Bioclimatic Approch for Low Operational Energy in Educational Buildings In Nigeria

Owolabi Olalekan Simeon and Halil Zafer Alibaba
Eastern Mediterranean University, Famagusta, North Cyprus, Via Mersin 10, Turkey
Email: owolabisimeon@gmail.com, E-mail: halil.alibaba@gmail.com

Abstract— Due to the increase in debates on climate change and sustainability in different regions, sustainable and green building constructions have been on the rise. It is important to note that building design processes must not ignore climate considerations, or else risk the interference of human activities within the building space. This paper aims at assessing bioclimatic approaches in relation to energy performance towards a sustainable environment and green buildings. Bioclimatic design approaches help to increase the comfort experienced within a building in all seasons without automated or mechanical means. These approaches also help to curtail the use of non-renewable energy for cooling, heating, ventilation and lighting. This leads to reduced energy costs. The application of this principle does not imply an increase in the cost of construction or installation of some automated systems. Building designs which are based on bioclimatic approaches are highly sustainable; more ventilated with better indoor air quality, and allow for better visual comfort. The energy efficiency of an existing building and a proposed building will be compared using simulation tools contained in a software – Revit Architecture. This paper suggests design methods using sustainable approaches, which will assist designers and the construction industry as a whole in the application of the concept of bioclimatic design. The advantages of this approach are carefully analyzed.

Index Terms— Bioclimatic design, operational energy, thermal performance, thermal comfort, durability, sustainability, comfort.

1 INTRODUCTION

Bioclimatic design is a concept that is closely associated with sustainability and puts into consideration climate and human relations in reviewing the feasibility of a building design (Larasati and Mochtar, 2012). Bio-climate can simply be defined as climate as it is being influenced, as well as its influence on biological organisms (Horia Tundrea, and Mihai Budescu 2013). Therefore, the bioclimatic design approach entails designing for the future in ensuring that biological species are not negatively affected in the building design process. At this particular point in time, quite an impressive number of architects and designers seemingly have a keen interest in designing with sustainable approaches. However, no significant difference has been noticed in actual project executions relative to the discussions pertaining to sustainability, very little is being done.

In the humid tropics where the average humidity is about 86% (Climatology and Geophysics BMKG2012), the outdoor temperature is lower than the indoor temperature within buildings (Energy Commission of Nigeria (2008). This can as a result, have a negative effect on the health of building occupants, as well as their level of productivity within the building confines. This means that in order for indoor thermal comfort to be achieved, one has to employ artificial cooling systems ranging from air conditioners, fans, humidifiers and room coolants. All these ultimately result in high energy consumption during the building operations.

To modify the running headings, select View | Header and Footer. Click inside the text box to type the name of the journal the article is being submitted to and the manuscript identification number. Click the forward arrow in the pop-up tool bar to modify the header or footer on subsequent pages.

2.0 Literature Review

2.1 Bioclimatic design

There are three interconnected considerations that strike the balance between the climate of a region and the buildings including biological needs, climate considerations, architectural applications and technological solutions (Olgyay, 1963). Two justifications were therefore introduced by Yeang (1996) on the concept of bioclimatic designs. The first is the achievement of the maximum level of comfort of users during a building's usage. The second is the minimum energy consumption and cost involved in a building's usage. However, these two approaches can be contradictory to each other; therefore, specific strategies must be utilized to ensure that they are implemented successfully. There is a relationship between the climate, environment and humans in the bioclimatic perspective.
This is illustrated in figure 1 below.

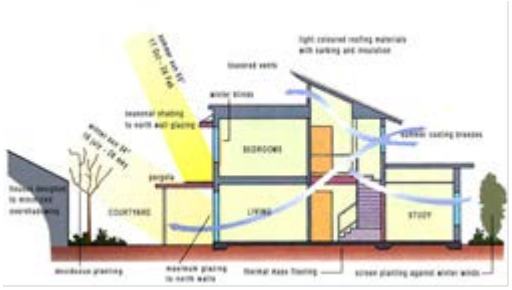

Fig. 1.Relationship in bioclimatic design perspective
Sources;https://www.google.com.tr/imgres?imgurl=http%3A%2F%2Fblog.croftandassociates.com

Case studies have shown that when buildings respond to climate conditions, they exhibit high levels of energy efficiency. Therefore, climate is one of the major peculiarities that require attention in a building design process. In humid regions, designs will have to vary from those in sub-tropical climate regions. The level of heat and sunlight in humid regions should be paid specific attention to in design and as such map the bioclimatic components of the building design (Mc Lennan, Jason F. 2004). In the case that any bioclimatic components have been mapped out, then an understanding is required of the implementation of these components in the application of sustainable design principles in humid regions, the number of components applicable and the necessary conditions for the optimal functioning of these components.

