Adoption of Energy Efficiency Strategies and Challenges in The Design of High-Rise Commercial Buildings in Lagos, Nigeria

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ABSTRACT

The rapid urbanization in Lagos, Nigeria, has led to increased energy consumption in high-rise commercial buildings, necessitating the adoption of energy-efficient strategies. This study aims to assess the adoption levels of energy efficiency strategies by architects in Lagos and identify challenges hindering widespread implementation. The research objectives include identifying applicable energy efficiency strategies, assessing current adoption levels, and analyzing barriers to adoption. A quantitative approach was employed, utilizing a structured questionnaire distributed to 75 architects selected through stratified random sampling. Key findings reveal high adoption of passive design strategies and natural ventilation techniques, with solar energy dominating renewable sources. Smart technology adoption varies, while client budget constraints emerge as the primary barrier. The study concludes that while architects demonstrate awareness of energy efficiency principles, practical implementation faces challenges. Recommendations include targeted training programs, policy interventions, innovative financing mechanisms, and client education. This research contributes to the understanding of energy efficiency adoption in developing urban contexts, offering insights for policymakers, educators, and practitioners to promote sustainable building practices in Lagos and similar environments.

Keywords: Energy Efficiency, Green Building, Sustainable Building Practices, Commercial High-rise structures, Nigerian Architecture Barriers

1. INTRODUCTION

The rapid urbanization and population growth in cities like Lagos, Nigeria, have led to an increased demand for office spaces, resulting in the proliferation of high-rise buildings. These structures serve as pivotal entities where organizations conduct administrative tasks to realize their goals and objectives (Simons, 2014; Akhimien, Adamolekun, & Isiwele, 2017; Duffy, 1997). As physical manifestations of organizational leadership, they play a crucial role in shaping skylines and reflecting economic and technological progress (Akhimien et al., 2017).

High-rise office buildings, characterized by their vertical elevation and ability to accommodate diverse activities within limited land space, have become iconic symbols of modern cities (Britannica, 2013; Ibrahim, 2007; Sari, 2017; Mousavi, 2017; NFPA, 2014; Knoke, 2006). The global surge in population, coupled with the need for efficient land use, has propelled the development of these structures, presenting both opportunities and challenges (Sari, 2017). However, these buildings are known for their substantial energy consumption, contributing significantly to urban carbon emissions (Akhimien et al., 2017).

In the context of Lagos, Nigeria, the adoption of energy-efficient strategies in high-rise office buildings has become paramount, especially in the face of resource scarcity, environmental concerns, and the overarching impacts of climate change (Cramer, 2018; David, 2013). The accelerated effects of climate change, intensified by increased commercial and industrial activities, underscore the necessity for sustainable building design practices (Cramer, 2018). The concept of energy efficiency in buildings encompasses a wide range of strategies, from passive design techniques to advanced technological solutions. These may include optimized building orientation, efficient HVAC systems, smart lighting controls, and the use of renewable energy sources. The adoption of these strategies can lead to significant reductions in energy consumption and operational costs while improving occupant comfort and productivity (Adewale & Ene, 2024).

With the building industry being a major contributor to global carbon emissions, there is an urgent need to transition towards sustainable design practices and clean, renewable energy sources. This shift is particularly crucial given the projection that 9 billion people are expected to live on the planet by 2050 (Griggs, 2013). The adoption of energy-efficient strategies aligns with the United Nations Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities) and SDG 7 (Affordable and Clean Energy), aiming to ensure access to affordable, reliable, and modern energy sources while making a tangible impact on sustainable urban development. Despite the clear benefits, the widespread adoption of energy-efficient strategies in high-rise office buildings around the world and most especially in Lagos faces several obstacles. These may include limited awareness, lack of technical expertise, financial constraints, and inadequate policy frameworks. Understanding these challenges is crucial for developing effective solutions and promoting sustainable urban development in the region (Adewale & Ene, 2024).

This study aims to assess the current level of adoption of energy efficiency strategies by architects in Lagos and identify the challenges hindering their widespread implementation. By focusing on the specific context of Lagos, this research seeks to provide valuable insights that can inform tailored interventions and policies for sustainable urban development in rapidly growing African cities.

