courtyard distributed around the corridors that lead to the classrooms and other activities. The inner courtyard takes the form of two squares Intertwined and extending around it the building block that contains voids in the external facade. The area of the inner courtyard is approximately 900 square meters, while the total area of the building is 10,000 square meters and the area of one floor is approximately 3600 square meters, and the following drawings show the internal distribution of the three floors.
The use of Thermistone refractory bricks, which achieve thermal insulation of the building and contribute to reducing the burden on the energy used to air-condition the building. This brick is a thermal insulator compared to traditional concrete that saves air conditioning load inside the building.

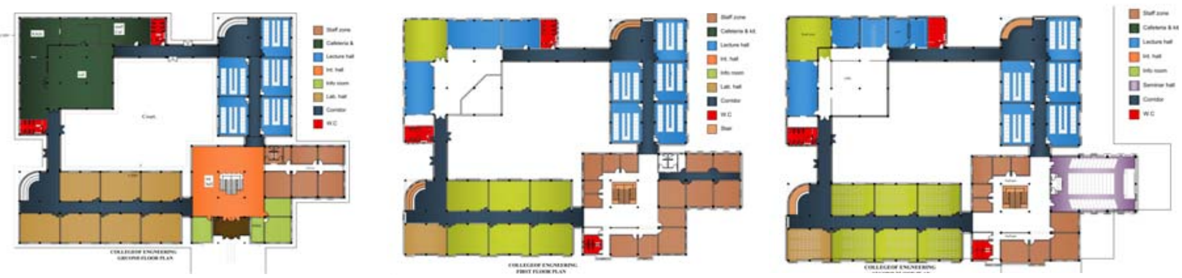


Fig. 2. Ground, first and second floor of Plans of NAGAH University

4. ANALYSES AND DISCUSSION

The first step is to inter the Najah engineering college specifications and dimensions to the Design Builder software to build a simulation model that simulates the building reality. It also simulates the energy consumption situation in the building. The software produces the next model shape

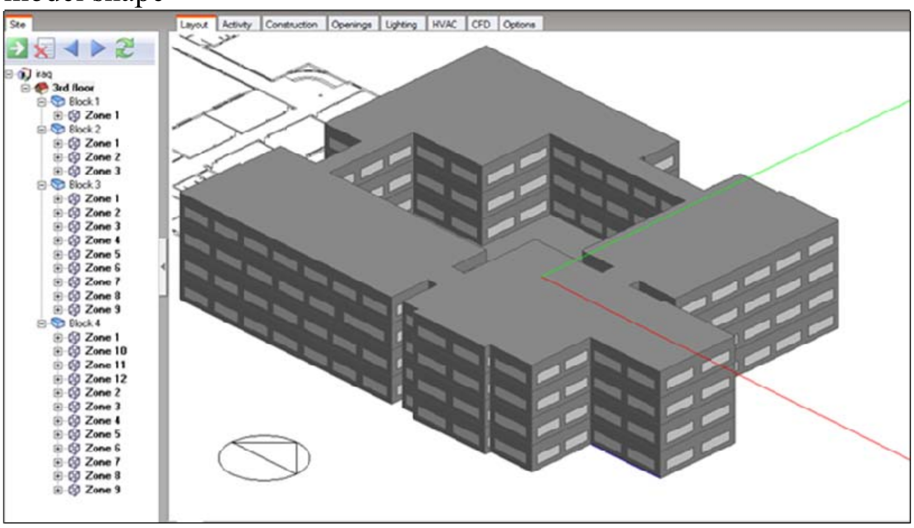


Fig. 3. Simulation model of engineering college at Najah university

The attributes of the Engineering college building of Najah university appears in the next the next table:

Table 1. Engineering college building of Najah University

General Characteristics	
Building direction	North-West
Number of floors	Four floors
The Area	10000 m2 per floor
Material of outside walls	Frames +clear glass Thurmaston blocks, Curtain walls,
Material of outside roof	Flat concrete roof
The use of spaces	Lectures-Laboratories-Offices-Corridors-Baths

The program has also been provided with information related to Site and Source Energy as in Table 2, and information on Source Conversion Factor Site => as well as in Table 3, and information on building area, air-conditioned space and non-air-conditioned areas as in Table 4.

