

Enhancing Sustainable Built Environment Renewable Energy Integration in Nigeria

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Abstract

The paper explored the integration of renewable energy sources into Nigeria's energy framework to drive sustainable development amid persistent challenges like energy poverty and fossil fuel dependency. It highlighted Nigeria's abundant solar, wind, hydro, and biomass potential while addressing barriers such as policy inconsistencies, infrastructure deficits, and financing gaps. The study proposed policy reforms, public-private partnerships, and technological innovations to accelerate adoption, ultimately fostering economic growth, environmental resilience, and improved energy access nationwide.

Keywords:

Sustainable development, Renewable Energy, Energy integration, Solar power, Energy Efficient Building Design

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Background to the Study

Nigeria faces a critical energy crisis characterized by unreliable power supply, heavy dependence on fossil fuels, and significant barriers to economic growth. Integrating renewable energy sources offers a pathway to sustainable development by addressing energy poverty, reducing carbon emissions, and fostering resilience in a tropical climate. Nigeria, Africa's most populous nation, grapples with chronic electricity shortages despite vast hydrocarbon reserves. Over 80 million people lack reliable access to power, hindering industrial productivity and quality of life. This overreliance on non-renewable sources exacerbates environmental degradation and climate vulnerability.

The country boasts abundant renewable resources, including solar irradiation exceeding 5.5 kWh/m²/day, wind speeds suitable for northern regions, and biomass from agricultural waste. Harnessing these could meet growing demand projected to reach 30,000 MW by 2030 while aligning with global Sustainable Development Goals (SDGs), particularly SDG 7 on affordable and clean energy. Environment is the collection of the physical, chemical, and sociological factors that affects the actions and behaviours of living and nonliving substances together with natural, economical and human factors. Buildings, which are the components of the environment and sustain this environmental interaction throughout their lifetime, cause serious environmental problems. Thus; architectural discipline aims at creating healthy and habitable environments where the physical requirements of the users are provided thoroughly. Moreover, architectural discipline intends to protect the natural environment such that the next generation continues to use it well and depend less on non-renewable energy resources (Crosbie, 1998). A fact today is that urbanization, population growth, and improved technology cause environmental and energy resource related problems, and by using a significant part of the natural resources, the construction sector distracts the ecological balance and threatens the environmental health conditions for human thus negatively affects the human natural environment (Akpu, 2012).

Construction activities consume about 50% of the energy resources of earth, and 42% of water sources, and in addition, 50% of gases responsible for global warming, 40% of water pollution, 24% of air pollution, and 50% of CFC and HCFC releases are caused by activities related to construction (Bradshaw, 2016). More than 90% of the energy consumed in the world and more than 85% of the energy consumed in Nigeria today is supplied from fossil sources such as coal, petroleum, and natural gas. The gases released to the atmosphere due to the usage of the fossil resources force the solar lights to be held in the atmosphere longer, which in turn causes global warming with drought, flood, and fire situations being the product. These situations severely damage the health and safety of the environment, and thereby threatens the safety of the entire habitats (Botkin and Keller 1998, Enger and Smith, 2006, Alozie 2014). The fact that recent increase in heating, cooling, and ventilating costs of the buildings, and the environmental problems caused by the fossil resources as mentioned earlier, necessitates and prioritizes the need for the usage of renewable and environment friendly energy resources, must be underscored. In order to protect the habitats and decrease environmental problems, World Wild Fund for Nature

(WWF) has been creating awareness, alerting countries to make interferences that will prevent excessive discharge of carbonic gases. An awareness that made countries to include the research and usage of renewable and environmentally friendly resources, in their energy strategies. Therefore, to prevent the problems caused by excessive usage of nonrenewable resources in the construction sector, sustainability approaches need to be a crucial context of the architecture discipline (Botkin and Keller 1998).