The research objectives are as follows:

1. Identify diverse energy efficiency strategies applicable in office buildings.
2. Assess the current adoption level of energy efficiency strategies in building designs by Architects in Lagos State.
3. Identify and analyze the challenges hindering the widespread adoption of energy efficiency in high-rise office buildings.

By addressing these objectives, this study aims to contribute to the broader goals of sustainable urban development. The findings of this research will provide a foundation for developing targeted strategies to enhance energy efficiency in high-rise office buildings in Lagos, potentially serving as a model for other rapidly urbanizing regions in Africa.

2. LITERATURE REVIEW

The United Nations adopted the 2030 Agenda for Sustainable Development in 2015 as a result of the urgent need to address environmental sustainability on a global scale. comprising 17 Sustainable Development Goals (SDGs) that span various critical areas, including climate action, responsible production/consumption, and aquatic conservation (Phillips, 2005). Buildings, as significant contributors to resource consumption and waste production, play a pivotal role in either hindering or realizing these SDGs. According to startling data, the building industry accounts for 36% of the world's energy consumption and 39% of its annual carbon dioxide emissions due to energy use (Renn & Marshall, 2016). Recognizing this impact, the integration of green building design principles becomes imperative for operational efficiency, resource conservation, and achieving sustainability targets. According to the World Green Building Council (WGBC), a green building prioritizes the health and comfort of its occupants while minimizing its negative effects on the environment over the course of its lifecycle (WGBC 2021). This involves holistic considerations, ranging from site sustainability to efficient resource use, waste reduction, indoor environmental quality, and critically - energy efficiency.

Energy efficiency, defined as delivering equal or superior building performance while minimizing energy inputs (Shapiro, 2020), is a multifaceted concept encompassing various strategies. Passive design techniques leverage architectural approaches such as optimal orientation, shading, natural lighting, and ventilation to reduce heating/cooling loads imposed by local climates (Adewale & Ene, 2024; Altan, 2016), thereby lessening reliance on mechanical systems. Reducing carbon emissions is made possible by the use of alternative sources of energy, such as wind power, solar power, and bioenergy, in addition to or instead of non-renewable grid electricity (Owusu, 2016). Smart automation, facilitated by sensor networks and building management software, optimizes energy performance by regulating equipment activity based on occupancy and climatic patterns (Chasta et al., 2016). Energy-efficient equipment, ranging from LED lighting to inverter ACs and variable speed motors in pumps/fans, further enhances overall efficiency (Yeh & Chung, 2009). Additionally, strategies like waste reduction through design improvements, retrocommissioning, and behavior change initiatives play a crucial role in minimizing transmission, distribution, and heat losses (Yang, 2015).

The evolution of purpose-built offices, marked by industrialization and organizational growth in the 18th century (Adamolekun, 2017), has witnessed contemporary variants emphasizing resilience, flexibility, and collaboration. Modern office features include open floor plans, mixed private and shared workstations, conferencing facilities, pantry spaces, and more (Shorr, 2017). Technological and sustainability considerations are gaining prominence, with the integration of smart automation, onsite renewables, and passive cooling systems aimed at enhancing efficiency and occupant experience (Jahanger et al., 2023). Given their role as economic centers facilitating decision-making, the enhanced energy performance of office buildings carries immense socio-economic value.

In tropical regions like Nigeria, where solar heat gain and ventilation efficacy are primary façade design concerns (Umar et al., 2021), specific strategies are essential for high-rise office buildings. These include limited glazing and shading devices on east/west orientations to minimize heat gain, double glazing with low emissivity coatings to reduce solar transmission through glass, and natural ventilation schemes alongside passive downdraft evaporative cooling techniques for thermal comfort (Umar et al., 2021). Siting workstations along north/south facades for quality daylight penetration (Li, Liu, & Peng, 2020), providing occupant controls over conditions to boost tolerance to wider temperature bands and enhance efficiency (Naylor, Gillott, & Lau, 2018), and implementing building automation systems integrating sensors, controls, and analytics to optimize performance (Aste, Manfren, & Marenzi, 2017) are additional considerations for tropical high-rises.

3. METHODOLOGY

This study employed a quantitative approach using a structured questionnaire to assess the adoption of energy-efficient practices among architects involved in designing high-rise commercial buildings in Lagos, Nigeria. The methodology was designed to evaluate knowledge levels, utilization rates, and barriers associated with major energy efficiency systems in the context of high-rise commercial architecture.

