Understanding Energy Use and Occupant Behavior in Office Buildings: Evidence from Dugbe, Ibadan

OYENEYE F. T.[1], AYINLA A.K.[2], ALAO R.[3]
[1,2,3]*Department of Architectural Ladoke Akintola University of Technology Ogbomoso, Nigeria*

Abstract- ***As Nigerian cities continue to urbanize and commercial activities intensify, energy demand in office buildings has risen significantly. These buildings, particularly in urban centers like Dugbe, Ibadan, consume substantial amounts of electricity due to extensive use of lighting, HVAC systems, and office equipment. While technological interventions have targeted efficiency, the behavioral patterns of occupants remain underexplored in energy studies. This study investigates how user behavior influences energy consumption in selected commercial office buildings in Dugbe and evaluates the effectiveness of existing energy efficiency measures. A quantitative survey method was employed, involving 246 respondents selected from five randomly chosen office buildings in Dugbe. Data were collected using structured questionnaires and analyzed using descriptive statistics. The findings reveal that the excessive use of electrical equipment, HVAC systems, artificial lighting, and building size are major drivers of energy consumption. Furthermore, while there is encouraging adoption of renewable energy sources (76.8%) and energy-efficient appliances (61.8%), areas such as HVAC upgrades (43.6%), smart energy monitoring (50.6%), and automated lighting controls (46.1%) remain underutilized. Occupant awareness also emerged as a key factor influencing energy use. The study concludes that both behavioral and infrastructural elements are critical in managing energy use in office buildings. It recommends targeted awareness campaigns, increased adoption of efficient technologies, and stronger institutional policies to promote sustainable energy practices in Nigeria's commercial sectors.***

Indexed Terms- ***Energy consumption, occupant behavior, energy efficiency, office buildings, Dugbe, Ibadan, Nigeria.***

I. INTRODUCTION

The rapid pace of urbanization and industrial development in Nigerian cities has led to a steady increase in energy consumption, particularly within the commercial sector. Office buildings, which serve as essential centers for administrative, managerial, and business operations, consume large amounts of electricity for lighting, heating, ventilation, air conditioning (HVAC), and office equipment (Ghazanfari et al., 2019). As these structures continue to multiply across urban Nigeria, their energy demand places significant pressure on already strained power systems and contributes to increased greenhouse gas emissions. The building sector globally accounts for about 39% of total energy consumption, a figure that underscores its centrality to energy and climate policy debates (Somu et al., 2020).

In Nigeria, where access to electricity is often inconsistent and energy costs are high, the need to enhance efficiency in the use of energy has become a matter of economic and environmental urgency. Technological interventions, such as the installation of energy-efficient lighting systems or HVAC upgrades, have been promoted as solutions. However, mounting evidence suggests that these technologies alone may not produce significant savings unless supported by appropriate user behavior. Occupants play a pivotal role in shaping the actual energy performance of buildings. Behavioral patterns such as excessive use of lighting, neglecting to turn off appliances, or misusing cooling systems can offset potential gains from efficiency upgrades (Masoso & Grobler, 2010; Hong et al., 2016).

Despite a growing body of literature on energy consumption in Nigerian buildings, research has predominantly focused on residential settings or

metropolitan areas like Abuja and Lagos, often overlooking the behavioral dimension of energy use (Aliyu & Abubakar, 2018; Oyeleke, 2018; Ezema & Maha, 2022). Moreover, most studies have approached energy performance from a design or policy perspective, paying insufficient attention to how everyday user practices impact consumption. Harputlugil and de Wilde (2021) emphasize the importance of situating energy use within its local context, noting that strategies detached from behavioral realities are less likely to succeed. There is a pressing need to understand how individuals and organizations interact with building systems and how those interactions influence energy use in practice.

This study focuses on Dugbe, the commercial and administrative core of Ibadan, the capital city of Oyo State in southwestern Nigeria. Dugbe is located in the Ibadan North-West Local Government Area, with geographic coordinates approximately at latitude 7° 23′ 15″ N and longitude 3° 52′ 46″ E. As the city's most vibrant economic hub, Dugbe houses a diverse range of office buildings, including government complexes, private banks, insurance companies, media houses, and administrative headquarters. Notable landmarks in the area include Cocoa House, the tallest building in West Africa at the time of its construction, and the Femi Johnson Glass House, alongside several mid-rise commercial and institutional buildings. These offices differ in age, design, and technological sophistication, yet they all contribute to the collective energy profile of the district.

Despite the strategic significance of Dugbe, little empirical research has examined the specific ways in which energy is consumed within its office buildings, especially from the perspective of occupant behavior. The few existing studies that touch on commercial energy use rarely capture the micro-level decisions made by building users that influence overall consumption. This knowledge gap limits the development of context-sensitive energy-saving strategies tailored to Nigerian urban centers beyond the most studied cities. Understanding how occupants behave in relation to energy use, and how such behavior interacts with existing efficiency measures, is critical for improving energy outcomes and sustainability in commercial buildings.