Sustainability is a key concept that requires careful and efficient usage of the natural resources in order to supply sufficient resources and healthy habitats for the next generations. Therefore architects, the main designers of the artificial environment, are supposed to create designs that provide energy efficiency by using renewable energy means (Bartelmus 1994). This study examined strategies for renewable energy integration in Nigeria's grid and off-grid systems. It analyzes policy frameworks, technological barriers, and economic viability to propose actionable pathways for sustainable development. By bridging gaps in current literature, the paper contributed to Nigeria's energy transition amid regional climate challenges.

Principles Of Sustainable Building Design

“Sustainable Building Design” is a comprehensive concept that considers buildings with respect to ecological, economic and social aspects and it requires decreasing the energy maintenance costs, and diseases related to the building, waste and pollution (Kohler 1999). Moreover, it necessitates increasing the efficiency and comfort of building materials, endurance and flexibility of the building, its components, as well as effective and efficient use of energy (Osso, 1996). The theme of the Sustainable Building Design concept is the design standards that change according to the sustainability aspect, and the environmentally friendly building materials and construction techniques selected in accordance with these standards. Therefore, the initial objective is to create environment friendly designs that offer the usage of renewable energy sources, and improves the energy efficiency in buildings (Osso, 1996).

In the processes of using and demolition of the buildings, natural resources are continuously used. These resources are transformed and returned to the nature as waste. At this stage, energy transforms into waste side materials, building materials into solid waste, water into waste water, consumer products into waste and renewable materials, wind into air pollution, and rain into underground water (Bourdeau, 1999). In this context, sustainability is assumed to be a negative and positive feed backed repeatable design principle through the life cycle of the building. Sustainable building design suggests efficient and effective usage of building through its life cycle, and the usage of renewable and environment friendly construction materials, it also requires designing healthy and longevity of buildings that could be conditioned to developments. This also could reduce inherent health risk resulting from buildings (Bourdeau 1999, WGSC, 2004 and Yeang 1999).

Renewable Materials in Buildings

Renewable energy sources have been utilized in different forms in architecture in the following forms; hydraulic, wave, wind, geothermal, biomass, and solar energy. Renewable energy sources help protect nature by preventing pollution, and by providing the usage of local energy sources. In the construction sector, one of the interferences that will eliminate the excessive usage of fossil sources is the usage of solar energy.

Solar Energy

In recent times, solar energy has become a preferable energy source because of its local applicability and free from inherent technology complexity. Solar energy is used not only for heating and cooling but also for producing hot water and electricity. Nigeria has better solar energy potential compared to most European countries, and the most common method to produce solar energy is by solar absorbers installed on the roof tops of buildings. Producing hot water by utilizing solar energy can either be held by a decision taken during the design stage or during the utilization of the building. By the help of solar energy, heating and cooling costs of the buildings are decreased significantly and energy preservation is provided (Daroda 2011).

The activities to preserve energy by using solar energy in buildings can be grouped as passive and active heating and cooling systems. Passive systems are mainly performed by the decisions taken during the planning stage. In these systems, solar lights exposed on the walls, windows, and ceilings of the buildings are absorbed and transferred to the interior parts by at least one of the transferring, transporting, or radiation methods (Abimare and Akingbohugbe 2013). South openings (windows, greenhouses, and ceiling openings), wall surfaces, winter garden, sun wall and sun ceiling and sections fitted with glass are basic examples of passive heating systems. In passive systems, various methods are performed in order to collect, store, distribute and control the solar energy (Heergween 2004). The most preferable method is the direct return system, which is mainly aimed to use the stored solar energy to create sera effect, and these forces the building to serve as energy absorber. To apply this method effectively, heat loss should be minimized on the openings where sun light is absorbed and stored, and to increase the amount of energy stored and transferred naturally to the interior space, and also to optimize the heat comfort, interior space should be kept small, and heat absorber mass space should be kept large. Even though window openings help the storage of heat and improvement of heat preservation during summer, they cause heat loss during cold when sun lights are not directly observed. For that reason, in cold climates, window openings should be kept large on south side and as small as possible on other sides of the building (Adebamowo, et al 2013).

