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# CHALLENGES TO THE DESIGN OF ENERGY EFFICIENT PUBLIC OFFICE BUILDINGS IN SOUTH-EAST NIGERIA

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**Abstract**

*Building design has become challenging with growing energy efficiency and sustainability concerns. About 40% of the world's energy is consumed in buildings. The high energy consumption in buildings tends to be more conspicuous in large or corporate buildings. Optimization of energy performance is a crucial factor in any office building design. This study assessed the challenges to the design of energy efficient office buildings in South-East Nigeria with a view to proffering strategies that would enhance building energy efficiency. Quantitative research design was adopted; this involved survey. A total of 226 copies of questionnaire were distributed to registered architects in South-East Nigeria. Using proportionate sampling technique 23, 89, 14, 63 and 166 copies of questionnaire were distributed to Abia, Anambra, Ebonyi, Enugu and Imo States respectively. Thirteen (13) variables from the challenges to the design of energy efficient office buildings were studied. Codes (CED-01 to CED-13) were used to represent the variables. Data were analysed using Spearman's rank-order correlation. The findings of the study revealed that the major challenge to the design of energy efficient office buildings in South-East Nigeria is no regulatory framework for achieving energy efficiency in office buildings. This is as attested by 63.5% (105) of the respondents. Based on the findings of the study, there is urgent need for the government to strengthen regulatory frameworks and enforce strict compliance to energy efficiency standards.*

**Keywords:** building design, energy efficiency, office buildings, sustainability

## INTRODUCTION

Building design has become challenging with growing energy efficiency and sustainability concerns (Ravichandran & Gopalakrishnan, 2023). According to Silva, Uwai, Ribeiro et al. (2016) building energy consumption has increased globally and it is expected to continue growing in the future. This is due to population growth, increased demand for building functions, indoor environmental quality as well as climate change (Kalua, 2020). The growing trends of urbanisation and climate change are forcing the cities to become warmer, thereby increasing the building energy demand. Ezzati, Mohammadi and Alizadehfard (2022) revealed that 40% of the world's energy is consumed in buildings. In the tropics, cooling is a major concern and as such there is high demand on the energy required for cooling. In Nigeria, the building sector accounts for the majority of electricity consumption (Building Energy Efficiency Guide [BEEG], 2016). However, there is a shortage of reliable data on energy consumption in buildings. An estimate of total energy consumption in Nigeria, is challenging due to poor metering of mains electricity and on-site generation of electricity from private petrol/diesel generators (BEEG, 2016).

The high energy consumption in buildings tends to be more conspicuous in large or corporate buildings (Yusuf, 2020; Muazu, 2015; Siew, Che-Ani, Tawil, Abdullah, & Mohd-Tahir, 2011). According to Owolabi and Adetunji (2021) energy consumption in office development, is 10 to 20 times more than that of the residential building. The utility of energy in office buildings is within the range of 100 to 1000 kWh per $m^2$ depending on the location of the buildings, building dimensions, the number and types of equipment used in the office buildings (Siew et al., 2011). According to Ferdous (2012) optimisation of energy performance is a crucial factor in any office building design.

Office buildings are great varieties of structures that play prominent roles in the economic growth of urban centres (Akhimien et al., 2018). They are a crucial component of the commercial building sector, accounting for a significant portion of worldwide energy consumption (Norouziasi & Jafari, 2023). European Commission Staff Working Document {SWD} (2016) defined office building as a building whose primary function is to provide space for administrative, financial, professional or customer services. Work spaces in an office are typically used for conventional office activities such as reading, writing and computer work. The main purpose of an office environment is to support its occupants in performing their jobs. According to McKeen and Fung (2014) achieving occupants' comfort is a priority that has a great effect on energy demand. There is need to minimize office building energy consumption without sacrificing the comfortable and healthy indoor environment (Fang & Cho, 2019). This implies achieving energy efficiency in the buildings.