The research process began with a thorough review of existing academic literature to establish a strong theoretical foundation and identify key areas of inquiry. This review informed the development of the research instruments and helped contextualize the study within the broader field of sustainable architecture and energy-efficient building design. The study population comprised registered and actively practicing architects in Lagos who have designed or participated in the design of high-rise commercial or office buildings. This specific criterion was established to ensure the reliability and relevance of the responses. Focusing on architects with direct experience in high-rise commercial projects aimed to gather insights from professionals with practical knowledge of the challenges and opportunities in implementing energy-efficient strategies in these complex structures.

A stratified random sampling method was employed, utilizing professional body databases such as the Architects Registration Council of Nigeria (ARCON) and the Nigerian Institute of Architects (NIA). The stratification process considered multiple factors to ensure a representative sample. Architects were categorized based on their involvement in high-rise commercial or office building projects, ensuring all respondents had relevant experience. Participants were grouped according to their years of professional experience, allowing for insights from both seasoned professionals and newer practitioners. Architects from various firm sizes were included to capture diverse perspectives that might be influenced by organizational resources and capacities.

The sample size was determined based on Krejcie and Morgan's table, considering a 95% confidence interval with a 5% margin of error. This statistical approach resulted in a sample of 75 architects, providing a balance between representativeness and feasibility. The sampling approach ensures relevance by focusing on architects with specific high-rise commercial building experience; achieves representativeness through stratification across experience levels and firm sizes; and maintains reliability by selecting respondents from official, recognized professional databases.Data collection was conducted through a structured questionnaire designed to address key areas of interest. The questionnaire covered demographic attributes, including age, years of experience, educational qualifications, and professional affiliations. This demographic information allows for potential correlations between these factors and energy efficiency knowledge or adoption rates. The questionnaire also assessed knowledge levels regarding renewable technologies and passive architecture, providing insights into the theoretical understanding of energy-efficient practices among the surveyed architects.

A crucial component of the questionnaire focused on the frequency of adoption for diverse efficiency techniques specifically in high-rise commercial building designs. This section aimed to bridge the gap between theoretical knowledge and practical application, offering a clear picture of how often various energy-efficient strategies are implemented in real-world projects. Additionally, the questionnaire explored factors hindering the integration of energy-efficient practices into designs, seeking to identify the primary obstacles faced by architects in Lagos. This information is vital for developing targeted interventions to promote wider adoption of energy-efficient practices. The questionnaire also solicited suggestions for propagation strategies among industry stakeholders, aiming to uncover potential avenues for disseminating knowledge and encouraging widespread adoption of energy-efficient practices in high-rise commercial building design.

To ensure the validity and reliability of the research instrument, a pilot study was conducted involving five architects with extensive experience in high-rise commercial building design in Lagos. This pilot study served multiple purposes: it helped refine the questionnaire, ensuring clarity and relevance of questions; it verified that the instrument effectively captured the required data; and it allowed for preliminary testing of data analysis procedures.

The data analysis process employed both descriptive and inferential statistical methods. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the responses and provide an overall picture of energy efficiency adoption and knowledge levels. Inferential statistics, such as chi-square tests and correlation analyses, were employed to examine relationships between variables (e.g., firm size and adoption rates) and test hypotheses about factors influencing energy efficiency implementation in high-rise commercial buildings.

Throughout the research process, ethical considerations were paramount. The study adhered to ethical research principles, including informed consent, confidentiality, and the right to withdraw. Participants were fully informed about the study's purpose, the use of their data, and their rights before agreeing to participate. This ethical approach not only protected the participants but also helped to ensure the integrity and credibility of the research findings.

This methodology was designed to provide a reliable and nuanced assessment of energy efficiency adoption in high-rise commercial building designs in Lagos. By focusing on architects with relevant experience, using a stratified sampling approach, and employing a carefully designed and validated questionnaire, the study aimed to gather insights that accurately reflect the current state of energy-efficient practices in the industry. The resulting data and analysis offer valuable insights into the challenges and opportunities for promoting sustainable, energy-efficient design in Lagos's rapidly evolving urban landscape.

