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Eco-Efficient and Innovative Measures for Sustainable University Senate Buildings in Nigeria: The Case for Research

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ABSTRACT

In Nigeria, buildings for office use have grown tremendously in contemporary time. However, it is perceived that this trend will continue to grow due to the rapid economic growth that comes with numerous environmental challenges, which leads in increasing concern of climate change. To this end, there is need to create buildings with high performance in relation to the environment. Meanwhile, knowledge about environmentally sustainable university office buildings is still very limited. This paper seeks to provide insights on eco-efficiency and energy consumption of university senate buildings. The objective is to develop a holistic approach for integration of eco-efficient measures and innovations for environmental sustainability of university senate buildings in Nigeria. A critical review methodology is applied on literatures focused on eco-efficiency and energy conservation of buildings using advanced search from Google Scholar. Findings reveal that, innovative approaches tailored towards sustainability of buildings when adopted would make university senate buildings in Nigeria key into the philosophy of eco-efficiency. Based on these findings, the paper recommends the adoption of eco efficiency as a key element for sustainable office buildings. In conclusion, the paper advocates innovative approaches that would enable a paradigm shift in the design of university senate buildings as very fundamental.

Key words: Building Performance, Eco-efficiency, Environmental friendliness, Innovations, Office Buildings

INTRODUCTION

In 2010, buildings accounted for about 32% of total global final energy use, 19% of energy-related GHG emissions (including electricity related), approximately one-third of black carbon emissions, and an eighth to a third of F-gases (Zhang, 2017). This energy use and related emissions may double or even triple by mid-century due to the likely trends in the built environment and as the environmental impacts of building activities is pervasive today, discourses tailored towards eco efficiency has taken pole position (Lucon*et al.,* 2014).Institutional buildings on the other hand, are a key indicator of the socio-economic development of any nation offering numerous benefits to the society. But still, dramatic environmental and social consequences are created throughout the life cycle of buildings (Rajeev, *et. al.,* 2016).

Eco efficiency is the practice of increasing the efficiency with which buildings use resources: energy, water and materials, while reducing building impact on human health and the environment (Taraj*et al.,* 2013). In part it can be achieved by reducing carbon waste and avoiding excessive use of non-renewable resource, encouraging recycling and reducing hazardous emissions and by-products as well as having a rationale that considers the environment.

In some cases, eco efficiency is used interchangeably with sustainability and high building performance. In the opinion of Sakar (2013), to achieve eco efficiency, a tripartite relationship that resolves around the minimization of impacts on the environment, enhancing the health conditions of occupants, and a technological boost must be in place if eco-efficient buildings are to be attained.

In recent years, industrialization and economic growth has led countries and regions around the world to develop extensively, has brought about

environmental degradation and global concerns on climate change. To mitigate or address these anomalies, buildings of the future have to take into account the challenges brought about by this technological, environmental and societal changes. Due to the urgency of measures related to climate change and the need to provide a proper environment for working. This has led academicians as well as experts in the built environment to modify existing systems, trigger paradigm shifts to adopting completely new technologies and processes for the built environment which guarantees a more holistic performance of buildings in relation to the environment.

Moving on, global warming being a major threat to the environment in recent years, has necessitated the need for architects, designers and building practitioners to be meticulous and thorough in their analysis and evaluation. Hence there is a need for architects and designers to produce sustainable building designs and construction as buildings consume resources and energy, contribute to pollution of air, water and soil, impact the health and well-being of populations and constitute an important part of the built environment in which we live. More so, office buildings pose a high tendency of energy consumption, CO_2 emissions, other unfavourable impact of buildings on the environment and its users due to the activities that are carried out within them. Improving the energy efficiency of functional buildings is an important step in minimizing the environmental effects of the building stock (Kneifel, 2010).

The basic principle of the building energy efficiency is to use less energy for operations (for heating, cooling, lighting and other appliances), without impacting the health and comfort of its occupants. This approach would eventually reduce primary energy use and CO2 (Nikolaou *et al.,* 2011), which will overtime increase the energy efficiency of functional buildings and provide many environmental and economic benefits such as reduced GHG emissions and operational cost savings. Eco-efficiency being a tool for attaining sustainability, would then be an all-inclusive model to be incorporated into the built environments for policy on design of sustainable buildings in preventing further environmental degradation. Thus the rationale for this paper is that university senate buildings in Nigeria have not made concession to efficient energy use by addressing energy efficiency issues of their buildings from the point of view of appropriate eco-efficiency measures such as the application of window and passive technologies (e.g. solar), passive ventilation systems and daylighting strategies etc.

