Appraising the Adoption of Passive House Concept for a Sustainable Building Construction in Nigeria

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Abstract

The prevailing global environmental condition is a consequence of the increasing consumption of natural resources whose depletion exceeds what is sustainable. The construction sector is a considerable contributor in this regard and for sustainability in resource utilization and a balanced ecosystem, it is expected to adopt efficient and effective mode and standard form of construction processes, operation and maintenance activities. Passive House is a building, which is designed and constructed using the Passive House Planning Package (PHPP). It is a building standard that is truly energy efficient, comfortable and ecological at the same time. The objectives of the paper being to determine the level of awareness by stakeholders in the building construction industry of passive house concept, the extent by which basic passive principles regarding cooling and humidity control in buildings is been considered and the challenges confronting the implementation of passive house components. Professionals and property owners were identified as sources of data information. The Statistical Package for Social Scientist (SPSS) package was used in analyzing the data collected at 5% level of confidence. The results indicate that only 28% and 22% of the professionals and owners that responded claims to be knowledgeable and aware of PHPP, respectively. On the other hand, the consideration of basic passive principles for cooling and humidity control in design and construction is encouraging. The research indicates that adequate knowledge of passive house concept is important for capacity building of stakeholders in the industry, which will be able to mitigate environmental, economic and socio-cultural impacts on communities.

Keywords: Construction, Environmental, Passive-House, Sustainability, Awareness of PHPP

INTRODUCTION

A building designed and constructed using the software Passive House Planning Package (PHPP) developed by the 'Passivhous' Institute; Germany is called a Passive House. The passive house is a building standard that is truly energy efficient, comfortable, affordable and ecological at the same time (passipedia.org, 2014). The Passive House Institute in reference to ISO 7730, defined a passive house as a building for which thermal comfort can be achieved solely by post-heating or post-cooling the fresh air mass which is required to achieve indoor air quality condition without the need for additional recirculation of air.

Rees (1999) and Persson (2009) noted that the construction sector is a considerable contributor to global resource depletion. Nigeria is Africa's energy giant according to Oyedepo (2012) as shown by its energy export as the mainstay of the economy. However, there has been a supply and demand gap as a result of the inadequate development and inefficient management of the energy sector with electricity supply, which is the country's most used energy resource been erratic (Okafor & Joe-Uzegbu 2010; Oyedepo, 2012). Furthermore, Nigeria's energy is sourced mainly from carbon emitting (non-renewable) substances that are harmful to the environment when burnt leading to sustainability question and climate related problems.

To ameliorate the issue of energy crises, ecological degradation and economic uncertainly, the trend has been to construct buildings requiring little or no energy to function normally. Consequently, the

Passive House Standard was developed by the Passive House Institute (PHI) in Germany as contained in the passive house brochure (International Passive House Association-IPHA, 2014).

The aim of the paper is to find out the possibility of adopting the Passive House Concept as sustainability instrument in the building construction industry in Nigeria. The objectives seeks to determine whether stakeholders in the building industry in Nigeria have adequate information about Passive House Concept and whether they consider principles of passive design in planning and construction of building projects in addition to challenges affecting implementation of the concept.

Energy Sources in Nigeria

Nigeria is a country blessed with abundant energy resources. These energy resources are in two categories, the renewable and non-renewable energy resources. Each of these resources can be used to power construction activities and in the operation of buildings. Non-renewable sources of energy like fossil fuels and fire wood are at present Nigeria's major energy source and are fast depleting (Enete and Alabi, 2011). These fossil fuels include coal, natural gas and crude oil (petroleum). Iwayemi (2008) gave the estimates of Nigeria's crude oil and natural gas reserves as 35 billion barrels and 185 trillion cubic feet respectively, and that of coal as 275 billion metric tons. Furthermore, an estimate of hydro electricity resources is about 14,750 megawatts, solar radiation 3.5-7.0 kilowatt hour/m^2 per day, wind energy at 150,000 Terra Joule per year and biomass at 144 million tons per year. These are quite substantial and can take many years of exploitation and utilization even though they are major contributors to climate change agents. Renewable source of energy are those that can be replaced as they are used. They are continually replenished.