Table 2. Site and Source Energy

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	2786234.82	242.46	242.46
Net Site Energy	2786234.82	242.46	242.46
Total Source Energy	6061428.62	527.46	527.46
Net Source Energy	6061428.62	527.46	527.46

Table 3. Site=>Source Conversion Factor

	Electricity	Natural Gas	District Cooling	District Heating	Steam	Gasoline	Diesel	Coal	Fuel Oil #1	Fuel Oil #2	Propane
Site=>Source Conversion Factor	3.167	1.084	1.056	3.613	0.3	1.05	1.05	1.05	1.05	1.05	1.05

Table 4. Information about the building and its area

	Total Energy [kWh]	Energy Per Total Building Area [kWh/m2]	Energy Per Conditioned Building Area [kWh/m2]
Total Site Energy	2786234.82	242.46	242.46
Net Site Energy	2786234.82	242.46	242.46
Total Source Energy	6061428.62	527.46	527.46
Net Source Energy	6061428.62	527.46	527.46

4.1 THE BASE CASE

The energy consumption in the building during the year is presented in the base case in the next fig. 3. It appears in the figure that the energy consumption reduced during June and December; the minimum consumption is in July. Also, we can notice that the energy face the higher consumption in cooling zone, therefore the heat gain should be minimized.

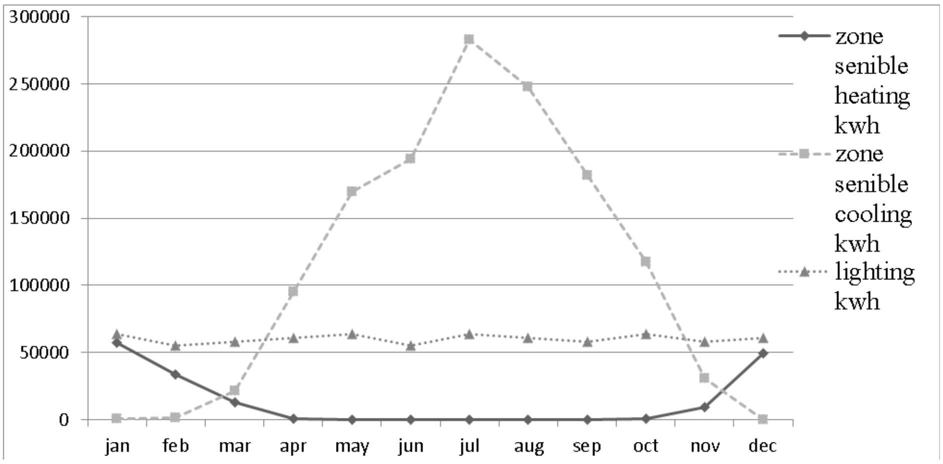


Fig. 4. The energy consumption in the building during the year

The light analysis introduced that the lighting near to the windows is higher than other areas; it reduces in the direction of inside the halls in the building.

4.2 APPLYING OF DESIGN ALTERNATIVES

Seven alternatives applied to the building to test the energy efficiency in the building by making use of design options and the amount of saved energy by applying these options:

1) The use of triple-glazing: this option applied to the simulation model and it appears that it can reduce energy consumption by 3% from the whole consumption **which appears in Fig. 5.**

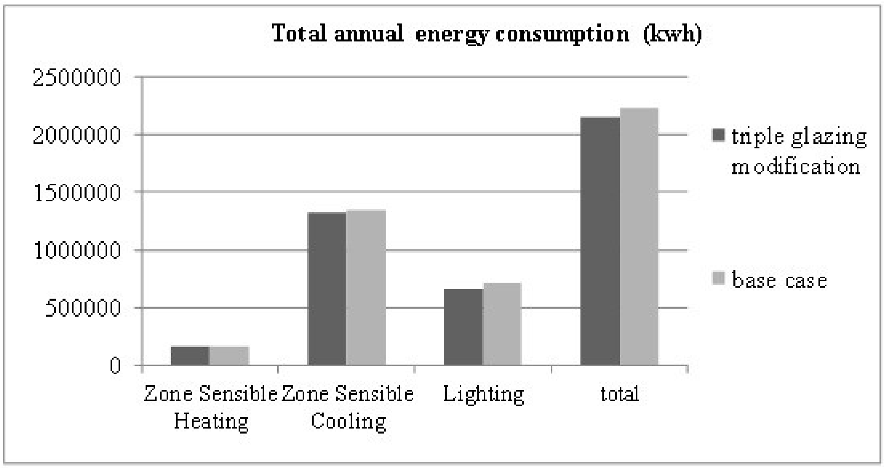


Fig. 5. Saving energy by using Triple glazing in kWh

2) The use of Shading: this option applied to the simulation model and it appears that it can reduce energy consumption by 11% from the whole consumption which appears in Fig. 6.