Based on the aforementioned, this research identifies the bioclimatic components of sustainable designs and the developmental procedures of bioclimatic designs that can be used in humid regions such as Nigeria.

2.2 Cost of Bioclimatic designs

Bioclimatic designs are not designs that require the purchase or installation of complicated mechanisms as they use regular design principles to improve the energy performance of a building and provide thermal comfort. Low operational energy costs begin with designing buildings in order to maximize the available asset(s) of the site. This method of design imposes principles of guidelines, while still having the freedom to design in accordance to personal taste. These guidelines include the orientation of a building, the sun's rays, and collection of rain water among many others. The objective is to have a building that is energy-efficient in relation with respect to its natural environment.

2.3 Set Back of Bioclimatic designs

Generally, cosmeticism have become more valuable to us and taken over thermal comfort. As a result, the functionality of buildings and quality of living in most cities have been lost. The word 'building' means more than just a habitable place, for many it is a show-off of prestige and consumerism. Bearing that symbol, it must adapt to the established standards of status like convenience and leisure, while sometimes ignoring basic functionalities like the environment (i.e. Mc Mansions).

In a society where consumption is used to promote growth in the economy, the principle of conservation of energy is viewed as a discomfort and a thing of low status. It sees waste as easy and prestigious living. As a result, many scientists regard global warming as having no immediate consequence, allowing energy to be wasted continuously and neglect the fact that there are ways to reduce these operational energies and waste in relationship to their life styles. Consumerism encourages people to use artificial sources of energy in order to keep their businesses going. Therefore, this begs the question of whether societal success can still be attained through techniques for refinement as opposed to expansion.

Most times, professionals in the building industry fail to look beyond the profit in their businesses to provide other alternatives. Often times, they don't strive to introduce new alternatives to their customers. In economics, this is known as the Rational Man Model', which is defined as "maximizing and promoting true self interest".

2.4 Operational Energy Principles

Mechanical means of ventilation such as air – conditioners require a lot of energy (Hegger, 2008). Optimization of operational energy used can be minimized to the barest minimum by applying the following strategies (Sarte, 2010).

2.4.1. Cross – ventilation

Cross – ventilation can be achieved by the right placement of building windows. A minimum of two windows positioned at different sides of the room can be used to ease the inflow and outflow of air. Inadequate airflow into and out of the room could be a cause for artificial medium; this could also cause poor indoor air quality.

2.4.2 Natural lighting

Visual comfort can be achieved by ensuring that there is adequate daylight coming into the building. Correct positioning of windows and the use of adequate sizes of windows contribute to visual comfort. The right proportion of light into a building does not only contribute to the reduction of operational energy costs but also to energy efficiency. Insufficient daylight into a building requires a high demand for artificial light during the day (Bauer2007).

2.4.3 Building orientation

The impact of a building's orientation on energy consumption cannot be over-emphasized. A building's optimum orientation is often overlooked due to other design considerations such as the orientation of the land, topography or gradient of the site, views etc. In the tropics, rectangular buildings with long elevations facing north and south are preferred so as to minimize solar heat gain.

2.4.4 Planting of trees and shrubs

The planting of trees and shrubs at a building's perimeters is an effective way to achieve a healthy environment. This provides good shading effects to a house. Planting of trees and shrubs also helps reduce carbon dioxide and release oxygen into the atmosphere (photosynthesis), thereby purifying the atmosphere.

2.4.5 Configuration of building

The configuration of a building entails the form and such building's envelope (Sharma, 2002). The selection of eco-friendly materials, shading devices and green roofs makes a big difference in a sustainable building.

3.0 Methodology

The figure below shows the design of a typical institutional building, which was positioned at the university of Abuja permit site located in the state capital of Nigeria. The building on the left is plain and finished with concrete while the one on the right is built of eco-friendly and sustainable materials such as red bricks as against the conventional cement bricks. PV panels were installed on the roof and larger windows were

employed. Both buildings were simulated and the results were compared in the following sections.

