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INCLUSION OF ZERO ENERGY (GREEN)BUILDING AS A COMPONENT OF NATIONAL BUILDING CODE: AN OPTION FOR ENERGY CONSERVATION AND ENVIRONMENTAL SUSTAINABILITY

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Abstract

Goal 7 of Millennium Development Goal (MDG) is biased towards ensuring environmental sustainability. Its target is to integrate the principle of sustainable development into country policies and programs. This is aimed at reversing the loss of environmental resources. Nigeria is committed to the MDG, especially as it affects the provision of houses for all. The paper recommends that the houses be provided with on-site renewable energy production, conservation, and utilization to ameliorate depleting fossil fuel resources and energy price volatility. A building equipped to generate on-site renewable energy is a green building that could be categorized as a Zero-energy building (ZEB), Energy plus building, and Nearly zero-energy building. ZEB will reduce the dependence of residential and commercial buildings on the national grid for energy supply and ensure a sustainable environment, especially in a country that relies mainly on fossil fuel for energy generation. Buildings, including commercial and residential ones, are major contributors to energy consumption. Energy consumption in buildings significantly increases every year due to the increased human comfort needs. The building sector alone consumes 40 percent of total global energy utilization. Therefore, there are significant opportunities that ZEB will save as much as 40 percent of energy from the national grid if adopted as a component of the National Building Code. ZEB provides green energy; therefore, its concept is a solution for reducing greenhouse gas (GHG) emissions and a guarantee for energy security and sustainability. ZEB will only need grid power just for makeup power on the occasion of the nonavailability of renewable power. This paper discusses the possibility of harvesting the energy needs of a house from within the house's envelope and the inclusion of green building issues in Nigeria's building code. The attempt is made to explain the concept and technologies to be incorporated in the national building code to achieve ZEB.

Keywords: Net-Zero Energy Building, Green Building, National Building Code, and Renewable Energy.

1. Introduction

Energy experts point out that reserves are less than 40 years for Petroleum, 60 years for Natural Gas, and 250 years for Coal [1-2]. This revelation is quite disturbing, especially when viewed against the fact that fossil fuels are major sources of energy all over the world [3]. Due to world population growth and advance in technologies that depend on fossil fuels, fossil fuel reserves eventually may not meet energy demand. In the last decade, energy costs have been rising, fuels are running out, and there have been global warming issues. For example, the United Kingdom has only 2 years of gas reserve, which has been put on hold of usage and is currently buying from other countries such as Qatar and the United States [4]. Projections of world energy production and consumption from 1994 to 2030 are illustrated in Table 1.1 [5].

Table 1: Some extracted values of world primary and fossil energy projected production and consumption.

Year	Primary Energy Prodn. (Mtoe)	Primary Energy Cons. (Mtoe)	Oil Prodn. (Mtoe)	Oil Cons. (Mtoe)	Coal Prodn. (Mtoe)	Coal Cons. (Mtoe)	NG Prodn. (Mtoe)	NG Cons. (Mtoe)
1994	8,996.9	8,310.1	3,237.1	3,204.4	2,178.1	2,185.5	1,891.2	1,876.7
2000	9,981.9	9,079.8	3,614.0	3,538.7	2,112.4	2,148.1	2,189.9	2,194.5
2006	10,930.3	10,115.7	3,833.1	3,767.0	2,475.3	2,515.7	2,470.5	2,471.8
2012	11,822.5	10,953.4	4,099.9	4,020.0	2,595.6	2,654.8	2,744.9	2,749.5
2018	12,714.7	11,791.1	4,366.7	4,273.1	2,715.9	2,793.8	3,019.2	3,027.1
2024	13,606.9	12,128.8	4,633.5	4,526.1	2,836.2	2,932.9	3,293.6	3,304.7
2030	14,499.2	13,466.5	4,900.4	4,779.2	2,956.5	3,071.9	3,568.0	3,582.3

Mtoe = Million tons of oil equivalent; **Prodn** = Production; **Cons** =Consumption; **NG** = Natural Gas

The data in Table 1 reveal that conventional energy resources shortage and the attendant price increases are likely to occur, although there are occasions when their prices nose dive due to an interplay of market forces. Alternative green energy could solve the ever-increasing energy demand and the ever-depleting reserves of fossil fuels.