Energy Demand and Supply Crisis in Nigeria

Nigeria has a rapidly growing population of approximately 159.25 million and has also one of the fastest urbanizing rates in Africa even though construction is only 1.4% of the gross Domestic Product, GDP (Ahmed, Isa, Olayande and Ojosu, 2014). This has led to increase in demand for energy and power to service life endeavors in agriculture, transportation, construction, housing, manufacturing, recreation and sport. Nonetheless, though the country is potentially endowed with abundant energy resources such as oil and natural gas, lignite, coal and renewable resources as further enunciated by Ahmad *et al.,* (2014), Nigeria still suffers from inadequate supply of usable energy and power due to rapidly increasing demand typical of developing economy. More reasons have been attributed for the shortfall in supply of energy in Nigeria of which are frequent system collapse of oil and gas supply network due to militancy and vandalism especially in the Niger-Delta region, inadequate and chronic infrastructural gap despite huge budgetary allocation, low capacity utilization of existing generating, transmitting and distribution facilities leading to inefficiency, poor policy and policy implementation, high indebtedness by both public and private consumers to supplier of energy resources like the Power Holding Company of Nigeria (PHCN) and marketers amongst others (Iwayemi 2008, Alawiyi 2011, Oyedepo 2012 and Ahmed *et al*., 2014). The energy crisis is also evident by electricity black-out and the reliance on self-generating electricity with its toll on economic, social life and environmental equilibrium.

Passive House Concept

According to IPHA (2014), the concept of Passive House is based on a clearly defined standard for building in all climatic zones. Thus the Passive House Institute Brochure provides solution for the sustainable use of natural resources consumption in building for heating or cooling to roughly 80% lower than those of conventional buildings, having a realistic option for cost effective structure that provides high level of comfort. An energy system ready for the future must be sustainable. A sustainable building standard that enhance energy sustainability is the Passive House Concept.

The Passive House Concept describes a performance standard not a specific construction method. Energy requirement for Passive House are so small and can be met through active solar gains or other renewable sources located on site or nearby.

Passive House Criteria

For the purpose of approval, the Passive House Institute (PHI) has come up with criteria to be met for building to be certified as passive house. The passive house principle remains valid and can be effectively applied internationally no matter the region or climate zones and the Passive House Planning Package (PHPP) is used with local data to provide energy balance to achieving the principles as stipulated in IPHA Brochure (2014) in Table 1.

Table 1: Passive House Criteria

Space heating demand	Less or equal 15kwh OR 10W (peak demand) per square metre of usable living space.
Space cooling demand	Roughly matches the heat demand with an additional, climate dependent allowance for dehumidification.
Primary energy demand	Not to exceed 120kwh annually for all domestic applications (heating, cooling, hot water and domestic electricity) per square metre of usable living space.
Air-tightness	Maximum of 0.6 air changes per hour at 50 Pascal pressure verified on site pressure to test in both pressurized and depressurized state.
Thermal comfort	Must be for all living areas year-round with not more than 10% of the hours in any given year over 25^{o}C

Source: IPHA Brochure (2014)

Passive Design and Construction

Passive design may be assisted by the use of 'Passivhous' Planning Package (PHPP) which uses specifically designed computer simulation in order for a Passive House to perform as designed in keeping to quality needs at every step of the planning and construction process (Wikipedia.org, 2014). Santi (2010) describes Passive design as design that doesn't need mechanical heating and cooling and that building that are passively designed take advantage of natural climate to maintain thermal comfort. Passive design basically has to do with designing for the climate and considering the buildings orientation so that the building envelopes (the roof, walls, windows, floors and internal walls) maximize cooling air movement and avoids the sun. This leads to saving in energy required for the operation of the building. The PHPP is the energy balance design tools for planning of Passive House and other highly efficient building. Using excel, the PHPP makes use of tested algorithms to yield a building's heating, cooling, and primary energy demand, a building's heating and cooling loads, its tendency to overheat, and much more. The tools can also be used to dimension ventilation systems and determine the energetic effects of the substitution of any product or of any design changes be it the site's weather data, orientation, type of construction, materials used, window design and location, ventilation system, appliances, lighting and other electrical equipment used on the building (Cam W.C, 2012; IPHA, 2014)

The Passive House and Sustainability in Building Construction

The concept of sustainability regarding building and construction is about the whole process from the stages of pre-design and design, procurement, construction towards products life time, operation, maintenance, refurbishment, re-construction, demolition and recycling, whereas sustainable building concerns the final product, which is the building unit. The passive house combines the two aspects to meeting the functional and performance of building constructed to passive house standard. This is seen in the entire lifecycle of the building in terms of comfort, affordability and efficiency of the operated property. Kohler (1999) gives a graphic description of sustainable building as shown in figure 1 with

regard to ecological, economic and social /cultural development of which Cam's explanation of passive house contributions fulfills.