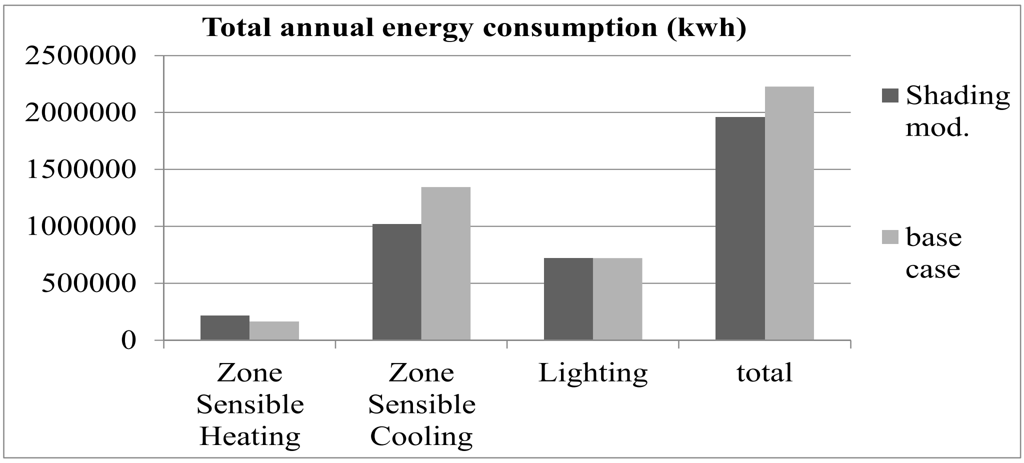


Fig. 6. Saving energy by using shading in kWh

3) The use of green roofs: this option applied to the simulation model and it appears that it can reduce energy consumption by 3% from the whole **consumption which appears in Fig. 7.**

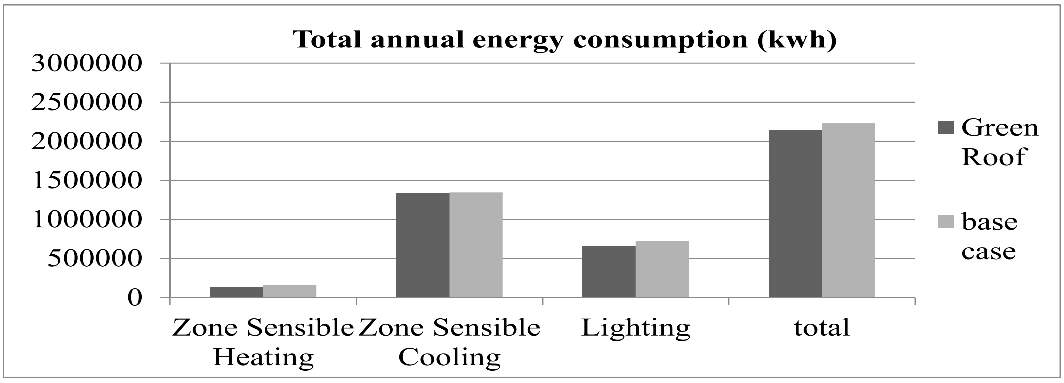


Fig. 7. Saving energy by using green roofs in kWh

4) The use of green roofs, shading, and triple glazing: this option applied to the simulation model and it appears that it can reduce energy consumption by 6% from the whole consumption which appears in Fig. 8.