It is based on the forgoing, that this paper makes a case for the establishment of eco efficiency measures and their integration into administrative university buildings to achieve their sustainability through conservation and efficient use of energy. Meanwhile, the key objective that this paper seeks to achieve is to develop a holistic approach for integrating eco-efficient measures for rapid innovations in environmental sustainability of university senate buildings in Nigeria.

METHODOLOGY

This paper adopts a conceptual review approach using a critical review methodology involving a review of related literatures on eco-efficiency and energy conservation. Using this approach, only peer-reviewed journal articles were sourced from 10academic databases (Emerald, Elsevier, Heinonline, Inderscience, Cambridge Journal, Jstor, Wiley, Taylor & Francis, Sage and Springer) known to have high quality publications. In accessing the articles from these databases, "Eco-efficiency + energy conservation in buildings" all titled with exact phrase was used as the search combination using advanced search from Google Scholar. This methodology was deemed appropriate considering the fact that peer-reviewed articles offer scholarly opinion and insights that would ensure the robustness of this study.

Literature Review

To fulfil the overall objective of this paper, this section explores literatures to identify models and indicator measures of eco-efficiency and energy conservation in buildings that designers and

practitioners in the built environment would adopt in order to achieve the eco-efficiency philosophy.

Eco-Efficiency and Energy Conservation in Buildings

Sakar (2013), described eco- efficiency of buildings as the practice of reducing the environmental effect of a building, by increasing the efficiency with which buildings make use of resources such as water, energy and materials. Buildings consume resources and energy, contribute to pollution of our air, water and soil, impact the health and well-being of populations and constitute an important part of the built environment in which we live. In part, he also described energy conservation is the efficient use of energy in a building to prevent it from being wasted and also reduce the use of energy to prevent the environmental effect of building energy use.

The rationale for adopting eco-efficiency and energy conservation of buildings is to check the consumption level of resources and energy, their contribution to pollution of air, water and soil, impact on the health and well-being of populations and the entire ecosystem.

According to Zhang (2017), buildings accounted for 32% of total global energy use. This energy use may potentially double or even triple due to increasing growth of urban areas and construction of infrastructures. Perez *et al.* (2007) stated that the highest energy consuming component in a building is the heating ventilating and conditioning system (HVAC). This is suggestive that for an office building to perform its function optimally, HVAC system must be in place and functional. Hence, the ability to assess designs automatically from drawings to reduce environmental and economic cost impacts will enable building design professionals to make informed decisions on such impacts of building structures.

Aditya (2017) stated that the energy saving potential of a well-insulated house varies from between 50% to 90% compared to other conventional buildings. This would then mean that, insulating a building thermally helps to preserve the conservation of energy as it reduces the demand for HVAC systems in such building. This thermal insulation can be done with the use of innovative insulating materials, and the selection of such materials depends on the geographical location, and space types. These materials can be applied to insulate walls, floors, roofs, ceilings, windows and roofs.

In addition, Chedwal (2015) examined the possibility of reducing energy consumption of commercial buildings by implementing the energy conservation building codes (ECBC), such as the building envelop, HVAC systems, and lighting systems, the result demonstrated an energy saving potential of between 18.42% to 37.3 %.The study revealed that by implementing the ECBC building codes increases the energy saving potential of commercial buildings, and facilitates advanced level energy saving measures of buildings.

More so, considering the fact that lighting systems in a building contribute to a large extent to the energy consumption of a building, the importance of day lighting in buildings with the use of window glazing to promote energy savings in such buildings is paramount (Hee, 2015). Often time, office buildings depend on the lighting system for visual comfort within the building. However, different types of glazing are available and its application to a building depends on the amount of light needed with the space and the purpose of the glazing.

Moving on, Chwieduk (2017) proposed the incorporation of traditional and modern options of energy conservation in a building. Typically, this is done by using materials, building form, building orientation and basic passive techniques that can be incorporated in the initial design stage (traditional means) and renewable energy sources like solar energy (modern means). All options are then assessed and incorporate as it would then mean that designers have a basis for evaluating the energy consumption rate of buildings and opportunity of designing a robust eco-efficient building.

Contrary to the opinion of Chwieduk (2017), Ascione (2017) stressed that the use of modern energy conservation technique (renewable

energy) is not enough in supplying the energy required for the buildings to use. In his opinion, buildings have to be equipped to face the impact of climate change and reduce cooling demands in conserving energy use in buildings. He suggests that strategies such as greening of facades, nocturnal convective cooling, phase change materials, and new technologies such as breathing walls and dynamic insulation are measures that can be taken in ensuring energy conservation and sustainability of buildings.