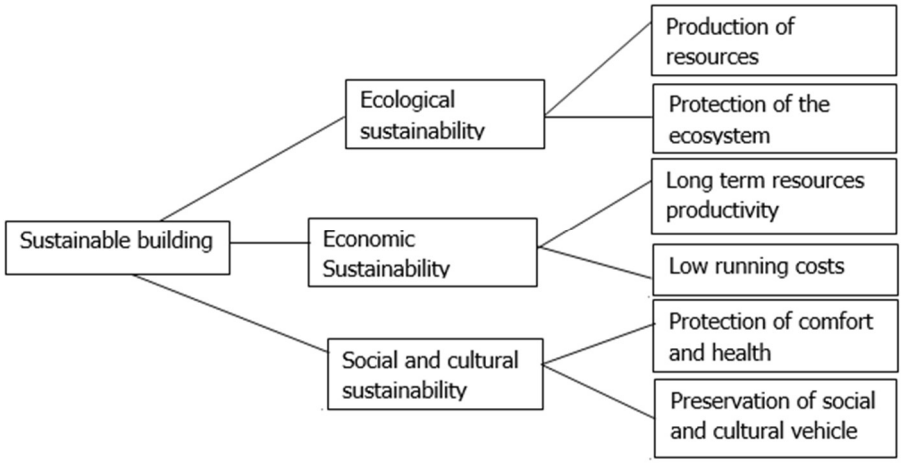

Figure 1: Sustainable Building (Source: Adopted from Kohler, 1999)

METHODOLOGY

Two groups of respondents were targeted; the professionals in the built environment and the property owners/households. 61 and 90 questionnaires were sent out to the professionals and the owners/households, and a stratified sampling method was used to arrive at 32 and 75 considered for analysis, respectively. On the issue of knowledge of the PHPP responding professionals were required to make an option from 'very much', 'much', 'little', 'very little' and 'none at all' on a 5-point scale with rating of '1', '2', '3', '4' and '5' respectively. On level of awareness, respondents were simply asked to tick 'Yes' or 'No'. The SPSS tool was employed to run the analysis, with 5% level of confidence.

RESULTS AND DISCUSSION

The study revealed that construction professionals in Nigeria and clients/owners have less knowledge of PHPP. The results indicate that only 28% and 22% of the professionals and clients/owners responding claim to be knowledgeable, respectively. Tables 2 and 3 contain the outcome of the respective analysis.

Table 2: Practitioners Knowledge of Passive House Planning Package (PHPP)

Knowledge of PHPP	Frequency	Percent	Valid Percent	Cumulative Percent
Very much	1	3.1	3.1	3.1
Much	8	25.0	25.0	28.1
Little	11	34.4	34.4	62.5
Very little	8	25.0	25.0	87.5
None at all	4	12.5	12.5	100.0
Total	32	100.0	100.0	

Source: Field Survey (Yerima, 2015)

Table 3: Awareness of Passive House Components by House Owners

Response	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	16	21.3	21.9	21.9
No	57	76.0	78.1	100.0
Total	73	97.3	100.0	
Missing system	2	2.7		
Grand Total	**75**	100.0		

Source: ***Field Survey (Yerima, 2015)***

Challenges of Implementation of Basic Principles for Passive House Humidity Control

Professionals in the course of responding made a graphical rating of the challenges of passive humidity control in figure 2. The bar-charts present the degree of challenges militating against the adoption and implementation of basic principle in design and construction for passive humidity control in buildings. Looking at the chart, it is easily observed that the greatest challenge is client acceptance, and material/components availability followed by construction cost in that order. In percentages, practitioners rated client acceptance and material/component availability at 78.1% respectively, planning authority support at 46.9%, information gap at 56.3%, while others at 9.4%.