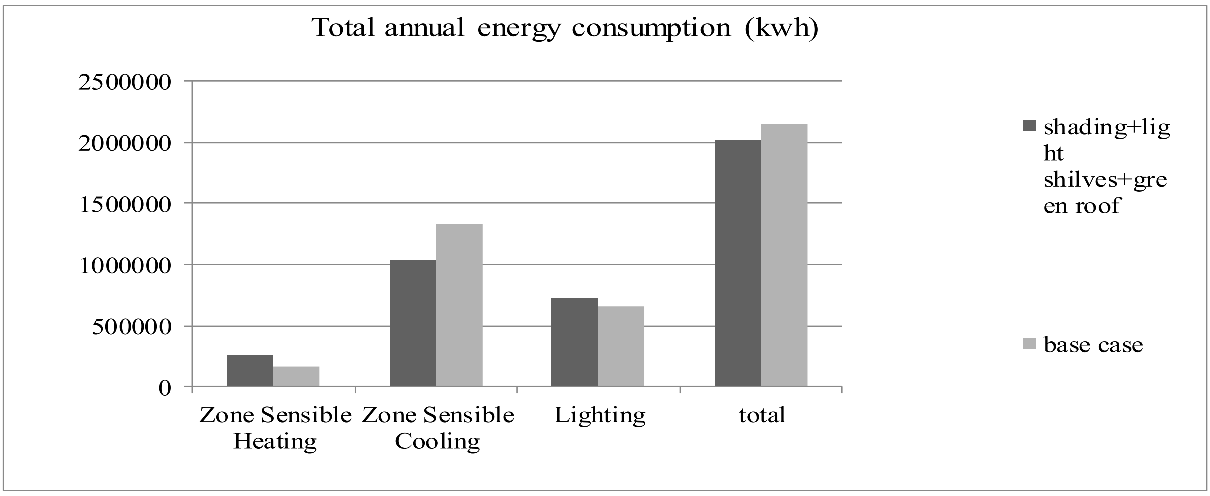


Fig. 8. Saving energy by using green roofs, shading, and triple glazing in kWh

5) The use of green roofs and triple glazing: this option applied to the simulation model and it appears that it can reduce energy consumption by 8% from the whole consumption which appears in Fig. 9.

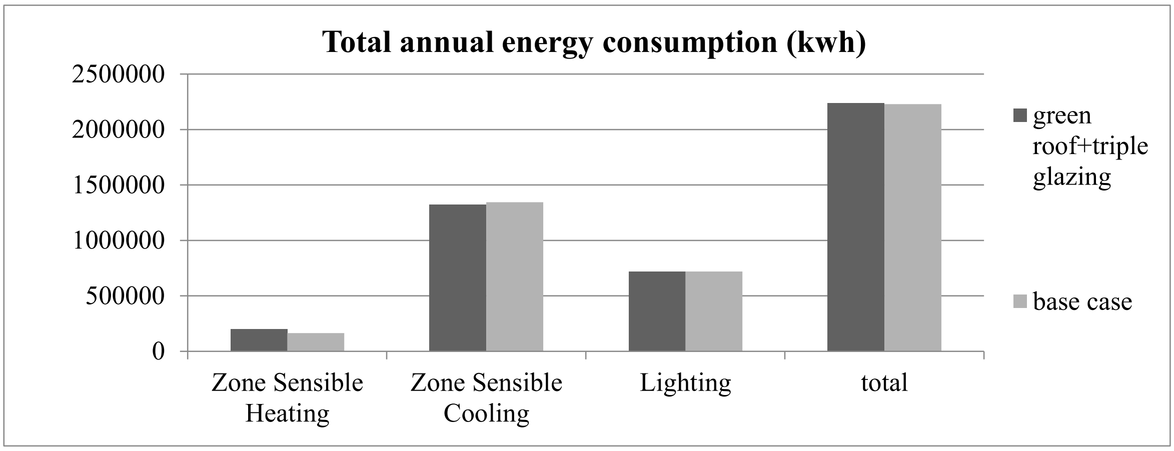


Fig. 9. Saving energy by using green roofs and triple glazing in kWh

6) The use of shading and triple glazing: this option applied to the simulation model and it appears that it can reduce energy consumption by 13% from the whole consumption which appears in Fig. 10.