Moreover, for cold nights, night insulation and for summer day's sun protection are suggested. In case, south side efficiency cannot be utilized because of neighbor buildings, and topography, solar energy should be stored by ceiling openings to achieve sufficient heat storage. However, the disadvantage of ceiling openings is extreme heating during

summer and high heat loss during winter, and the necessity of night insulation. Another method for passive heating systems is indirect return systems. In this system, the heat transferring from the glass surface to the wall by the mediation of a heating mass, which is placed mainly on the glass surface and to the back of the glass surface, is transferred into indoor space by transporting or radiation. Direct return system provides easier interior heat control, and sun wall, water wall, and greenhouse addition are possible methods being used for this system (Means, 2011).

Furthermore, this system provides construction easiness and does not require any dynamic parts except for insulation, yet the time required for the heat mass to get warm is long, and heat transferred to the interior space cannot be controlled in this system, which can be regarded as the possible disadvantage. Active heating system includes addition of mechanical equipment and extra heat storing precautions to utilize solar energy. Moreover, heat distribution is controlled automatically; water air collectors, highly efficient collectors and photovoltaic panels are used in this system. Solar energy is collected by flat collectors in the active systems that are not used for directly heating the indoor spaces, the collected energy is stored in storage tanks near the building or below the building or on gravelly area, and the indoor spaces are heated by the stored energy by the mediation of hot water dispensed by pump and pipes. Passive and active systems, which are used to obtain heating and cooling from solar energy, are environment friendly and by the implementation of energy efficient building materials prevent any possible harm to the environment.

Solar Energy Potential in Nigeria

Nigeria has a higher solar energy potential compared to most other countries in the world with the help of its geographical position. According to the research conducted lately, most tropical environments such as Nigeria has average sun absorption duration of 2640 hours per year, and sun radiation power of over 1311 kWh/m². If solar energy potential is utilized efficiently and actively, amount of energy achieved is estimated to be approximately 1015 kWh. By the decisions taken during the design and usage stages and the changes performed, the building can be improved in terms of energy saving, using the passive and active heating cooling systems (Alozie 2016b, 2016a and 2015).

In Nigeria, the most common usage of the solar energy is supplying light point, this is grossly underutilization, since solar energy has the ability and capacity to do more than just that. The solar energy potential has the capacity to supply the entire hot water requirement for domestic usage and hot voltaic panels that could be placed on houses, office buildings, and factories. These panels are estimated to provide 40 milliard kWh electricity on the average. Even in the countries that possess much less solar energy potential compared to Nigeria, photovoltaic panels are used widely to produce electricity due to the inexistence of mechanical depreciation, easiness of operations, quick preparedness for service, and long-life cycle. Photovoltaic panel applications will be providing electricity without any fuel cost, and much less release of CO₂ to the environment, which decreases the environment problems significantly (Smith, Bradshaw 2006).

Conclusion

At present day, industrialization and population growth causes environment pollution, and excessive use of energy resources. Sera gas releases due to the use of fossil-based fuels results with local and regional climate changes, and global warming and serious environmental problems resulting to global warming. Therefore, building sector should start taking precautions to limit the use of nonrenewable resources in order to constraint the environmental problems. With respect to these limiting efforts, buildings designs should enforce renewable resources so that less energy will be consumed, and the environment will not be harmed. Most significantly, solar energy should be utilized efficiently and more widely throughout Nigeria due to its infinite source and environment friendly properties. In Nigeria, even though there is huge potential of solar energy, required investments have not been made in order to utilize the solar energy potential, yet. Passive heating and cooling systems do not cause an extra financial burden for the building costs. Moreover, passive systems could be implemented in later stages of the building construction. Therefore, implementing passive systems will be an aid for Nigerian economy because of their efficiencies and affordable costs. Even though sustainable building design is a globally respected approach, it is not sufficiently known in Nigeria. The main usage of solar energy in Nigeria is in producing light points for households, yet only in applications used for improving energy efficiency is implemented on in government buildings or for academic researches. For that reason, architecture curriculum programs, should include studies that cover sustainability and energy preservation, issues such as ecology, energy active building design, and physical environment control.

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