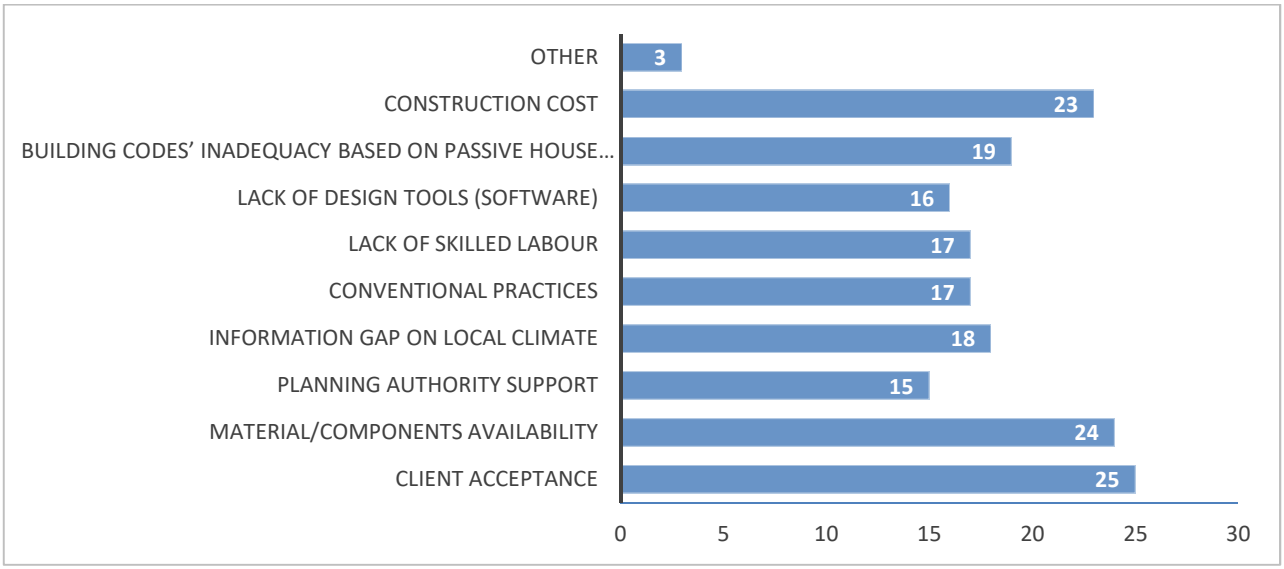

Figure 2: Rated Challenges of Passive Humidity Control by Practitioners. *Field Survey (Yerima, 2015)*

CONCLUSION

The passive house concept is basically a new idea that tends to address comfort, energy saving, global warming and environmental issues that enhances sustainability in the built environment. The paper made a cursory look at the Nigerian situation, which could apply to most developing and undeveloped countries. It was discovered that the model is seldom used and understood, hence the call to embrace it. The awareness when created will lead to more research on our local climate as to the most suitable practices and standards for passive house which would form design guidelines and standards based on our conditions to prospective entrants and practitioners alike in the built industry. This will equip them in the fight against global warming in addition to the conservation of our fast depleting energy resources through the construction of buildings that are economically, socio-culturally and ecologically sustainable. The main contribution of this research to knowledge of sustainability in construction works is the revelation of the lack of information and capacity about passive house construction in Nigeria, hence the proposal of the need for more information about Passive House and its concept to be made available.

RECOMMENDATIONS

1. The public and private sectors must make a deliberate policy to require stakeholders in the built environment adopt the use of PHPP in the process of production and the period of occupation by users.
2. Professionals involved in the built environment should as a matter of necessity integrate the PHPP into the building processes and its maintenance management schedules.
3. Manufacturers of building materials are to be required to upgrade the product4ion of the passive house components and materials for accessibility and affordability.
4. Like in Nigeria, all developing and the undeveloped countries should imbibe the culture of using PHPP with greater sensitization for the attendant benefits.

5. To facilitate stronger uptake and implementation of passive house concept, good support from institutional settings such as local building codes based on passive principles should be researched upon and made available to practitioner as well as supporting demonstrations in public building projects. Furthermore, capacity building and local workforce training should be undertaken by training institutions and professional bodies in the built environment in this regard.

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