3.0 Methodology

Comparison of two typical design finishing with different materials and then simulated, which was positioned at the university of Abuja permit site located in the state capital of Nigeria. The building on the left is plain and finished with concrete while the one on the right is built of eco-friendly and sustainable materials such as red bricks as against the conventional cement bricks. PV panels were installed on the roof and larger windows were employed. Both buildings were simulated and the results were compared in the following sections. 3Sections

As demonstrated in this document, the numbering for sections upper case Arabic numerals, then upper case Arabic numerals, separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

3.0 Methodology

Comparison of two typical design finishing with different materials and then simulated, which was positioned at the university of Abuja permit site located in the state capital of Nigeria. The building on the left is plain and finished with concrete while the one on the right is built of eco-friendly and sustainable materials such as red bricks as against the conventional cement bricks. PV panels were installed on the roof and larger windows were employed. Both buildings were simulated and the results were compared in the following sections. 3Sections

As demonstrated in this document, the numbering for sections upper case Arabic numerals, then upper case Arabic numerals, separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

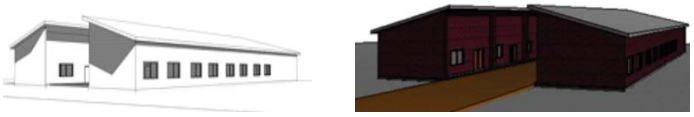

Figure 2. Annual carbon emissions from the proposed institutional building in Nigeria
Source autodesk revit 2017

3.0 Findings and Discussions

Figure 3 below shows that the proposed institutional building exhibits the same energy-use level but from the diagram on the right-hand side, there are photovoltaic panels which enable the building to reduce its carbon emissions. Having PV panels installed on the roof helped to reduce electricity consumption thereby reducing CO2 emissions from the building.

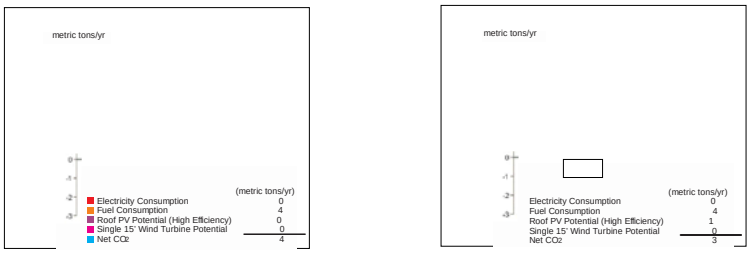

Figure 3. Annual carbon emissions from the proposed institutional building in Nigeria
Source autodesk revit 2017

Figure 4 below shows that the building made of concrete and without PV panels displayed a high level of energy use/cost per year compared to the institutional building with walls made of bricks and roof with an installation of PV panels.

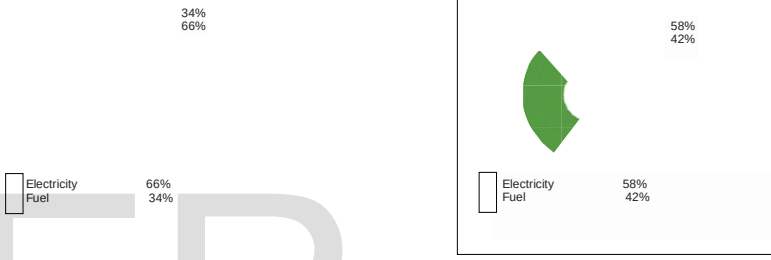

Figure 4. Annual energy use/cost of the proposed institutional building in Nigeria
Source autodesk revit 2017

The results from Figure 5 below show that the amount of money saved from the use of bioclimatic approaches on the institutional building was considerably higher than the building to which no bioclimatic approach was taken.

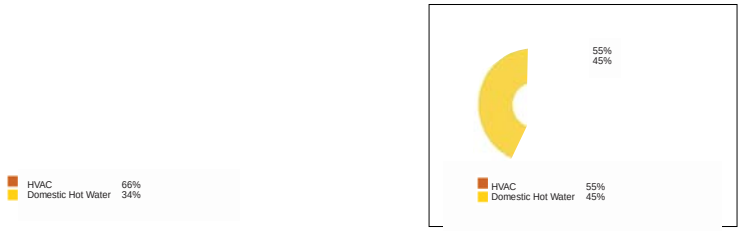

Figure 5. Energy use (Fuel consumption) of the proposed institutional building in Nigeria
Source autodesk revit 2017

Figure 6 shows the different monthly cooling loads such as light fixtures and infiltration for the proposed institutional building. The monthly cooling load for the proposed building with no bioclimatic approaches such as the use of PV panels was higher than that of the proposed building with PV panels and brick walls.