Several efforts have been made in Nigeria towards achieving energy efficiency in buildings. These include the formation of Green Building Council of Nigeria (GBCN), and launching of National Building Energy Efficiency Code (BEEC) in 2017, with the collective aim to provide practical guide to professionals in Nigeria on how to design, construct and operate more sustainable and comfortable buildings (BEEG, 2016). In the year 2015, Federal Ministry of Housing, Land and Urban Development in Nigeria recommended climate adaptive design which takes into consideration local conditions and microclimates as strategic step for energy efficiency (Owolabi & Adetunji 2020). However, the chances of meeting the target of energy efficiency in buildings based on the National Energy Efficiency Action Plans (2015-2030) in Nigeria is threatened (Okoye *et al*., 2020). Nigeria is faced with many challenges with regard to realizing improvements in energy efficiency in buildings. Despite the numerous benefits of energy efficient buildings practicing architects still navigate between theory and practical application. This study thus aims to investigate challenges to the design of energy efficient office buildings in South-East Nigeria with a view to proffering strategies that would enhance building energy efficiency.

## LITERATURE REVIEW

Manzano-Agugliaro et al. (2015) explained the concept of energy efficiency in buildings as the amount of energy required to achieve the desired environmental conditions while minimizing energy consumption. Energy efficiency is the relationship between the quality of internal thermal environment in a building and the amount of energy consumption required to maintain this environment. Building Energy Efficiency Guideline [BEEG] (2016) defined energy efficient buildings as those which consume less energy while maintaining or even improving the comfort conditions for their occupants compared to standard buildings. In the design of energy efficient building, the architect cannot interfere with the climatic conditions at the building site, but the design decisions on the building characteristics could influence thermal performance (Touloupaki & Theodosiou, 2017).

### Benefits of Energy Efficient Buildings

According to Del 2.4.4 Guide for bioclimatic design (2015) energy efficient buildings have social, economic and environmental benefits as shown in figure 1.

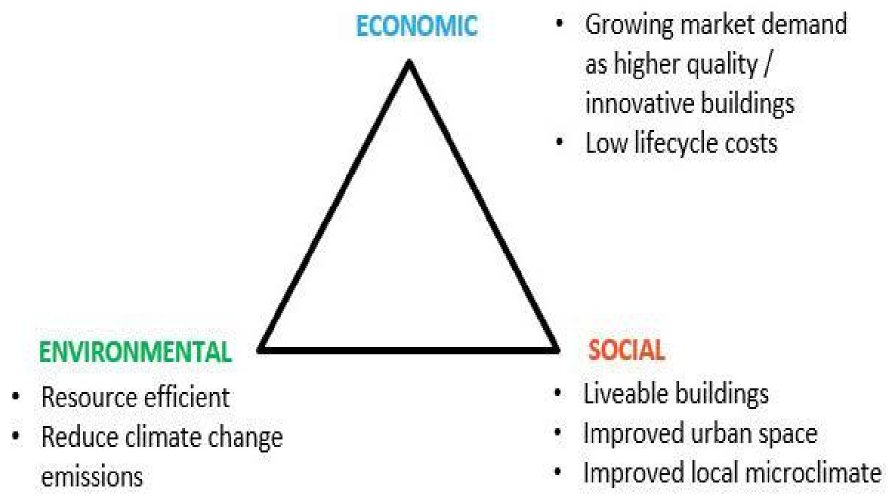


**Figure 1: Benefits of energy efficient buildings**
*Source: Del 2.4.4 Guide for bioclimatic design (2015)*

Other benefits of energy efficient buildings revealed by Owolabi and Adetunji (2021) include savings in personal income; the study reveals that energy efficient buildings can reduce the cost of energy used in buildings to about 75%. Energy efficient buildings reduce dependency on fossil fuel; minimize the emission of greenhouse gases and environmental impact. Energy efficient buildings also help in enhancement of employment and economic growth, innovation of energy efficient technology, increase in productivity and general wellbeing.