4. DATA ANLYSIS AND DISCSSION

4.1 Introduction

This chapter presents the analysis and discussion of data collected through the questionnaire survey. The analysis is structured to address the research objectives systematically, incorporating relevant literature to contextualize the findings.

4.2 Energy Efficiency Strategies in Office Buildings

A review of existing literature reveals several key energy efficiency strategies applicable to office buildings. These strategies can be categorized into five main groups as shown in Table 1 below.

Table 1: Energy Efficient Strategies Applied in Office Buildings

S/N	Energy efficiency strategies	Description
i	Renewable energy	Solar energy
		Wind energy
		Hydro energy
		Geo-thermal energy
		Bio-fuels
ii	Passive design	Building Orientation
		Building form
		Natural ventilation
		Shading devices
		Landscaping
		Use of sustainable materials
		Thermal insulation
iii	Smart technologies	Smart doors
		Smart lighting
		Smart HVAC systems
iv	Low energy appliances	The use of low energy appliances and equipment
V	Reduction of energy waste	The use of systems to prevent energy waste such as a Building Management System (BMS)

Source: Adopted from Adewale & Ene (2024)

The literature indicates that the integration of these strategies can significantly reduce energy consumption in office buildings. For instance, Pérez-Lombard et al. (2008) and Adewale & Ene (2024) found that passive design strategies alone can reduce energy consumption by up to 40% in commercial buildings. Similarly, Ahmad et al. (2016) demonstrated that the implementation of smart technologies, particularly in lighting and HVAC systems, can lead to energy savings of 20-30%.

4.3 Analysis of Energy Efficiency Knowledge and Adoption Levels

4.3.1 Demographic Profile of Respondents

The study collected demographic data to contextualize the responses and identify potential correlations with knowledge and adoption levels.