Energy consumed by buildings was reported to compose a relatively large proportion of the global energy consumption [6]. Building division is one of the biggest consumers of energy (consuming at least 40% of the total fossil energy in such a developed nation like the US). It is responsible for considerable energy-related carbon dioxide emissions worldwide [7]. The average figure of energy consumed by the building sector may be higher in a developing nation like Nigeria. The rapid growth of population and urbanization leads to the enormous demand for buildings in Nigeria, which means higher demand for energy from the grids. Nations worldwide are investing heavily into renewable energy production, conservation, and research as part of the solution for the lingering energy crisis. The building sector is one such area that can be used to produce on-site renewable energy. Recent developments have proven that a building or cluster of the building can be constructed to harvest and conserve most of the energy it needs from renewable energy resources within its immediate environment. The most significant renewable sources for on-location energy generation for buildings are sunlight-based, little hydroelectric (for provincial houses close to a waterway or stream), and geothermal (the Earth's heat) [8]. Other active renewable energy resources that could be harvested on-site include wind energy and biogas energy. The excess surplus of such energy could be conserved for future use in the building or more still channeled to the national grid to boost the per capita consumption of the citizenry. Once transferred on the national grid, it will be paid for, thus affording additional income to the owners of the on-site energy.

A building that is equipped to generate on-site energy is called a green building. Significant opportunities of 30-40 percent energy saving have been achieved through retrofitting existing buildings into green buildings and constructing new ones [7]. Thus there is a new quest for green energy through the construction of green buildings. Therefore, governments are sponsoring urban developers to incorporate on-site green energy generation as a matter of policy. The National Building Codes of many nations are now emphasizing green buildings. For example, The Indian Green Building Council (IGBC) and U.S Green Building Council (USGBC) promote Green Building Certification in India and the U.S., respectively. The government of India has also developed the Code for Energy Conservation of Buildings (ECBC- Energy conservation building code) for industrial buildings whose connected load is 100 kW or more according to the Energy Conservation Act-2001 [9]. In India, till 2030, it has been planned to construct energy-efficient buildings to a large extent. The prediction plan-2030 recommends that 70% of buildings to be constructed must be green [10]. Many states in the United States are mandating many rules and regulations to reduce energy consumption. For example, New York and California, which house more than 20% of the United States' population, are leading the way in decreasing energy use through the proliferation of net-zero energy building in addition to other strategies [3].
Nigeria as a developing economy must join the comity of nations that have developed National Building Codes and equally factored green building in the Codes as a fundamental energy generation and conservation measure for energy security and sustainability.

1.1 Nigeria and The Journey to Evolve a Building Code

In 1987, the Defunct National Council of Works and Housing directed that a National Building Code be evolved for Nigeria. After that, the defunct Federal Ministry of Works and Housing organized a National workshop at ASCON, Badagry - Lagos State in 1989. A Draft National Building Code was adopted. The draft code was further fine-tuned in 1990 and approved by the then National Council on Housing in 1991. Unfortunately, this document was not ratified by the then Federal Executive Council for use in the Country. The National Council on Housing and Urban Development initiated another process of evolving a National Building Code under Dr. Olusegun Mimikoas, the Honorable Minister of Housing and Urban Development. The minister endorsed it on 2nd August 2006; unfortunately, it is yet to be ratified fifteen years later.

This paper suggests that a National Building Code should be evolved to capture the necessity for green building as a significant way to address energy shortage. The much-anticipated reforms in the power sector could harness the opportunities in green building. A typical investor can specialize in zero energy houses that are self-sufficient in terms of energy and export energy to the national grid.

1.2 Green Building

Green building is categorized and defined as follows:

(1) **Zero energy building (ZEB):** According to the US Department of Energy (DoE), a zero-energy building was defined as a building that produces enough renewable energy to meet its annual energy consumption requirements [11]. That implies that the building is autonomous of the grid supply. It is also referred to as Net-zero energy building (NZEB). It does not export or import energy. ZEB harvests conserve and utilize its energy from renewable sources, which means that the net carbon emission is equally zero. By way of the equation, for ZEB:

$$\text{Energy harvested} - \text{energy used} = 0 \tag{1}$$

(2) **Energy plus building:** This type of building produces more renewable energy than its own annual energy consumption requirements. By way of the equation, for energy plus building: Energy harvested - the energy used > 0
(2). Therefore, energy plus building could export its surplus energy to the grid or conserve it for future use.

(3) **Nearly zero energy building:** According to the European Union Article 2, a nearly zero-energy building is a building that has a very high energy performance where the building requires only low energy and which should be covered to a very significant extent from renewable sources.