## METHODOLOGY

This research was conducted in South-East geopolitical zone of Nigeria, which comprises five states namely: Abia, Anambra, Ebonyi, Enugu and Imo. The South-East geopolitical zone lies between Latitude 4° 45N and 7° 05N Longitude 7° 54E and 8° 27E as shown in Figure 2. It is dominated by the Igbo and majority of the indigenes speak Igbo language. The zone occupies a total land mass of 10,952,400 hectares.

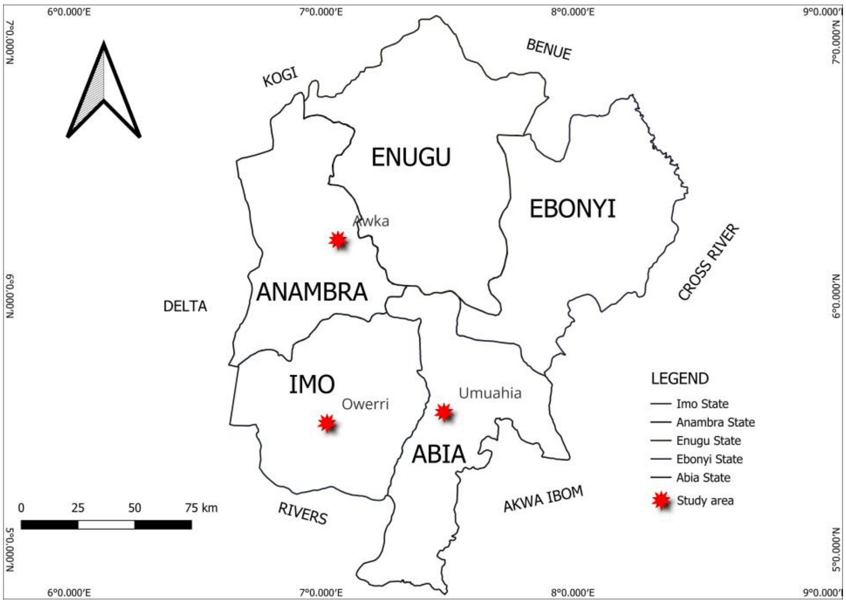


**Figure 2: Map of South-East geopolitical zone showing the selected cities**
*Source: Data base and modification from GIS*

In this study, quantitative research design was adopted; this involved survey. The population of the study consisted of registered architects who were resident or had their practice in South-East Nigeria. Registered architects were selected using simple random sampling from the membership register of the five state chapters of Nigeria Institute of Architects (NIA) in South-East Nigeria. The population of architects who were members of NIA in South-East Nigeria was four hundred and sixty seven (467) as obtained from the membership registers of all the state chapters. The sample size was determined using Yamane (1976) formula. A total of 226 copies of questionnaire were distributed to registered architects in South-East Nigeria. Using proportionate sampling technique 23, 89, 14, 63 and 166 copies of questionnaire were distributed to Abia, Anambra, Ebonyi, Enugu and Imo States respectively.

The questionnaire contained data on the socio-demographic information of the respondents as well as challenges to the design of energy efficient office buildings in South-East Nigeria. The research question that guided the study was; In what ways are the challenges to the design of energy efficient office buildings related in South-East Nigeria? A null hypothesis "There is no significant relationship in the various challenges to the design of energy efficient office buildings in South-East Nigeria" was formulated to answer the research question.

A total of thirteen (13) variables were obtained from the challenges to the design of energy efficient office buildings. Codes (CED-01 to CED-13) were used to represent the variables as follows; Lack of information on the energy efficient measures to be adopted in the design of office buildings (CED-01), Lack of readily available template for achieving energy efficiency in office buildings (CED-02), Lack of awareness on the benefits of energy efficient practices in office buildings, (CED-03), Lack of showcased energy efficient buildings to draw inspiration from, (CED-04), Lack of incentives for adopting energy efficient strategies (CED-05), Lack of mandatory building energy code to meet energy efficient requirements (CED-06), No strong government policies towards achieving energy efficiency in office buildings (CED-07), No regulatory frameworks for achieving energy efficiency in office buildings (CED-08), Unacceptable implementation of government policies towards achieving energy efficiency in office buildings (CED-09), Lack of technical expertise required for the application of energy efficient strategies, CED-10, Activities of quacks in the profession (CED-11), Lack of accountability on energy usage CED-12), Poverty (CED-13).

