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Evaluation of Energy-Efficient Approaches For Sustainable Hostel Buildings In Federal Universities of South East, Nigeria

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ABSTRACT

This research aims to evaluate energy efficient approaches for sustainable hostel buildings in federal universities of South East, Nigeria. The study adopted a survey research design since it is quantitative in nature. Data were obtained through questionnaire and analyzed with the use of descriptive statistics. The findings revealed that there are sustainable practices for achieving energy efficient hostel buildings in the study area. The major factors affecting energy efficient hostel buildings within the Federal Universities in South-east Nigeria are significant and there are environmental implications of energy inefficient buildings in the institutions. The study therefore concludes that, buildings that have tree planted around them could be shaded and record cooler ambient and internal temperatures than other buildings. The University management in collaboration with the government has to intensify the implementation of energy efficient programme and provide new legislation to aid in the implementation of energy efficient regulations in hostel buildings. The study therefore recommends planting of trees around buildings to assist in cooling of the environment, sun shedding, and installation of solar energy devices to supplement other power sources. There is, therefore, great potential for minimizing energy wastages and improving energy efficient hostel buildings lighting through retrofitting of incandescent light bulbs with compact fluorescent lighting bulbs (CFLS). It has the potential to reduce system load substantially and cost to the university.

Key Words: Energy efficient approaches, sustainable hostel, efficiency, South East Nigeria.

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INTRODUCTION

Energy efficiency in university hostel buildings has been a main topic of discussion due to the increase of energy usage in buildings annually. A study by Lo (2013) avers that energy efficient issue should become the main focus on campus because it has high energy consumers, high energy cost, contributes to climate changes and it is easily affected by the lack of resource of non-renewable energy.

Universities are considered as small towns due to their large number of users, sizes and are involved with complex activities and operations. The wastage of energy tends to occur by various space types, such as hostels, lecture auditorium, offices, workshop, computer rooms and laboratories. The increasing number of population and expansion of the existing campus also contribute to the increase of ecosystem degradation. It has become a major concern, especially to university policy makers and planners, in terms of sustainability issue. NESP (2014) posited that the energy usage of buildings contributes about 33 % of the final total energy consumption and has become the main source of worldwide carbon dioxide (CO_2) emissions. According to Tan, Yavuz, Otay and Çamlıbe, (2016), one of the effective ways to improve energy and ensure sustainability is to increase energy efficiency usage in existing buildings. This could be conducted through the replacement of existing building technology with more energy efficient, resulting in better reduction in energy expenditure. The energy efficient principle is basically to ensure that energy operations are reduced, such as cooling, heating, lighting and other appliances without affecting the occupants' comfort and health. Improvement of energy efficiency not only has environmental benefits, but also economic benefits especially in operational cost savings (Ruparathna, Hewage and Sadiq, 2016). Energy efficient buildings are those which consume less energy while maintaining the comfort conditions for their occupants compared to standard buildings. Energy efficient buildings result not only in less negative environmental impact but are

also economically sustainable.
The Nigerian construction industry has significant influence on the natural environment. It is the main energy consumer of all end-use industries, comprising a one-third of total energy demand and for a huge part of greenhouse gases (GHG) emissions in all economies.
Federal universities in South – east Nigeria have a central role to play in the reduction of carbon dioxide (CO_2) emissions and the fight against climate change, which are the historic challenges now facing our society. However, Akindoyemi (2012) states that buildings are the largest energy consuming sector in most developed countries, and offer the largest cost-effective opportunity for savings. Federal universities in South -east Nigeria can mitigate climate change by reducing energy consumption in the construction, maintenance and refurbishment of hostel buildings. Retrofitting existing hostel buildings in the universities with energy efficient technologies can at the same time offer important economic and employment opportunities, improve energy security, and save more than it costs (Akindoyeni, 2012). This can only come into existence if federal universities in South – East Nigeria implement stable, long-term policies and legislation, which will provide certainty to the market and transform the building sector. Energy use in university buildings has increased in recent years due to the growing demand in energy used for heating and cooling in hostel buildings.