Synthesizing these thoughts, Dixon (2014) suggested that occupants of buildings play an important role in the conservation of energy in their buildings. Based on this mind-set, he posits the involvement in checking energy conservation behaviours. For instance, unlike residential contexts, people typically do not have an interest to conserve energy at work or in an office environment as they do at their homes.

More so, Dixon (2014) suggested that even the lack of an energy bill means that, individuals are not primed to consider the energy used for work and have little understanding of how much energy they have used relative to previous periods. Work appliances are often used by multiple employees, which tends to diminish the degree to which employees feel they can individually affect energy consumption (Dixon, 2011). However, he recommended comparative feedback to help individuals overcome these barriers by priming them to consider their energy usage at work and increasing collective responsibility. This was closely supported byKhashe (2016), wherein he advocated that the effectiveness of social messages on energy conservation in a building promotes energy conservation behaviour among commercial building users.

FINDINGS AND RESULTS

As alluded to the introductory section of this paper, literatures were examined to reveal recent commentaries on eco-efficiency and energy conservation of office buildings to satisfy the overall objective of this review. Based on literatures explored, this section reiterates the findings that would provide a holistic approach for sustaining office buildings in Nigerian Universities if applied.

From the evidences gotten, it was revealed that eco-efficiency is the buzz word for designers and other stakeholders in the built environment considering the fact that industrialization and global warming has forced them to adopt innovative strategies to meet policy requirements of nations in making the ecosystem sustainable.

Also, eco-efficiency and sustainable building practices are cost-effective and efficient measures of conserving energy and providing additional value to buildings and their occupants.

There exists a relationship between the need for achieving eco-efficiency in buildings and the energy conservation behaviours of individuals. As revealed from literatures, workers in most cases are not disposed to managing energy at their places of work but, would conserve energy in their residents (homes). These disparities pose a challenge to achieving eco-efficiency of buildings by way of energy conservation.

Option of choosing to adopt either a traditional or modern method is one way of conserving energy. Whilst the traditional method seeks to factor all the designs and building (from foundation to completion), the modern method seeks to complement these and provide for innovative means of conserving or mitigating energy wastes in buildings.

Despite the innovativeness of adopting the traditional or modern methods, cutting-edge methods exists and includes greening of facades, nocturnal convective cooling, phase change materials, and new technologies such as breathing walls and dynamic insulation are measures that can be taken in ensuring energy conservation and sustainability of buildings.

Heating Ventilating and Air Conditioning system (HVAC) is a way of striking a balance between energy wastes and energy conservation. However, insulating a building thermally helps to preserve the conservation of energy as it reduces the demand for HVAC systems in such building.

DISCUSSION OF FINDINGS

Based on the findings obtained from the literature, it can be deduced that eco-efficiency is

not just a word, in recent times it has engendered positive opportunities for the future of the built environment. In the time past, models and architectural designs of buildings although robust and comprehensive, were hitherto not green oriented. This is quite understandable because, the demand for buildings as at that time and populations across the globe were quite manageable. However, industrialization and rapid economic growth has intensified the need for sustainable buildings of the future. Whilst this militating factors which are unavoidable, eco-efficiency offers a tremendous advantage for the built environment. So, developing an all-inclusive or holistic approach of using sustainable means as revealed from the findings is a continuous process. One cannot authoritatively posit that the use of modern methods and negligence of traditional methods offers the most advantage for buildings. Other aspects like the geographical locations and availability of resources is a determining factor. Hence, Nigerian universities senate buildings adopting a traditional or modern method considering the costs and benefits obtainable from them would offer tremendous advantages.

More so, other innovative methods such as greening of facades, nocturnal convective cooling, phase change materials, and new technologies such as breathing walls and dynamic insulation as measures of ensuring energy conservation and sustainability of buildings offers a new paradigm for builders and occupants of Nigerian university senate buildings in that it will not only address issues of capillary action (rising water levels or flooding) but increase their perspectives on eco-efficiency. In addition, the findings are suggestive that breathing walls and insulation mechanism known for their coolants or cooling effects take pole positions in modern architectural designs and models.

Furthermore, as revealed from literatures, Heating Ventilating and Conditioning system (HVAC) thermally helps to preserve the conservation of energy. Hence, it serves as mechanism for striking a balance between energy wastes and energy conservation. This would then imply that if Nigerian university senate buildings adopt such, it would serve as a recycling mechanism in that, energy wastes and their re-conversions would ensure their efficiency.