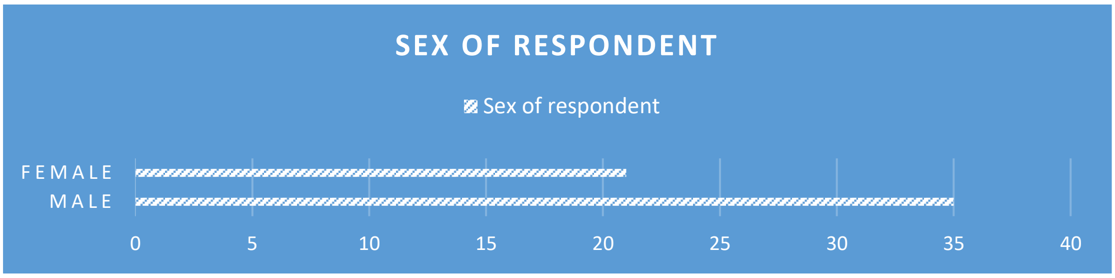

Figure 1: Sex of respondent

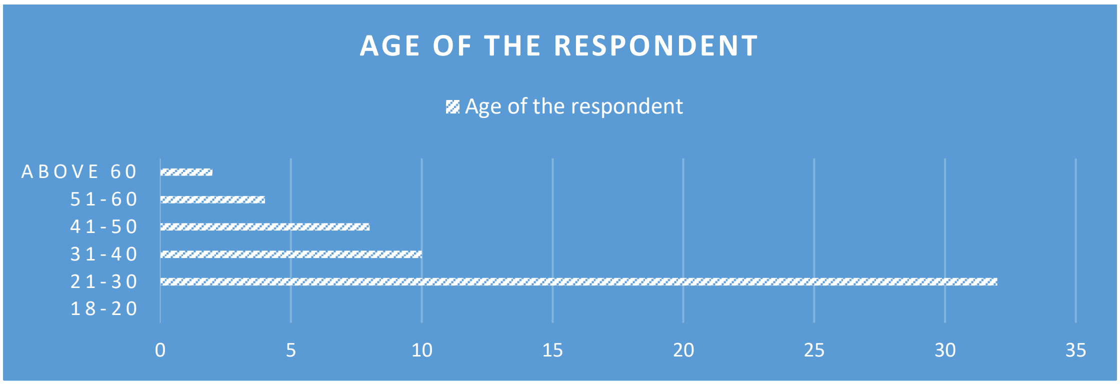

Figure 2: Age of the respondent

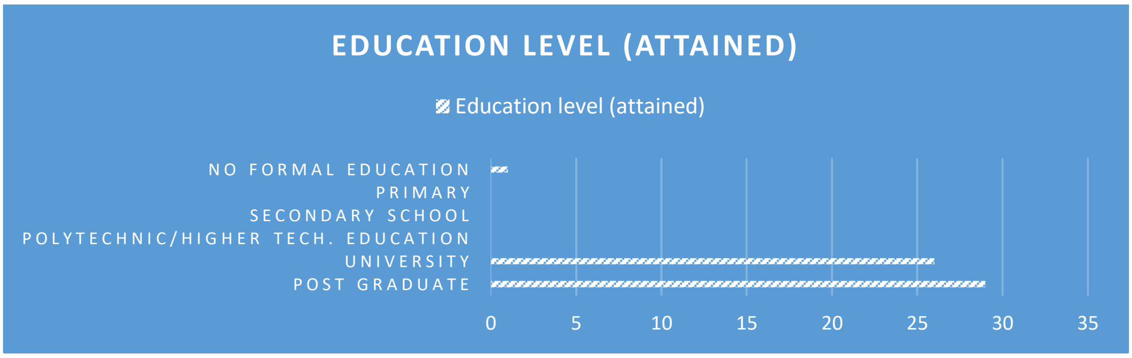

Figure 3: Education level of the respondent

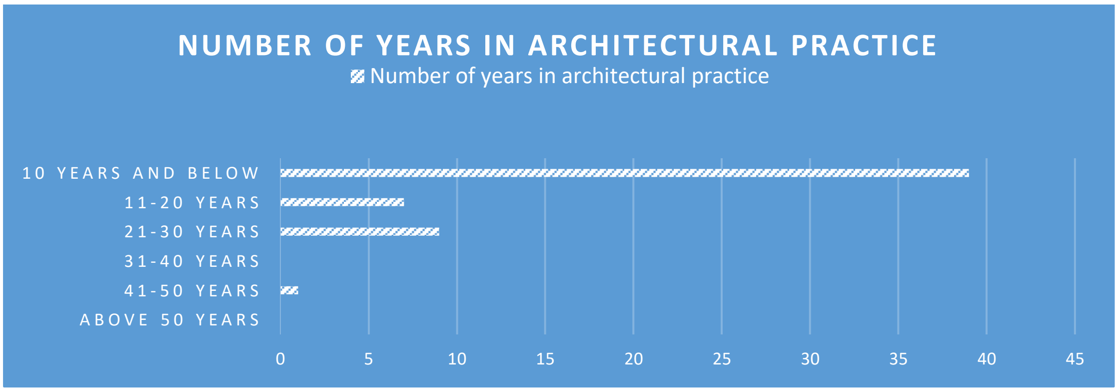

Figure 4: Years of professional Architectural practice

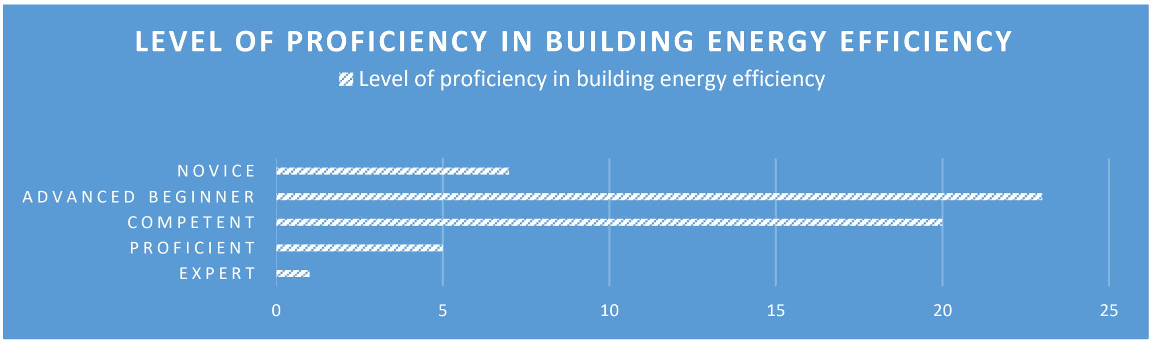

Figure 6: Level of proficiency in building energy efficiency

The demographic data reveals a predominantly young workforce (57.1% aged 21-30), with high educational attainment (51.8% with postgraduate degrees). However, the majority (69.6%) have less than ten years of professional experience. This demographic profile suggests a potential gap between theoretical knowledge and practical experience in energy-efficient design.