Statement of the Research Problem

Insufficient electricity generation coupled with increasing load demand has escalated the challenges of energy access and availability with the resultant effect on the socio-economic development of South-east Nigeria. The problem government or organizations faces in trying to constitute a public energy efficient hostel building programme in federal universities in South-East Nigeria is that there are few resources available and there is no widely recognized strategy or process for developing energy efficient hostel buildings. In the federal universities system in South-East Nigeria, built assets pose great danger to staff and students due to the emission of carbon dioxide and other greenhouse gases within the university environment.
A study by Emerole (2002) indicates that inadequate capacity of university management to deliver hostel buildings was one of the key challenges of the federal university hostel buildings in South-East Nigeria. Federal universities in South-East Nigeria usually have high level of energy consumption due to their considerable electrical usage for lighting, cooling and operation of equipment especially in the hostels, classrooms, offices and laboratories. Federal universities in the South –East Nigeria rely on fossil fuel and generator for electricity. Due to fuel price rises and shortages, generating electricity with these petrol and diesel generators is not only inefficient in carbon emissions terms, but also very expensive and unsustainable.
One of the greatest challenges facing energy planning has been lack of good data. There is shortage of reliable data on energy consumption in federal university hostel buildings in South-East Nigeria. This is partly due to poor metering of main electricity and the fact that most hostel buildings also generate electricity using petrol and diesel generators, which increases emission. In late 2014, Nebo estimated that 55% of Nigeria electricity users are not metered (Nebo, 2014). This is recognized as a major barrier to energy efficiency.
The availability and use of energy in hostel buildings are pivotal to their functionality within the confines of their purpose. However, if energy use in hostel buildings is not regulated, it can steadily lead to costly waste to the students in the hostels and more importantly results in continuous release of carbon dioxide (CO_2) into the atmosphere leading to global rising temperature and climate change. The federal universities hostels buildings in South-East Nigeria are most poorly designed in terms of utilizing passive design strategies. For instance, some buildings lack enough illumination to be functional within the day and end up using artificial means for illumination. Also hostels, offices and lecture halls become too hot due to excess solar heat gain and require alternative cooling methods, such as ventilation and air conditioning to mitigate the problems and ensure sustainable development.

Proposed Solutions

The energy-efficient principle is basically to ensure that energy operations are reduced, such as cooling, heating, lighting and other appliances without affecting the occupants' comfort and health. Improvement of energy efficiency entails not only environmental benefits, but also economic benefits, especially in operational cost savings (Ruparathna, Hewage & Sadiq, 2016). It lowers the levels of heat by turning down the levels of thermostat, sets standards for appliances, and sets limits to appliances' consumption and capacity.
According to Akindoyemi (2012), buildings are the largest energy consuming sector in most developed countries, and offer the largest cost-effective opportunity for savings. Universities can mitigate climate change by reducing energy consumption in the construction, maintenance and refurbishment of buildings. Retrofitting existing building in the universities with energy-efficient technologies can at the same time offer important economic and employment opportunities, improve energy security, and save more than it costs (Akindoyeni, 2012). Since buildings consume a significant amount of energy, particularly for heating and cooling (32%), and because existing buildings comprise the largest segment of the built environment, it is important to initiate energy conservation retrofits to reduce energy consumption and the cost of heating, cooling, and lighting buildings.

LITERATURE REVIEW

Basic Principles of Energy-Efficient Hostel Buildings

Reducing heating, cooling and lighting loads

A simple strategy for reducing heating and cooling loads is to isolate abuilding from its environment by using high levels of insulation, optimizing the glazing area and minimizing the infiltration of outside air. This approach is

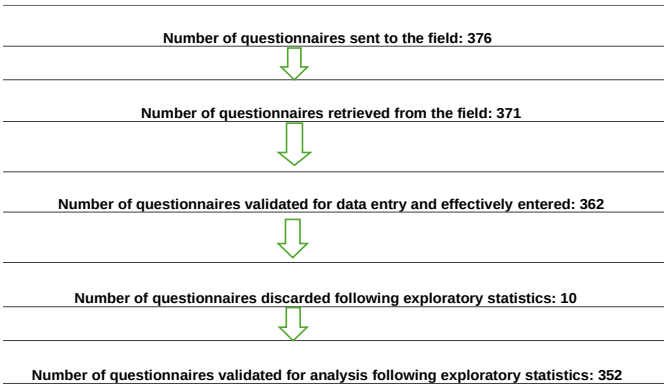

Figure 1: Sample flow chart.

most appropriate for cold, overcast climates.