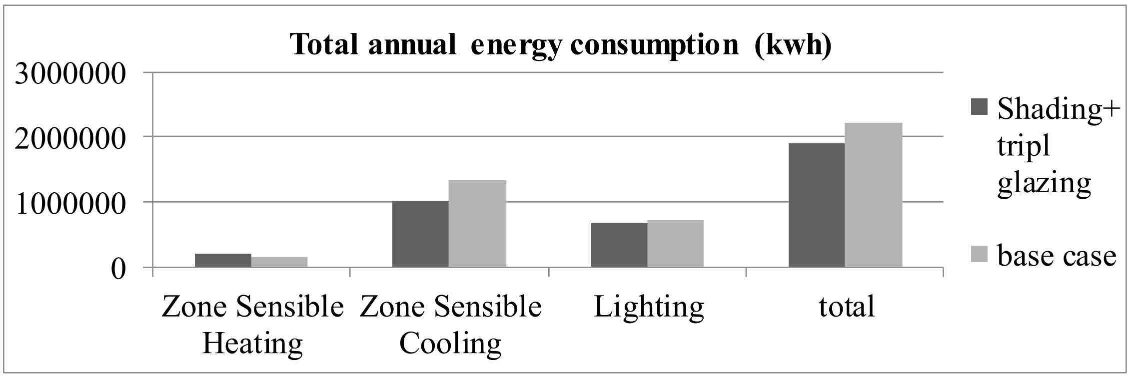


Fig. 10. Saving energy by using shading and triple glazing in kWh

The use of shading and green roofs: this option applied to the simulation model and it appears that it can reduce energy consumption by 9% from the whole consumption which appears in Fig. 11.

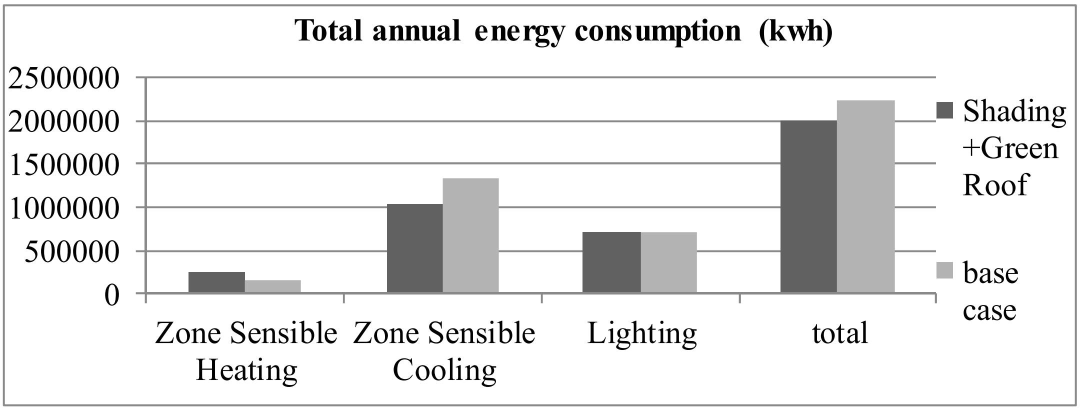
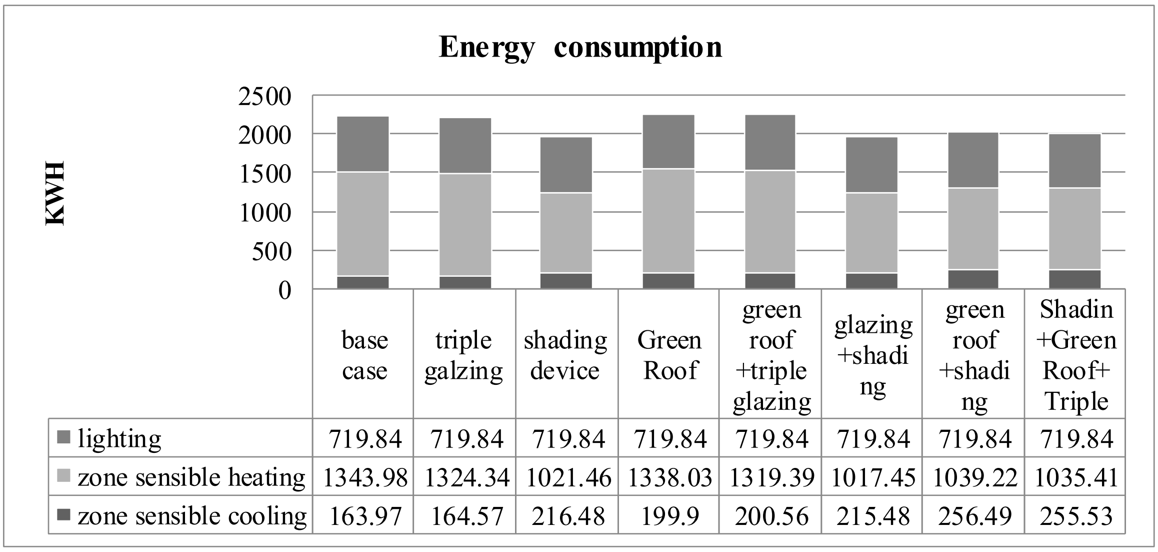