4.3.2 Knowledge Levels of Energy Efficiency Strategies

To assess knowledge levels, respondents were asked to self-evaluate their understanding of various energy efficiency strategies on a scale from Poor to Excellent

Table 2: Knowledge Levels of Energy Efficiency Strategies

Sub-Theme	Poor	Fair	Average	Good	Excellent
Renewable Energy knowledge	1	3	7	32	13
Passive design principle knowledge	0	3	9	27	17
Smart Technology knowledge	2	4	14	30	6
knowledge on Low energy appliances and equipment	0	3	17	32	4
knowledge on reduction of energy waste	1	4	15	30	5

Source: Authors' field work, 2024

The data indicates generally high levels of self-reported knowledge across all strategies. However, it's important to note that this represents perceived knowledge rather than objectively measured competence. Future studies could benefit from incorporating objective knowledge assessments to validate these self-reports.

4.3.3 Adoption Levels of Energy Efficiency Strategies

The adoption levels were assessed by asking respondents to indicate the frequency with which they implement various energy efficiency strategies in their designs. The adoption of energy efficiency strategies among architects in Lagos reveals a nuanced landscape. Solar energy dominates renewable sources, aligning with Nigeria's high solar potential (Ohunakin et al., 2014), while passive design principles, particularly building orientation and form, are frequently applied, adhering to tropical climate recommendations (Adewale & Ene, 2024).

Natural ventilation relies more on simple strategies like windows than complex systems like atria. Shading devices, especially roof shading, are widely used, reflecting the need to mitigate solar heat gain. Landscaping focuses on ground-level elements rather than roof gardens. Sustainable materials are preferred over insulating ones, possibly due to availability or climate-specific needs. Smart technology adoption varies, with lighting systems more common than HVAC or building management systems. Low-energy appliances, particularly LED lighting and efficient HVAC systems, are frequently adopted. These trends indicate active engagement with energy efficiency, influenced by local climate, economic factors, and technological familiarity, suggesting areas for targeted improvement in comprehensive energy-efficient design practices.

Table 3: Respondents Adoption Levels of Energy Efficiency Strategies

Sub-Theme	Very Rarely	Rarely	Sometimes	Often	Very Often
Renewable Energy Strategies					
Frequency of application of solar panels	0	6	16	27	7
Frequency of the use of wind energy	39	12	3	2	0
Frequency of the use of hydro energy	40	8	4	3	1
Frequency of the use of bio energy	40	11	2	2	1
Frequency of the use of thermal energy	39	10	4	2	1
Passive Design Strategies					
Building orientation consideration	1	10	17	18	10
Building form consideration	0	10	21	19	6
Natural Ventilation					
Using windows and openings for natural ventilation in designs	0	0	8	22	26
Using atrium (for stack effect ventilation) designs	3	13	20	14	6
Using vent windows (for the dissipation of heated air) in designs	2	10	18	21	5
Adopting courtyards in designs	2	10	19	16	9
Shading Devices					
Using roof shading (eaves) in designs	0	1	6	35	14
Using overhanging shadings in designs	2	5	23	22	4
Using louvers and awnings in designs	2	5	23	22	4
Using buffer zones in designs	1	4	22	23	6
Landscaping					
Including trees in designs	0	0	9	31	16
Including green and soft elements (shrubs, grass, hedges and bushes) in designs	0	1	9	27	19
Including roof gardens in designs	2	13	19	17	5
Materials And Finishes					
Adopting the use of sustainable building materials	0	5	18	28	5
Adopting the use of insulating materials in designs	1	11	25	17	2
Smart Technologies					
Adopting the use of Smart/Motion sensor lighting	2	6	27	17	4
Adopting the use of smart HVAC systems in designs	2	12	24	14	4
Adoption of smart doors in designs	3	17	22	12	2
Adoption of the use of smart metering in designs	5	15	20	15	1
Adoption of smart building management systems in designs	10	16	17	13	0
Use Of Low Energy Appliances And Fittings					
Adoption of LED lighting in designs	0	3	10	19	24
Adopting the use of low energy HVAC systems (air conditioners, fans, heaters, e.t.c)	0	3	12	26	15
Adoption of low energy appliances in designs	0	3	18	25	10

Source: Authors' field work, 2024

4.4. Challenges Hindering Energy Efficiency Adoption

The study identified several key factors influencing the adoption of energy efficiency strategies:

The data suggests that client budget is the most significant factor influencing adoption, followed by client knowledge and available technology. This aligns with findings by Ametepey et al. (2015), who identified financial constraints as a major barrier to green building adoption in developing countries.