2 Proposed Building Code: Features and Strategies

The National Building Code for Nigeria should specify two major strategies for on-site energy generation, conservation, and utilization. The strategies are **passive design** and **active design** strategies. While active design strategy involves man-made efforts to harvest and utilize green energy from the building environment; passive design strategy emphasizes how to utilize the existing green energy resources within the building envelope economically. The type of strategy adopted determines the features of the building.

a. Features of active design strategy

(i) **Biogas plant:** The National Building Code for Nigeria should propose a biogas plant within the building envelope. This can run on the wastes of the occupants of the building. Where it is clustered building, a central biogas plant running on the wastes contributed from the domestic animals and occupants of each house in the quarters can be constructed. The gas is piped to each of the households for cooking and space heating purposes. Each housing unit should provide a pen for domestic animals, serving as sources of meat for human consumption (healthy living) and organic wastes (dung) for the biogas plant. Turning human and domestic animal wastes for energy generation in biogas plants will guarantee urban sanitation and less contamination of our streams with sewage. This will quickly recover our fast depleting forest reserves through less dependence on firewood (charcoal) for cooking, as each household could afford to use biogas instead. More trees will grow and, consequently, absorb CO_2 from the environment, which will ultimately reduce the incidence of global warming.

(ii) **Wind Turbines:** Another feature of the proposed National Building Code is wind turbine installation in the building environment. An average of one or two can be installed on each roof. Nigeria's wind resources in the northern and southern regions are enormous.

(iii) **Photovoltaic Systems and Solar Water Heater:** The National Building Code should propose solar energy production within the building space. Photovoltaic panels or solar water heaters should be installed in locations unobstructed from the south by shade or wooded surroundings to capture maximum solar energy for each day. The solar capacity of Nigeria in the northern part of the country round the year is enormous. The solar water heater is for the sole purpose of heating water. The hot water from the solar heater must be stored in insulated tanks pending its use.

b. Passive design strategy

The National Building Code should provide for the following passive design components:

(i) **Orientation:** This Building is oriented from the North-South directions to reduce heat absorption and solar irradiance.

(ii) **Weatherization:** This has to do with the proper installation of hermetically sealed double glazed windows for low heat transmittance and air leakage. It also includes adequate insulation of the attic and ceilings. Rock-wool insulation is recommended for its significant thermal insulation, acoustic and fire protection properties. Insulation is done to lessen the energy demand by creating a very effective thermal barrier. More importantly, weatherization emphasizes applying sun controls like recessing of windows, provision of the awning, and application of reflective films on the south and west-facing windows to reduce room solar gain.

(iii) **Natural (day) lighting:** The National Building Code should provide for daytime illumination with only daylight. Optimum window-wall ratio(WWR) is maintained for this purpose. At least 75% of the building floor area is daylit [7]; thus, it reduces the dependence on artificial lighting sources (electric bulbs) that consume energy. A central courtyard may be provided in the building to serve as a light well in the maximum areas. The interior walls should be painted with light-colored paints which reflect lights. This minimizes the need for artificial lighting.

(iv) **Artificial lighting:** Photocells and motion sensor bulbs are recommended for outdoor lighting. Sensor bulbs only light upon the approach of a human being and go off automatically when nobody is around it; during which time it is conserving energy. Luminescent (energy-saving) bulbs are recommended for lighting as they consume far less electrical energy than incandescent bulbs.

(v) **Landscaping:** The National Building Code should recommend tree planting to shade the home, thereby reducing cooling costs in the summer months and creating dead air spaces that can insulate the home in winter. Equal or more than 50 percent outside area of the building structure should be covered with a plantation [7]. Local species of trees and shrubs with low water demand in landscaping are planted within lawns created between connected roads such that the lawns allow water percolation and retention. By this, energy will not be spent often in pumping water for sprinkling the shrubs.

(vi) **Energy Conservation/Storage (Inverters):** The National Building Code should recommend energy storage facilities for buildings. The energy harvested during the peak period of sunny and windy days may be more than the energy consumed by the house. The excess energy can be stored for use during unsunny and unwind days using a battery/ inverter facility.

(vii) **Construction materials:** Hollow concrete blocks fabricated with low thermal conductivity (u-value) materials are recommended for construction. This will achieve thermal insulation in the building as air in the hollow block has a very low k- value.