Utilizing active solar energy and other environmental heat sources and sinks

A study by Obiegbu et al. (2017) indicates that active solar energy systems can provide electricity generation, hot water and space conditioning. The ground, groundwater, aquifers and open bodies of water, and less air can be used selectively as heat sources or sinks, either directly or by using heat pumps. Space cooling methods that dissipate heat directly to natural heat sinks without the use of refrigeration cycles (evaporative cooling, radiative cooling to the night sky, earth-pipe cooling) can be used.

Considering building form, orientation and related attributes

At the early design stages, key decisions – usually made by an architect – can greatly influence the subsequent opportunities to reduce building energy use. These include building form, orientation, self-shading, height-to-floor-area ratio and decisions affecting the opportunities for and effectiveness of passive ventilation and cooling. Many elements of traditional building designs in both developed and developing countries have been effective in reducing heating and cooling loads. Urban design, including the clustering of buildings and mixing of different building types within a given area greatly affect the opportunities for and cost of district heating and cooling systems (Revised Edition of the National Building Code, NBC, 2006).

Strategies for Achieving Energy-Efficient Hostel Buildings

Energy efficiency in hostel building is a cost-effective measure to achieve a design that saves a lot of money on energy bills. For example, universities can reduce their dependency on fossil fuels, which are often imported and subject to price volatility. Community research and development centre CREDC (2009) asserts that energy efficiency in hostel building has become an important aspect of sustainable development. The use of energy efficiency in hostel buildings can lead to the saving of university income, and school authority would not need to spend so much money paying for energy. It will help to reduce the building of more power stations, thus the money for building power stations will be spent on other sectors of the economy. In Nigeria, the inadequate supply of energy made it necessary for energy to be portioned/rationed. But, with good energy management at the university hostel buildings, there will be no need to ration the electricity supply.

A manual by the Energy Commission of Nigeria (2013) on sustainable design and energy efficiency measures grouped the strategies for achieving energy efficiency into three groups:

Strategies that reduce the whole energy load within the hostel building

Strategies that improve the efficiency of the systems

Strategies that involve on-site generation of electricity via the use of renewable resources.

METHODOLOGY

This study, which is essentially survey based and quantitative data, was derived from responses generated by questionnaire survey and fieldwork. A total of 376 questionnaires were administered to students of Nnamdi Azikiwe University, Awka Anambra State, Michael Okpara University of Agriculture, Umudike, Abia State and Federal University Ndufu-Alike, Ebonyi State. The students had spent more than two years living in the hostels. The questionnaire was designed to obtain representative views of the respondents on the basic principles for achieving energy efficient hostel buildings in South -East, Nigeria within a set of attributes rated.

Likert scales were developed on the variables that informed the study. The stated variables were provided on a rating scale of 1-5 to measure the varying degrees of the respondents' opinions about the relative worth of the attributes in the subsets. However, the questions were structured to explore the respondents' opinion to the energy efficient hostel buildings on campus and further reveal insights about the respondents' wellbeing in the universities' environment.

Out of the 376 questionnaires distributed to the respondents, 352 were duly completed and returned, corresponding to a response rate of about 94 percent (Figure 1). Data obtained from the questionnaires were

Table 1: Gender of the respondents.

Items	Number	Percentage %
Male	160	45.5
Female	192	54.5
Total	352	100

Source: Survey Questionnaire of the Study (2023).

Table 2: Age Bracket of Respondents.

Age	Number	Percentage %
16 – 40	298	84.6
41 – 50	40	11.4
51 and above	14	4.0
Total	352	100

Source: Survey Questionnaire of the Study, (2023).

Table 3: Programme of Study of the Respondents.

Items	Number	Percentage %
Undergraduate	238	67.6
Postgraduate	43	12.2
Parttime	60	17.1
Certificate	11	3.1
Total	352	100

Source: Survey Questionnaire of the Study, (2023).

analysed using simple tables, Likert scale, mean score and student T-test. All hypotheses were tested at 5% level of significance in order to ascertain the level of statistical error acceptable, making the result of the study significantly relevant. The results and interpretations shown in tables are presented as findings in section 4.0. Based on the response rate and findings of the study, the conclusion drawn may be deemed indicative of the basic principles for achieving energy efficient hostel buildings in the study context.