4.4.2. Summary of the Analysis for Objective Three

The purpose of objective four was to evaluate the many aspects that influence the responding architect's use of energy-saving techniques in their building designs. According to the findings, the vast majority of architects who responded said they were now aware of energy-efficient construction techniques and that their adoption of these tactics in their designs was influenced by the accessibility of technology and building expertise. A greater number of participants reported that the incorporation of energy efficiency measures into building design is contingent upon the client's awareness of these strategies. However, the majority of respondents said that the most common factor influencing the adoption of energy efficiency in building design is the client's budget. This suggests that the factor having the biggest influence on the respondent architects' actual use of energy-efficient building design techniques.

Table 4: Challenges Hindering Energy Efficiency Adoption

Sub-Theme	Very Rarely	Rarely	Sometimes	Often	Very Often
The architect's current knowledge of energy efficiency strategies affect his/her adoption of the strategies in designs	0	5	19	26	6
The client's knowledge of energy efficiency strategies affects the architect's adoption of the strategies in designs	0	3	18	31	4
The client's budget affects the adoption of the energy efficiency strategies in designs	0	1	3	19	33
The available technology and building skills affect my adoption of energy efficiency strategies in my design	0	7	17	22	9

Source: Authors' field work, 2024

4.5. Discussion

The findings of this study reveal a complex landscape of energy efficiency knowledge and adoption among architects in Lagos, which both aligns with and diverges from existing literature in several key areas.

The high self-reported knowledge levels among architects are consistent with the growing global awareness of energy efficiency in building design, as noted by Lucon et al. (2014) in the IPCC Fifth Assessment Report. However, the discrepancy between knowledge and adoption rates echoes the findings of Ametepey et al. (2015), who identified a gap between awareness and implementation of green building practices in developing countries.

The prevalent adoption of passive design strategies and natural ventilation techniques aligns with recommendations by Adewale & Ene (2024) and Givoni (1994) for tropical climates. This trend is particularly encouraging given the climatic conditions of Lagos and supports the findings of Lawal and Ojo (2011), who emphasized the suitability of these strategies for the Nigerian context. The preference for these low-tech solutions over more advanced systems is consistent with observations by Iwaro and Mwasha (2010), who noted the challenges of implementing high-tech energy efficiency measures in developing countries.

The dominance of solar energy among renewable strategies corroborates the findings of Ohunakin et al. (2014), who highlighted the high potential for solar energy in Nigeria. However, the low adoption of other renewable sources contrasts with global trends reported by REN21 (2020), suggesting a need for diversification in the local context.

The varied adoption of smart technologies, with a preference for lighting systems over HVAC or building management systems, reflects the global trend of incremental adoption of smart building technologies noted by Ghaffarianhoseini et al. (2016) and Adewale & Ene (2024). This pattern suggests a cautious approach to technology integration, possibly due to cost considerations or technical limitations.

The identified challenges, particularly client budget constraints, echo the findings of Darko and Chan (2017), who identified financial concerns as a major barrier to green building practices in developing countries. This highlights the need for innovative financing mechanisms and policy interventions, as suggested by Oyedepo (2012) for the Nigerian context. The preference for sustainable materials over insulating ones diverges from trends in temperate climates but aligns with climate-specific recommendations for tropical regions by Szokolay (2004). This suggests a nuanced understanding of local climatic needs among Lagos architects.

Overall, these findings indicate that while Lagos architects are engaging with energy efficiency principles, there is a need for targeted interventions to bridge the gap between knowledge and implementation. This aligns with the broader literature on sustainable building practices in developing countries (Du Plessis, 2007; Serpell et al., 2013; Adewale & Ene, 2024) and highlights the importance of context-specific strategies in promoting energy efficiency in building design.