(viii) **Air handling unit (AHU):** For government houses and high-capacity houses owned by individuals, the use of a central air-conditioning system is recommended. Here cooling is provided to various rooms through ducts from a central unit which is powered by one or two compressors. Energy is saved by the use of one or two compressors in the AHU instead of installing a split unit or packaged unit powered by an individual compressor for each room.

3 Energy Conservation Tips for Zeb

The National Building Code could emphasize the following energy conservation tips:

- ❖ Air dry clothes instead of spinning in the washing machine which consumes much energy. The energy saved by drying cloth in the air stream could be put to other uses.
- ❖ Buy energy-efficient models of appliances as they run on low energy.
- ❖ Turn power strips off when electronic and computer equipment is in standby mode, otherwise, they are still consuming energy.

- Where possible, use fans during summer instead of the air conditioner as fans consume less energy.
- Use heaters and hot plates with programmable thermostats.
- Use a solar heater or biogas plant to provide hot water for domestic use instead of using an electric heater that consumes much energy.

4 Prospects of Zeb

- Nigeria is located in the tropics, where there are abundant wind and solar resources. China generated 73 200 GWh from wind turbines in 2011 [12]. Nigeria can do as much.
- The technology for distributed energy generation from renewable energy sources is not novel
- A typical biogas plant can last for upwards of 15 years, while photovoltaic systems have as much as a 25-year warranty [12].

4.1 Advantages of Zeb

- Sustainable environment and less dependence on fossil fuel
- Owners of ZEBs are shielded from energy price fluctuations
- Comfort due to stable interior conditions
- Since the harvesting and consumption of the energy are localized (take place within the same location), transmission and distribution losses are eliminated
- Cases of thefts and vandalization of the facility are eliminated since both the facility and owner are in the same place.
- Reduced cost of operation

4.2 The Role of Government

i. The national building code should be evolved to incorporate energy efficiency provisions and on-site renewable energy production for buildings.

ii. Government should take the lead in investing in ZEB by making sure that its future clustered quarters are ZEB modelled. Other countries are modelling green government buildings. For example, Jordan in its Executive Order 13514 - Federal Leadership in Environmental, Energy, and Economic Performance, Amman, Jordan recommends that "beginning from 2020 and thereafter, all new Federal buildings that enter the planning process are designed to achieve zero-net-energy by 2030 [13].

iii. The energy sector should be liberalized further as a matter of urgency, while prospective investors and estate and urban developers should be encouraged to invest in ZEB. The encouragement could be given in tax exemptions as is the proposed case in the UK. The UK government announced in December 2006 that by 2016 all new homes in England would be zero energy buildings. To encourage this, an exemption from stamp duty land tax was planned. Other nations like the US, China, Norway, Malaysia, etc., are in one way or the other encouraging ZEB projects.

iv. Ministry or Commission for non-conventional energy should be established to coordinate and sponsor research into renewable energy and related areas like ZEB.

4.3 Challenges

i. The primary challenge to ZEB in Nigeria is the lack of a National Building Code that will specify the requirements for renewable energy development in the building sector. The code should indicate the Building Code enforcement agents and the penalty for Building Code violations.

ii. The next major challenge facing ZEB development in Nigeria is ignorance (lack of awareness). This can be addressed through promotions and exhibitions that the relevant Federal Ministry can champion, for example, the proposed ministry of non-conventional energy.

iii. Thirdly is the discipline required to curtail extravagance and adopt energy efficiency measures in energy use, which Nigerians must imbibe. Every element of energy harvested in a ZEB must be effectively utilized otherwise, the occupants of the green building will end up importing energy from the grid system.

iv. The fourth major challenge is the huge initial capital outlay to start the ZEB project, especially building structures. However, this will be offset soon with the gains from energy self-sufficiency. Besides, the cost of solar panels and wind turbines is coming down yearly.

v. Finally, is the challenge of the initial manpower need of the project. This can be overcome within a short time by short-term training programmes for youths and possible incorporation of renewable energy as a programme in the national curriculum.

5 CONCLUSION

The rest of the world is emphasizing issues related to energy efficiency and less dependence on fossil fuels. ZEB is one of the avenues for meeting this need and the MDG's target of sustainable development. Nigeria must not be left behind in this quest for green building and environmental conservation. Appropriate legislative tools must be put in place to realize it. We must tap into new technologies and move along with the comity of nations to embrace development and modern life.

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