RECOMMENDATIONS

Based on the findings from literatures, this study makes the following recommendations:

Eco-efficiency and energy conservation requires attention and action from built environment professionals and users of public buildings such as university administrative senate buildings as such buildings needs to be designed to demand little energy and to achieve local generation of energy. Therefore, the professionals engaged in the design of these buildings should ensure that these buildings satisfy the conditions of having minimal or low environmental impact by integrating innovative technologies in managing energy use in such buildings.

Whilst it has been recommended that traditional and modern methods of conserving energies is efficient, this study recommends a more robust approach of combining both methods viz-a-viz a balancing of the cost-benefits derivable from them. Since energy conservation is not a onetime issue as it is a continuous process; thus it is recommended that university administrative senate buildings should constantly be designed and delivered in line with growing global trends of environmental sustainability. This would not only reduce cost but also ensure demand reduction and efficiency in delivery of required energy services.

Furthermore, conflicting user's behavior in university administrative senate buildings should be given attention to sensitize the users on the effect of global warming and the need for energy saving practices while using the buildings. Additionally, adopting new technologies such as sensors that would automatically switch on/off lights amongst others could be the new paradigm.

Lastly, this study recommends an empirical examination of Nigerian university senate buildings and the green initiatives of such

universities. This would help with empirical evidences as to whether or not these universities adopt eco-efficient measures.

CONCLUSION

In conclusion, eco-efficiency and energy conservation in buildings in recent time is gaining momentum owing to the adverse of climate change amongst other factors. However, buildings of the future or current time strive to be eco-efficient compliant as they have been found to be cost-effective and highly innovative. Thus, this paper makes a case for research into eco-efficiency of university senate buildings and posits that the investigation of energy use and the promotion of eco-efficiency innovation are important elements to enhance sustainability of university senate buildings in Nigeria. The sensible use of non-renewable resources would complete this responsible approach. Therefore, it is important for management of university senate buildings to reduce its energy consumption through efficient energy management and the use of innovative technologies.

REFERENCES

Aditya, L., Mahlia, T. M. I., Rismanchi, B., Ng, H. M., Hasan, M. H., Metselaar, H. S. C., &Aditiya, H. B. (2017). A review on insulation materials for energy conservation in buildings. *Renewable and Sustainable Energy Reviews*, *73*, 1352-1365.

Chwieduk, D. A. (2017). Towards modern options of energy conservation in buildings. *Renewable Energy*, *101*, 1194-1202.

Chedwal, R., Mathur, J., Agarwal, G. D., & Dhaka, S. (2015). Energy saving potential through Energy Conservation Building Code and advance energy efficiency measures in hotel buildings of Jaipur City, India. *Energy and Buildings*, *92*, 282-295.

Khashe, S., Heydarian, A., Becerik-Gerber, B., & Wood, W. (2016). Exploring the effectiveness of social messages on promoting energy conservation behavior in buildings. *Building and Environment*, *102*, 83-94.

Ascione, F. (2017). Energy conservation and renewable technologies for buildings to face the impact of the climate change and minimize the use of cooling. *Solar Energy*, *154*, 34-100.

Dixon, G. N., Deline, M. B., McComas, K., Chambliss, L., & Hoffmann, M. (2015). Using comparative feedback to influence workplace energy conservation: A case study of a university campaign. *Environment and Behavior*, *47*(6), 667-693.

Hee, W. J., Alghoul, M. A., Bakhtyar, B., Elayeb, O., Shameri, M. A., Alrubaih, M. S., &Sopian, K. (2015). The role of window glazing on day lighting and energy saving in buildings. *Renewable and Sustainable Energy Reviews*, *42*, 323-343.

Lucon O., et al. (2014). Buildings in Climate change: mitigation of climate change. Contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Nikolaou T, Kolokotsa D, Stavrakakis G., (2011). Review on methodologies for energy benchmarking, rating and classification of buildings. Adv Build Energy Res 2011; 5:53–70.

Kneifel J. (2010). Life-cycle carbon and cost analysis of energy efficiency measures in new commercialbuildings.EnergyBuild2010; 42:333–40.

Kylili, A., &Fokaides, P. A. (2015). European smart cities: The role of zero energy buildings. *Sustainable Cities and Society*, *15*, 86-95.

Sarkar A.N., (2013). Promoting Eco-innovations to Leverage Sustainable Development of Eco-industry and Green Growth *European Journal of Sustainable*

Development (2013), **2**, 1, 171-224 ISSN: 2239-5938.

TarjaHäkkinen D., PekkaHuovila, Kai Tattari (2013). Eco efficient building process. *Building and Environment*, *93*, 56-71.

Zhang, Y., Wang, J., Hu, F., & Wang, Y. (2017). Comparison of evaluation standards for green building in China, Britain, United States. *Renewable and sustainable energy reviews*, *68*, 262-271.