The purpose of this study is to explore how occupant behavior influences energy consumption in selected office buildings in Dugbe, Ibadan, and to assess the effectiveness of existing energy efficiency strategies within these settings. The research specifically seeks to evaluate the behavioral factors shaping energy use among office workers and to examine the strategies currently employed to manage and reduce energy demand. By doing so, the study seeks to contribute empirical evidence that supports the design of more user-aware, sustainable energy interventions for commercial office environments in Nigeria.

II. LITERATURE REVIEW

Energy consumption in buildings has attracted increasing attention due to its significant contribution to global energy demand and environmental degradation. According to the International Energy Agency (IEA, 2021), buildings account for approximately 40% of total global energy use and nearly one-third of greenhouse gas emissions. Commercial buildings, especially office structures, consume large amounts of energy through lighting, HVAC systems, equipment use, and other operational demands. As Nigeria continues to urbanize rapidly, commercial office buildings in major urban centers such as Ibadan are becoming substantial energy consumers due to prolonged usage patterns and the demand for thermal comfort and productivity-enhancing environments.

Energy use in office buildings is influenced not only by physical systems and architectural design but also by user behavior. As Harputlugil and de Wilde (2021) argue, the interaction between humans and buildings significantly determines the actual energy performance. Factors such as lighting habits, temperature preferences, and appliance usage all reflect behavioral dimensions that impact energy outcomes. Hong et al. (2016) further emphasize that energy-efficient technologies often fail to achieve expected results due to lack of behavioral compliance or awareness among occupants.

In Nigeria, limited studies have examined these human factors in depth, particularly in office buildings. For instance, Masoso and Grobler (2010) observed that 56% of energy consumption in

commercial buildings occurred during off-peak hours due to occupants leaving lights and devices on after work. This aligns with Virote and Neves (2014), who emphasized that unregulated occupant activities often result in excessive and wasteful energy usage. Despite these findings, most existing studies in Nigeria have concentrated on residential or institutional buildings, creating a significant knowledge gap in the commercial office sector, especially in mid-sized cities like Ibadan.

Several studies have assessed the technical aspects of energy efficiency in Nigerian office buildings. For example, Aliyu and Abubakar (2018) evaluated energy optimization in Abuja's office buildings, while Ezema and Maha (2022) investigated high-rise offices in Lagos. However, Dugbe a key commercial node in Ibadan remains underexplored despite its concentration of diverse office buildings and notable energy intensity. The lack of localized research makes it difficult to generalize existing solutions to this context, where the interplay between user behavior and outdated systems creates unique consumption patterns.

In terms of factors influencing energy consumption, the design and orientation of buildings play critical roles in regulating heat gain, natural lighting, and ventilation. Morrissey et al. (2011) noted that building envelope characteristics significantly affect thermal loads and, consequently, energy demand for cooling or heating. HVAC systems and lighting are consistently identified as the most energy-intensive components of office buildings, especially in tropical climates like that of southwestern Nigeria. Equipment such as computers, printers, and cooling appliances also contribute substantially to energy loads, especially where outdated or inefficient models are used (IEA, 2017; The Carbon Trust, 2018).

Occupant behavior remains one of the most unpredictable yet impactful variables in energy studies. Hong et al. (2016) outlined key behavioral factors such as equipment usage patterns, thermostat adjustments, and movement patterns within office spaces. These behaviors are shaped by personal comfort preferences, institutional culture, and the availability of control mechanisms. Studies have shown that without user training or behavioral interventions, even the most advanced energy systems may underperform (Kaveh, 2023; Elham & Javad, 2018).

To mitigate high energy usage, a variety of energy efficiency strategies have been proposed and tested. These include the installation of LED lighting, inverter air conditioners, smart meters, and solar photovoltaic systems. In Dugbe, recent surveys have shown a growing but uneven adoption of these technologies. For instance, while 76.8% of surveyed buildings had adopted solar power, only 51.5% had transitioned to LED lighting, and less than half utilized smart energy meters or efficient HVAC systems. This uneven uptake suggests structural and behavioral barriers to implementation that warrant further investigation.

Lastly, the presence of energy-efficient systems does not automatically guarantee performance. As Ofori-Boadu et al. (2015) noted, regulatory enforcement, awareness campaigns, and monitoring frameworks are essential to ensuring sustainable energy practices in buildings. These measures are particularly relevant in contexts like Dugbe, where many buildings operate without regular audits or energy performance benchmarks.

III. METHODOLOGY

This study was carried out in Dugbe, a central commercial district in Ibadan North-West Local Government Area of Oyo State, Nigeria. Geographically, Dugbe is located at approximately latitude 7° 23' 15.22" N and longitude 3° 52' 46.31" E.

The study adopted a quantitative research approach, utilizing a survey research design to investigate behavioral influences on energy consumption and assess existing energy efficiency measures in commercial office buildings. Data were collected through a structured questionnaire administered to office occupants across selected buildings in the study area.