The respondents were asked to indicate their level of agreement with the challenges to the design of energy efficient office buildings in South-East Nigeria based on the following 4-point likert scale: 1 = Strongly disagree; 2 = disagree; 3 = agree; 4 = Strongly agree. The aforementioned hypothesis was examined by using Spearman's rank-order correlation to study relevant variables. It is significant to notice that the dataset's scatterplots demonstrate that the variables have a monotonic relationship and are ordinal scaled. Spearman's rank-order correlation (ρ) coefficient is computed using the formula below:

$$\text{Spearman's coefficient } (\rho) = \frac{6\sum([rg(P_i) - rg(Q_i])^2}{n(n^2-1)} = \frac{6\sum d_i^2}{n(n^2-1)}$$

Where:

$rg(P_i)$ = rank for each observation of the P variable;

$rg(Q_i)$ = rank for each observation of the Q variable;

$d_i^2$ = difference between the two ranks for each observation;

$n$ = number of observations.

The decision rule is that the null hypothesis is rejected if the significance level is less than or equal to the chosen alpha (α) level (p =.005) showing a significant relationship

## RESULTS AND DISCUSSION

Table 1 revealed that 64.1 percent (107) of the respondents were between the age of 26 – 45 years. While 34.1 percent (57) were between the ages of 46 – 65 years, only 1.8 percent (3) was above 65 years. This implies that majority of the respondents were young architects.

**Table 1: Age of the Study Respondents**

| Age Category | Abakaliki | Awka | Enugu | Owerri | Umuahia | Others | Total |
|---|---|---|---|---|---|---|---|
| | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| 26 – 45 years | 18 (10.8) | 12 (7.2) | 22 (13.2) | 29 (17.4) | 2 (1.2) | 24 (14.4) | 107 (64.1) |
| 46 – 65 years | 8 (4.8) | 8 (4.8) | 11 (6.6) | 16 (9.6) | - | 14 (8.4) | 57 (34.1) |
| Above 65 years | - | 1 (0.6) | 1 (0.6) | 1 (0.6) | 1 (0.6) | - | 3 (1.8) |

*Source: Fieldwork, 2025*

Table 2 shows that 64.1 percent (107) of the respondents had Master of Science degree, 26.3 percent (44) had Doctorate degree and 9.6 percent (16) had B.Sc/HND. This reflects the structure of architecture as a six-year programm consisting of 4 years bachelor's degree and 2 years Master's degree.

**Table 2: Level of Education**

| Education | Abakaliki | Awka | Enugu | Owerri | Umuahia | Others | Total |
|---|---|---|---|---|---|---|---|
| | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| Degree/Higher Diploma | 3 (1.8) | 2 (1.2) | 2 (1.2) | 3 (1.8) | - | 6 (3.6) | 16 (9.6) |
| Master of Science | 18 (10.8) | 14 (8.4) | 24 (14.4) | 28 (16.8) | 2 (1.2) | 21 (12.6) | 107 (64.1) |
| Doctorate | 5 (3) | 5 (3) | 8 (4.8) | 15 (9) | - | 11 (6.6) | 44 (26.3) |

*Source: Fieldwork, 2025*

Table 3 revealed that 40.7 percent (68) had between 11 – 20 years of post-graduation experience, 29.9 (50) had above twenty years of post-graduation experience while 29.3 percent (49) had ten year and below professional experience.