RESULT AND DISCUSSIONS

The result of the study are presented in tables and analyzed Table 1 shows that 54.5% of the respondents were females and 45.5% were males. This is an over-representation of female respondents in the survey which could lead to bias. However, it does reflect the Nigerian university education system, which is dominated by female students.

Table 2 shows that 84.6% of the respondents were between the ages 16-40 who were undergraduate, 11.4% and 4.0% were between the ages of 41-50 and 51 years and above respectively who were Postgraduate, part-time and Certificate students. Accordingly, more than 84.6 % of the data were obtained from people of between 16 -40 years of age. Hence, it is shown that most of the data for this study were obtained from undergraduate students of the federal universities, which is good for research of this kind.

Table 3 shows that 67.6% of the respondents were undergraduate students, 12.2% were postgraduate students, and 17.1 were portals. This shows that the majority of the respondents were undergraduate students.

Table 4 shows the basic principles for achieving sustainable energy-efficient hostel buildings in the study area, considering their mean scores ranging from 4.1-4.9.

Planting of trees around the hostel buildings to assist in cooling of the environment and sun shedding, installation of solar energy devices to supplement other power sources, consideration of building form, orientation and related attributes, re-commissioning all energy and water systems to verify if they are functioning at optimum performance, and renovating energy and water systems to minimize consumption have the highest rank in terms of importance, with a mean score values of 4.9, 4.6, 4.5 and 4.4, respectively. Increasing the efficiency of appliances, heating and cooling of equipment, providing ventilation in the hostels, reducing heating loads by using desirable solar heat gain, insulating the hostels, such as installing or replacing high voltage bulbs with fluorescent lights, installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices, mounting of solar energy devices and assessing hostel patterns, and applying daylight heating, ventilation and air conditioning (HVAC) and lighting sensors where suitable rank lower in terms of importance, with a mean score values of 4.3 and 4.2, respectively.

Installation of a cool or green roof surface that shades against solar radiation has the lowest rank in terms of importance with a mean score values of 4.1. Sample t-test was used to compare the results in Table 4 and it is

Table 4: Mean Score of the Responses on Basic Principles for Achieving Energy Efficient Hostel Building(n=352).

SN	Items	Mean Score
1	Planting of trees around the building to assist in cooling of the environment and sun shedding	4.9
2	Installation of solar energy devices to supplement other power sources	4.6
3	Consider building form, orientation and related attributes	4.5
4	Re-commission all energy and water systems to verify if they are functioning at optimum performance; then renovate energy and water systems to minimize consumption	4.4
5	Increase the efficiency of appliances, heating and cooling equipment and ventilation in the hostel.	4.3
6	Reducing heating loads by using desirable solar heat gain	4.3
7	Insulating the hostel such as installing or replacing high voltage bulbs with fluorescent lights	4.3
8	Installation of solar shading devices for windows and doors, as well as those that generate electricity by photovoltaic (PV) devices	4.3
9	Mounting of solar energy devices	4.3
10	Assess hostel patterns, and then apply daylight heating, ventilation and air conditioning (HVAC) and lighting sensors where suitable.	4.2
11	Reduce heating, cooling and lighting loads.	4.2
12	Utilize active solar energy and other environmental heat sources and sinks	4.2
13	Putting off electrical appliances when not in used to reduce cost.	4.2
14	Change behaviour	4.2
15	Utilize system approaches to building design.	4.2
16	Using more efficient heating and cooling equipment to reduce loads	4.2
17	Installation of a cool or green roof surface that shade against solar radiation	4.1
	Total Mean Score	81.7

Survey Questionnaire of the Study, (2023).

Table 5: T-Test on One-Sample Statistics on Mean Score of the Responses on Basic Principles for Achieving Energy Efficient Hostel Building.

	N	Mean	Std. Deviation	Std. Error Mean
Basic principle for achieving energy efficient hostel buildings	352	81.5938	16.45203	.87690

Source: Survey Questionnaire of the Study Extracted from SPSS, (2023).

presented in Table 5.