Fig. 11. Saving energy by using shading and green roofs in kWh

4.3 A COMPARISON BETWEEN DESIGN OPTIONS – ENERGY CONSUMPTION AND SAVING

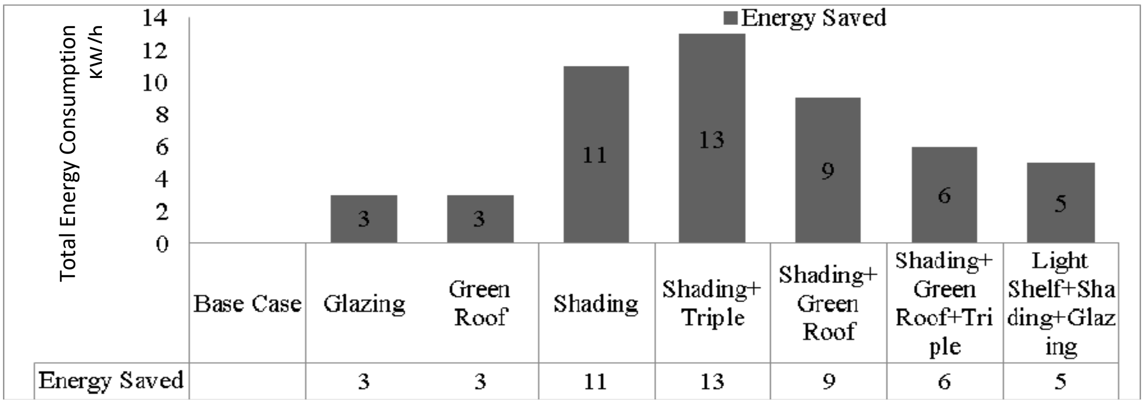
It appears that using of design options will reduce the energy consumptions in lighting, cooling, and heating. The next fig. 12. represents the amount of energy needed in lighting, heating, and cooling the building with the use of the seven design options.



	base case	triple galzing	shading device	Green Roof	green roof +triple glazing	glazing +shading	green roof +shading	Shadin +Green Roof+ Triple
lighting	719.84	719.84	719.84	719.84	719.84	719.84	719.84	719.84
zone sensible heating	1343.98	1324.34	1021.46	1338.03	1319.39	1017.45	1039.22	1035.41
zone sensible cooling	163.97	164.57	216.48	199.9	200.56	215.48	256.49	255.53

Fig. 12. Energy consumption by design options in kWh

Examine design options results that the option shading and triple glazing is the most effective one that can save 13% from the total energy consumption in the building then shading which save 11%.



	Base Case	Glazing	Green Roof	Shading	Shading+ Triple	Shading+ Green Roof	Shading+ Green Roof+Triple	Light Shelf+Shading+Glazing
Energy Saved		3	3	11	13	9	6	5

Fig. 13. Energy saving percentage by design options

4.4 APPLYING DESIGN OPTIONS ON EDUCATIONAL HALLS.

Triple glazing, shading, and triple glazing + shading options applied to tow educational halls located in the college building.

1) The east hall: Applying triple glazing, shading, and shading+ triple glazing to the east hall will save energy as shown in Fig. 14. 15.