**Table 3: Post-graduation Experience**

| Postgraduation Experience | Abakaliki | Awka | Enugu | Owerri | Umuahia | Others | Total |
|---|---|---|---|---|---|---|---|
| | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| 10 years and below | 16 (9.6) | 5 (3) | 7 (4.2) | 11 (6.6) | 1 (0.6) | 9 (5.4) | 49 (29.3) |
| 11 – 20 years | 5 (3) | 11 (6.6) | 15 (9) | 19 (11.4) | 1 (0.6) | 17 (10.2) | 68 (40.7) |
| Above 20 years | 5 (3) | 5 (3) | 12 (7.2) | 16 (9.6) | - | 12 (7.2) | 50 (29.9) |

*Source: Fieldwork, 2025*

Table 4 shows the frequency rankings of challenges to energy efficient design of office buildings in the study area.

**Table 4: Frequency rankings of challenges to energy efficient design of office buildings in the study area**

| Variable | Strongly disagree [n (%)] | Disagree [n (%)] | agree [n (%)] | Strongly agree [n (%)] | Min. | Max. | Mean |
|---|---|---|---|---|---|---|---|
| CED-01 | 37 (22.2) | 39 (23.4) | 19 (11.4) | 72 (43.1) | 1 | 4 | 2.75 |
| CED-02 | 29 (17.4) | 23 (13.8) | 21 (12.6) | 94 (56.3) | 1 | 4 | 3.08 |
| CED-03 | 29 (17.4) | 31 (18.6) | 21 (12.6) | 86 (51.5) | 1 | 4 | 2.98 |
| CED-04 | 13 (7.8) | 53 (31.7) | 17 (10.2) | 84 (50.3) | 1 | 4 | 3.03 |
| CED-05 | 18 (10.8) | 49 (29.3) | 24 (14.4) | 76 (45.5) | 1 | 4 | 2.95 |
| CED-06 | 31 (18.6) | 25 (15) | 24 (14.4) | 87 (52.1) | 1 | 4 | 3.00 |
| CED-07 | 34 (20.4) | 21 (12.6) | 23 (13.8) | 89 (53.3) | 1 | 4 | 3.00 |
| CED-08 | 28 (16.8) | 12 (7.2) | 21 (12.6) | 106 (63.5) | 1 | 4 | 3.23 |
| CED-09 | 23 (13.8) | 33 (19.8) | 33 (19.8) | 78 (46.7) | 1 | 4 | 2.99 |
| CED-10 | 19 (11.4) | 24 (14.4) | 33 (19.8) | 91 (54.5) | 1 | 4 | 3.17 |
| CED-11 | 34 (20.4) | 16 (9.6) | 25 (15) | 92 (55.1) | 1 | 4 | 3.05 |
| CED-12 | 24 (14.4) | 21 (12.6) | 30 (18) | 92 (55.1) | 1 | 4 | 3.14 |
| CED-13 | 26 (15.6) | 24 (14.4) | 44 (26.3) | 73 (43.7) | 1 | 4 | 2.98 |

*Source: Fieldwork, 2025*

Table 4 shows that the highest number of respondents 63.5% (106) strongly agreed that No regulatory frameworks for achieving energy efficiency in office buildings (CED-08) is a major challenge to the design of energy efficient office buildings in South-East Nigeria. This was followed by lack of readily available template for achieving energy efficiency in office buildings (CED-02), which accounted for 56.3% (94) of the respondents. More than half of the respondents 55.1% (92) strongly agreed that activities of quacks in the profession (CED-11) as well as lack of accountability on energy usage CED-12) are challenges to the design of energy efficient office buildings in the study area. Only 43.1% (72) strongly agreed that lack of information on the energy efficient measures to be adopted in the design of office buildings (CED-01) is a challenge to the design of energy efficient office building in the study area.

Table 5 shows the results of the 13 variables applied in the test. Rank-order Correlation coefficients for the 13 variables from challenges to the design of energy efficient office buildings indicate that there was a total of seventy-eight correlations among designated variables.