4.5.5. Study Limitations

This study, while providing valuable insights, has several limitations that point to opportunities for future research:

1) Self-reported data: The reliance on self-reported knowledge and adoption rates may introduce bias. Future studies could incorporate objective measures of knowledge and verify adoption through building performance data or case studies.
2) Focus on architects: While crucial, the architect-centric approach doesn't capture the full picture of energy efficiency adoption. Future research could include perspectives from clients, contractors, policymakers, and end-users for a more comprehensive understanding.
3) Cross-sectional nature: The study provides a snapshot of current practices but doesn't capture changes over time. Longitudinal studies could offer insights into evolving adoption patterns and the long-term impacts of interventions.
4) Limited exploration of solutions: While barriers are identified, the effectiveness of potential solutions isn't deeply explored. Future research could evaluate the impact of specific interventions such as policy changes, education programs, or financial incentives.
5) Geographical limitation: The focus on Lagos limits generalizability. Comparative studies across different Nigerian cities or other African countries could provide insights into the role of local contexts in shaping energy efficiency adoption.

6) Quantitative approach: The study's quantitative nature may miss nuanced insights. Mixed-method approaches, incorporating qualitative data, could provide deeper understanding of motivations and challenges.
7) Limited scope of energy efficiency measures: While covering major strategies, the study may not encompass all relevant measures. Future research could explore emerging technologies and innovative approaches to energy efficiency.
8) Lack of economic analysis: The study doesn't delve into the cost-benefit aspects of adopting energy efficiency measures. Future research could include economic analyses to support decision-making.

Addressing these limitations in future research would contribute to a more comprehensive understanding of energy efficiency adoption in the building sector, particularly in developing urban contexts, and could inform more effective strategies for promoting sustainable building practices.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

This study has provided valuable insights into the adoption of energy efficiency strategies by architects in Lagos, Nigeria. The research reveals a complex landscape where theoretical knowledge of energy efficiency principles is generally high, but practical adoption varies significantly across different strategies. Key findings include a prevalence of passive design strategies and natural ventilation techniques, which are well-suited to Lagos' tropical climate. Solar energy dominates as the preferred renewable energy source, while other forms are rarely utilized. Adoption of smart technologies is uneven, with lighting systems being more commonly implemented than HVAC or building management systems. Low-energy appliances, particularly LED lighting and efficient HVAC systems, are widely adopted. Client budget constraints emerge as the most significant barrier to implementing energy efficiency measures. These findings highlight a growing awareness of energy efficiency principles among Lagos architects but also reveal gaps between knowledge and implementation. The study underscores the influence of local climate, economic factors, and technological familiarity on energy efficiency adoption in building design.

5.2 Recommendations

Based on the study's findings, several recommendations are proposed. Firstly, developing targeted training programs for architects is essential to bridge the gap between theoretical knowledge and practical implementation of energy efficiency strategies. Secondly, advocating for government policies that incentivize the adoption of energy-efficient building practices, such as tax breaks or expedited permit processes for buildings meeting certain efficiency standards, would be beneficial. Exploring innovative financing options, such as green building loans or energy performance contracting, can help overcome budget constraints. Additionally, promoting underutilized technologies, particularly in renewable energy and smart building systems, through demonstration projects and knowledge-sharing platforms is recommended. Educating clients on the long-term benefits of energy-efficient buildings, including potential cost savings and improved occupant comfort, is crucial. Developing energy efficiency standards and guidelines specific to Lagos' climate and building typologies would further support sustainable practices. Fostering partnerships between architects, engineers, contractors, and suppliers can create an ecosystem that supports energy-efficient building design and construction. Investing in research to adapt global energy efficiency technologies to the local context and develop innovative solutions suited to Lagos' unique environmental and economic conditions is also important. Implementing post-occupancy evaluations and energy performance monitoring to provide data on the effectiveness of various energy efficiency strategies in real-world conditions can enhance future practices. Finally, establishing recognition programs or certifications for architects and firms demonstrating excellence in energy-efficient design can incentivize higher standards.

By implementing these recommendations, Lagos can make significant strides towards a more energy-efficient building stock, contributing to sustainable urban development and mitigating the impacts of climate change. Future research should focus on evaluating the effectiveness of these interventions and exploring emerging technologies and approaches to further advance energy efficiency in the built environment.

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