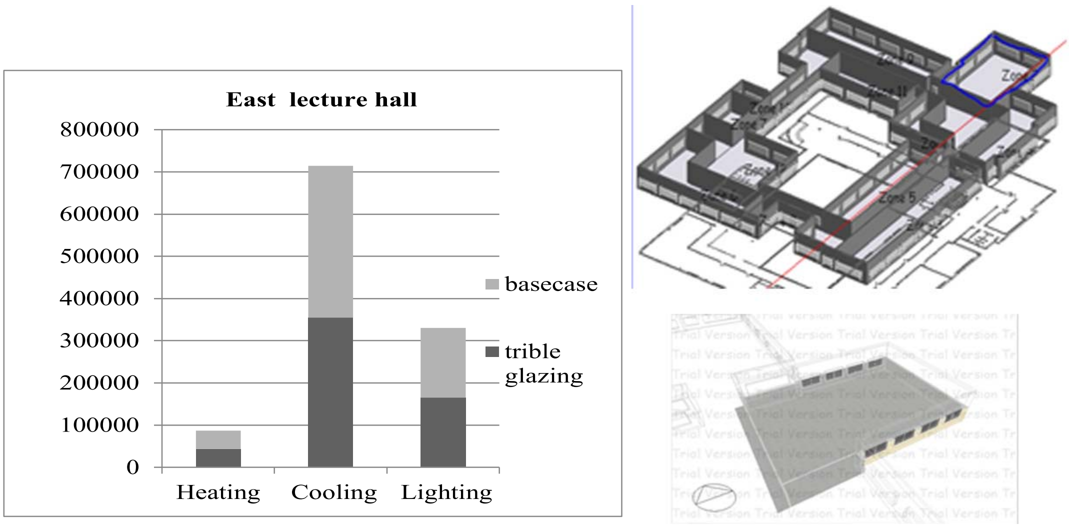


Fig. 14. Energy saving in kWh by using triple glazing in the east hall

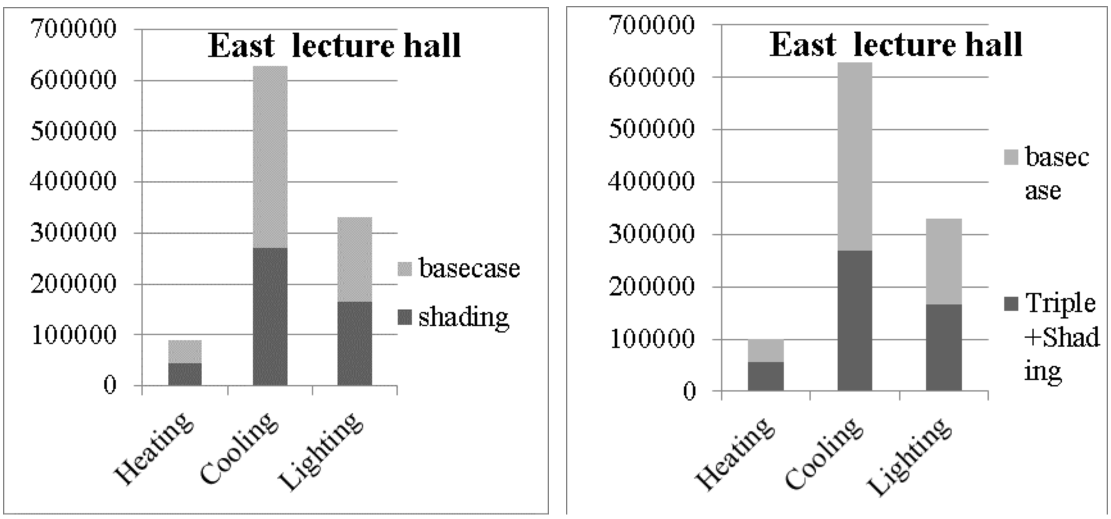


Fig. 15. Energy saving in kWh by using shading and shading+ triple glazing in the east hall

2) The south hall: Applying shading and shading+ triple glazing to the south hall will save energy as shown in Fig. 16. 17.