**Table 5: Spearman's Rank-order Correlation coefficients for the 13 variables from challenges to the design of energy efficient office buildings in Southeast Nigeria**

| Variable | CED-01 | CED-02 | CED-03 | CED-04 | CED-05 | CED-06 | CED-07 | CED-08 | CED-09 | CED-10 | CED-11 | CED-12 | CED-13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CED-01 | 1.000 | | | | | | | | | | | | |
| CED-02 | .410** | 1.000 | | | | | | | | | | | |
| CED-03 | .277** | .357** | 1.000 | | | | | | | | | | |
| CED-04 | .251** | .407** | .189* | 1.000 | | | | | | | | | |
| CED-05 | .519** | .241** | .273** | .259** | 1.000 | | | | | | | | |
| CED-06 | .268** | .331** | .174* | .182* | .279** | 1.000 | | | | | | | |
| CED-07 | .208** | .305** | .088 | .166* | .089 | .425** | 1.000 | | | | | | |
| CED-08 | .199** | .181* | .072 | .120 | .219** | .423** | .406** | 1.000 | | | | | |
| CED-09 | .293** | .200** | .136 | .112 | .279** | .162* | .336** | .327** | 1.000 | | | | |
| CED-10 | .220** | .183* | .030 | .282** | .174* | .114 | .107 | .253** | .182* | 1.000 | | | |
| CED-11 | .182* | .222** | .165* | .134 | .241** | .272** | .189* | .196* | .170* | .158* | 1.000 | | |
| CED-12 | /.175* | .237** | .125 | .147 | .198* | .434** | .326** | .258** | .207** | .158* | .381** | 1.000 | |
| CED-13 | .124 | .196* | .167* | .141 | .121 | .204** | .135 | .228** | .104 | .093 | .196* | .166* | 1.000 |

* = significant; p ≤ 0.05; ** = significant; p ≤ 0.01.

*Source: Fieldwork, 2025*

Overall, sixty inter-correlations were significant, out of which thirty-eight were significant at the .01 level. Results indicate that the inter-correlation with correlation coefficient above .500 is CED-01/CED-05 (.519). In the same vein, six inter-correlations were above .400 (CED-01/CED-02 = .410, CED-02/CED-04 = .407, CED-06/CED-07 = .425, CED-06/CED-08 = .423, CED-06/CED-12 = .434, CED-07/CED-08 = .406). It is also pertinent to state that all the correlation coefficients in Table 4.41 are positive (an increase in one also leads to an increase in the other, and vice versa).

Results showed that CED-02 and CED-11 had the highest number of inter-correlations with each of them having twelve significant correlations. In addition, CED-01 and CED-06 each had eleven inter-correlations while CED-05 and CED-08 and CED-12 each had ten significant inter-correlations. In the same vein, CED-09 had nine significant inter-correlations. Other inter-correlations with high coefficient values that are significant in Table 4.41 are: CED-01/CED-09 (.293), CED-02/CED-07 (.305), CED-02/CED-06 (.331), CED-02/CED-03 (.357), CED-07/CED-09 (.336), CED-08/CED-09 (.327), CED-07/CED-12 (.326), and CED-11/CED-12 (.381).

Decision: Based on the study results, the null hypothesis ($H_05$) was rejected since the calculated significant level most of the correlations were less than the .05 Alpha (α) level. This implies that there is significant relationship between the various challenges to the design of energy efficient office buildings in South-East Nigeria.

## CONCLUSION

The study sought to assess the challenges to the design of energy efficient public office buildings in South-East Nigeria. The findings of the study revealed that the major challenge to the design of energy efficient office buildings in South-East Nigeria is no regulatory framework for achieving energy efficiency in office buildings. This is as attested by 63.5% (105) of the respondents.

Given the findings of the study, the following recommendations were made; there is urgent need for the government to strengthen regulatory frameworks and enforce strict compliance to energy efficiency standards. Financial incentives as well as public awareness campaigns are essential in promoting the culture of energy-conscious design. Professional institutions and academic bodies should prioritize the integration of sustainable design principles into education and practice.

The study concludes that achieving energy efficiency in office buildings in South-East Nigeria will not only reduce building energy consumption and associated carbon emissions but also enhance occupants' comfort in the buildings.

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