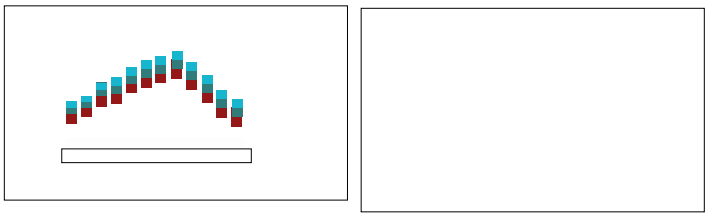

Figure 6. Monthly cooling loads of the proposed institutional building in Nigeria
Source autodesk revit 2017

5. Conclusion.

Sustainability, in general, is being practiced in several countries of the world using various approaches. The installation of PV panels is becoming a common practice in the construction industry in Nigeria and this has helped to boost the sustainability of buildings in Nigeria. The usage of large span windows, green roofs are also bioclimatic approaches that are taken towards ensuring sustainability in buildings in Nigeria.

Power supply which is a major source of concern in Nigeria can be tackled through the use of photovoltaic panels. Another benefit of using PV panels can be explained in terms of CO2 emissions. Fuel generators which emit large quantities of CO2 in producing electricity will not be needed when there is solar energy being used in a building.

Lastly, water-harvesting is another bioclimatic approach which fits well into the Nigerian context if applied efficiently. The country as a whole experiences high levels of rainfall at most times of the year. Hence, the need to develop this natural resource towards achieving bioclimatic designs in Nigeria. Nowadays, there are water-harvesting systems used in Nigeria but they can be better modified in terms of their functionality. This can serve as a possible extension for this project. As the concept of sustainability continues to gain recognition worldwide, bioclimatic designs in Nigeria have come to stay.

4 Conclusion

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Authors are strongly encouraged not to call out multiple figures or tables in the conclusion—these should be referenced in the body of the paper.

Acknowledgment

I want to thank my parents in ensuring that I have all the necessary requirements for my education and also the efforts of my supervisor (Ass. Prof. Dr Halil. Zafer Alibaba) for guiding me through the process of publishing this paper.

REFERENCES

[1] Agency of Meteorology, Climatology and Geophysics (2012). Analysis of the dry season of 2011 and the analysis of the rainy season 2011/2012. Teluk Betung climatological station, Tangerang, Indonesia.

[2] Bauer, M., Mösle, P., & Schwarz, M. (2009). *Green building: Guidebook for sustainable architecture*. Berlin: Springer Science & Business Media.

[3] Energy Commission of Nigeria (2008). An assessment of Energy Options and Strategies for Nigeria: Energy Demand, Supply and Environmental Analysis for Sustainable Energy Development (2000-2030). Report No. ECN/ EPA/ 2008/ 01.

[4] Hegger, M., Fuchs, M., Stark, T., & Zeumer, M. (2008). *Energy manual: Sustainable architecture*. Basel, Switzerland:Institut für Internationale Architekturdokumentation

[5] McLennan, & Jason, F. (2004). *The philosophy of sustainable design: The future of architecture*. Georgia: Ecotone publishing, Bainbridge.

[6] Olgyay, V. (2015). Design with climate: Bioclimatic approach to architectural regionalism. Princeton University Press.

[7] Sarté, S. B. (2010). *Sustainable infrastructure: The guide to green engineering and design*. Hoboken, New Jersey: John Wiley & Sons Inc.

[8] Sharma, A., Dhote, K. K., & Tiwari, R. (2003). Climatic responsive energy efficient passive techniques in buildings. *IE (I) J AR*, *84*, 17-26.

[9] Tundrea, H., & Budescu, M. (2013). Bioclimatic architecture, a sensible and logical approach towards the future of building development. *Buletinul Institutului Politehnic din Iasi. Sectia Constructii, Arhitectura*, *59*(6), 109.

[10] Yeang, K. (1996). The skyscraper bioclimatically considered: A design primer. London, UK: Wiley-Academy Group, Ltd.

[11]. Zr, D. L., & Mochtar, S. (2013). Application of bioclimatic parameter as sustainability approach on multi-story building design in tropical area. *Procedia Environmental Sciences*, *17*, 822-830.