Tables 4 and 5, with mean value of 81.5938 > 3.01, show the mean value from table 4.8 indicates that there are some basic principles and strategies of energy efficient hostel buildings**.** When the total mean from Table 4 was compared with t-test table carried out through SPSS, it was discovered that the total mean value is 81.7, while that of t-test table was 81.59, approximately 82. This disparity calls for further test in order to establish the authenticity of the first result obtained.

From the result presented in in Table 6, the sustainable approaches or practices energy efficient hostel buildings in the study area were categorized into behavioural, technical and renewable approaches (with a mean score value of 3.8). Particularly, the respondents agreed that the single use of inefficient heating equipment and non-simultaneous use of multiple appliances in the hostel (with mean score values of 4.3 and 4.2 > 3.00 respectively) are very important behavioural approaches.

On the technical approaches, the students agreed that reducing energy used for heating water and reducing electricity consumption of hostel equipment and appliances (with mean score values of 4.5 and 4.3 > 3.00, respectively) are very important. On the renewable approaches, the students also agreed that very important renewable energy approaches like, Solar power, Photovoltaic, Biomass and Light-emitting diodes (with mean score values of 4.7, 4.2, 4.1 and 4.0 > 3.0) respectively should be considered. This is corroborated by the findings of Obiegbu, Nnodu & Eneche (2017), which indicated that active solar energy systems can provide electricity generation, hot water and space conditioning. Therefore, independent sample t-test was used to compare the results of the three groups in Table 5 and presented in Table 6.

CONCLUSION

The aim of this study is to evaluate the energy-efficient approaches for sustainable hostel buildings in federal universities of South East, Nigeria. Insufficient electricity generation coupled with increasing load demand has escalated the challenges of energy accessibility and availability. This has negatively affected the socio-economic development of South-East Nigeria The problem government or organizations face in trying to constitute a public energy efficient hostel building programme in federal Universities in South-East Nigeria is that there are few resources available and there is no widely recognized strategy or process for developing energy efficient hostel buildings.

Data of the were elicited via questionnaire. Likert scales were provided on a rating scale of 1-5 to measure the varying degrees of the respondents' opinions about the

Table 6: Mean Score of the responses on the sustainable approaches or practices for energy-efficient hostel buildings (n=352).

S/No	Item	Mean Score
	BEHAVIOURAL APPROACHES	
1	Single use of inefficient heating equipment	4.3
2	Non simultaneous Use of Multiple Appliances in the hostel	4.2
3	Non purchase of second-hand appliances	3.9
4	Not leaving appliances on standby mode	3.8
5	Putting appliance off when not in Use	3.8
6	Switching off outdoor lighting during the day	3.7
7	Putting off light when not in use	3.6
	TECHNICAL APPROACHES	
8	Reducing energy used for heating water	4.5
9	Reducing electricity consumption of hostel equipment and appliances	4.3
10	Reducing heating demand	3.9
11	Reducing cooling demand	3.9
12	Good housekeeping and people solutions	3.9
13	Reducing the energy requirements for ventilation	3.8
14	Reducing energy use for lighting	3.8
	RENEWABLE ENERGY SOURCES	
15	Solar power	4.7
16	Photovoltaic	4.2
17	Biomass	4.1
18	Light-emitting diodes	4.0
19	Compact fluorescent lamps	3.8
20	Geothermal	2.9
21	Hydro sources	2.4
	Mean Score	**3.8**

Source: Field Survey, 2023.

relative worth of the attributes in the subsets. However, the questions were structured to explore the respondents' opinion on the energy efficient hostel buildings on campus and further reveal insights about the respondents' wellbeing in the universities' environment.

The results from the study show that universities rely on fossil fuels and generators, leading to inefficiencies, high costs and poor detailed financial implications. Therefore, there are pronounced potentials for minimizing energy wastages and improving energy efficient hostel building lighting through retrofitting of incandescent light bulbs with compact fluorescent lighting bulbs (CFLS). This has the potential to reduce system load substantially and cost to the university.

The study consequently recommends planting of trees around hostel buildings to assist in cooling of the environment, besides sun shedding, installation of solar energy devices to supplement other power sources.

Due to the disparity in the total mean value calculated (81.7), and the tabulated t-test table value (81.59), it is therefore recommended that further research be conducted to harmonize disparity in the two mean values to attain statistical conformity via SPSS.

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