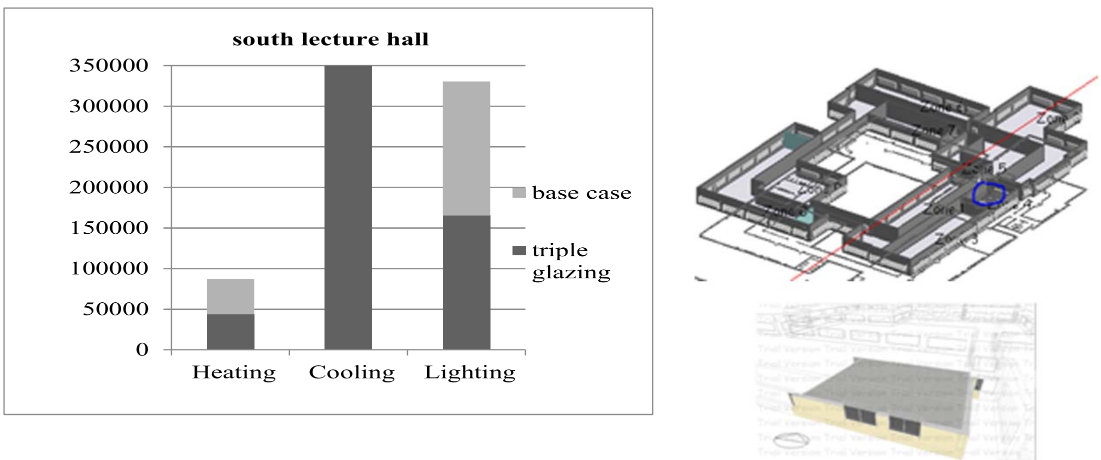


Fig. 16. Energy saving in kWh by using shading in the south hall

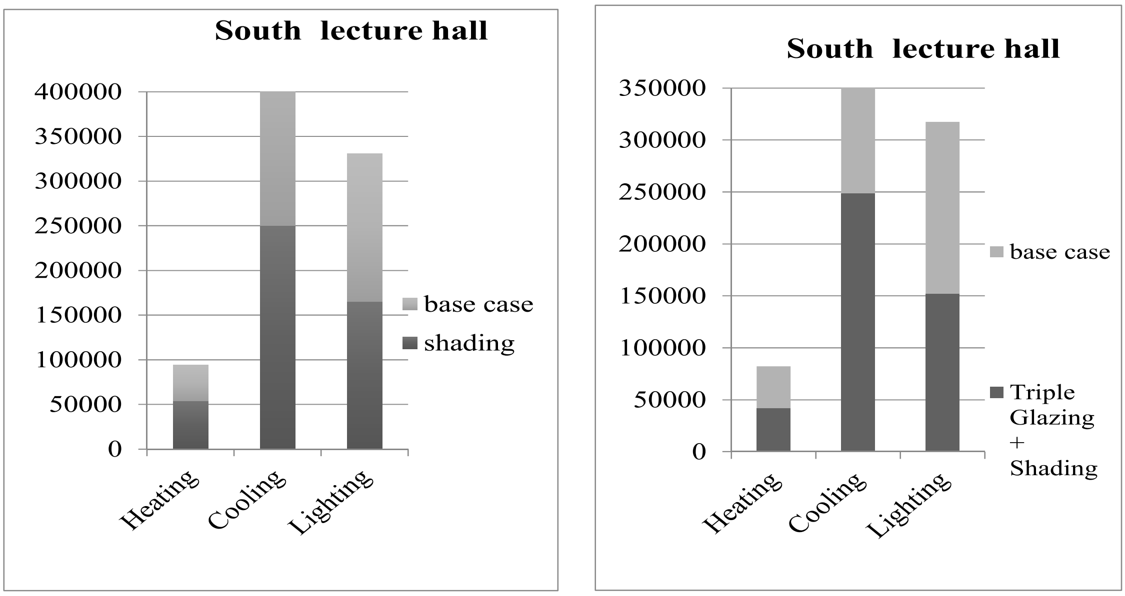


Fig. 17. Energy saving in kWh by using shading and shading+ triple glazing in the south hall

Finally, the results can be summarized in the following:

By applying of design alternatives on the case study, the most effective choice to decries energy consumption is to use shading and triple glazing that can save 13% from the total energy consumption, the second choice is shading which save 11%. These results were confirmed by applying them to the eastern and naval hall of the building.

5. CONCLUSIONS

Design options could save energy and minimize energy consumptions within buildings. Applying many design options for engineering college building in Najah university improve energy efficacy. It appears that using shading and triple glazing could reduce energy consumption 13 %. Then using shading will save 11 % of the total energy used in the building. Air quality indoor can be improved by making use of design options that will save energy, minimize energy consumption, conserve resources, minimize pollution results from using fuels to generate energy, and lower the life cycle cost of constructing buildings. Passive design is a preferred option to save energy and rise educational building indoor quality in the developing countries.

6. RECOMMENDATIONS

One of the most important recommendation of the research is to recommended design guidelines that help to improve effective environmental performance by suggestion many design alternatives and measuring their ability to reduce energy consumption. by creating a matrix between each of the three design variables are triple glazing, green roof, shading. By collecting many data and results on similar projects using specialized programs, different solutions and alternatives can be accessed for appropriate design in different environments with the standardization of some variables during application.

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LIST OF SYMBOLS

kWh	kilowatt hour
IAQ	indoor air quality