A multistage sampling technique was employed. In the first stage, Dugbe was purposively selected due to its concentration of diverse office building types and

its role as the commercial epicenter of Ibadan. In the second stage, five office buildings were randomly selected from a comprehensive list of 31 identified office buildings in the area. The selected buildings included: Cocoa House, Oduduwa Cooperative Conglomerate Building, Femi Johnson Broking House, Oxford House, and the Federal Mortgage Bank of Nigeria building.

From these five buildings, the target population comprised 640 office occupants. Using Slovin's formula at a 95% confidence level and 0.05 margin of error, a sample size of 246 respondents was determined. This sample represents approximately 38% of the total population of office users in the selected buildings.

Questionnaires were administered randomly to the occupants during peak working hours (10:00 AM to 2:00 PM) on Mondays, Tuesdays, and Wednesdays, periods identified as the most active within the week. The questionnaire captured information on energy-use behavior, awareness of energy efficiency practices, and user interaction with energy-consuming systems such as lighting, HVAC, and office equipment.

The data collected were analyzed using descriptive statistical tools, including frequencies, means, percentages, and graphical illustrations

IV. RESULTS AND DISCUSSION

Factors Influencing Energy Consumption in Office Buildings in the Study area

The data in Table 1 presents respondents' responses on factors influencing energy consumption in their office buildings within selected commercial buildings in Dugbe, Ibadan. HVAC systems (heating, ventilation, and air conditioning) stand out as a significant factor, with 88.0% of respondents acknowledging it as a key contributor to energy consumption. This is closely followed by the excessive use of electrical equipment, which 93.4% of respondents identified as a major factor influencing energy consumption. Additionally, the use of artificial lighting also contributes notably to energy consumption, with 78.4% of respondents identifying it. The size of the building was recognized by 80.9% of respondents as another critical factor impacting energy use, showing that larger spaces may demand more energy for lighting, cooling, and equipment usage.

Other factors identified include lack of awareness about energy-saving practices, noted by 72.6% of respondents, and the absence of energy-efficient appliances, which 31.1% of respondents cited as a contributing factor. Moreover, a poor energy management system was identified by 29.9% of respondents as influencing energy consumption. Factors such as the use of diesel generators and lack of sufficient insulation were recognized to a lesser extent, with 27.0% and 23.2% of respondents respectively considering them influential. The design and orientation of buildings were considered the least influential factor, with only 17.4% of respondents viewing it as a significant contributor to energy consumption.

Overall, the data reveal that both infrastructural and operational factors play crucial roles in energy usage within these office buildings, with HVAC systems and electrical equipment usage being primary drivers.

Implication

The data in Table 4.3 show that the most influential factor affecting energy consumption in commercial office buildings in Dugbe, Ibadan, is the excessive use of electrical equipment, as identified by 93.4% of respondents. This reveals the significant impact that operational practices have on energy use within these buildings. HVAC systems (88.0%) also play a crucial role, demonstrating that the climate control systems are major contributors to energy demand. Additionally, artificial lighting, identified by 78.4% of respondents, along with the building size (80.9%), further emphasizes that both the operational and structural elements of the buildings contribute substantially to energy consumption. This study shows that to effectively reduce energy use, a combination of improving equipment efficiency, optimizing HVAC systems, and considering building design and size is essential.

On the other hand, factors such as a lack of awareness about energy-saving practices (72.6%) and the absence of energy-efficient appliances (31.1%)

point to a need for education and better technology adoption to manage energy consumption more effectively. While some respondents identified poor energy management systems (29.9%) and other less influential factors like diesel generators (27.0%) and poor insulation (23.2%), these were seen as secondary contributors compared to the more prominent factors. The design and orientation of buildings were the least influential factor, with only 17.4% recognizing its impact. Overall, the data show that both operational habits and building infrastructure need attention in energy conservation efforts, with a particular focus on modernizing equipment and systems, raising awareness, and implementing efficient energy manasgement practices.

Table 1: Factors Influencing Energy Consumption in Office Buildings in the Study area

Respondents response to factors Influencing Energy Consumption in Office Buildings in the Study area	Freq.	%	Total (Freq)
Building's design and orientation	42	17.4	241
Lack of sufficient insulation	56	23.2	241
Size of the building	195	80.9	241
HVAC (heating, ventilation, and air conditioning)	212	88.0	241
Absence of energy-efficient appliances	75	31.1	241
Use of artificial lighting	189	78.4	241
Excessive use of electrical equipment	225	93.4	241
Use of diesel generator	65	27.0	241
Poor energy management system	72	29.9	241
Lack of awareness on energy saving	175	72.6	241

Source: Author's Field Survey, 2024

Energy Efficiency Measures in Office Buildings

The data from Table 2 presented the respondents response on the energy efficiency measures in their buildings across the selected commercial buildings in Dugbe, Ibadan. Regarding energy-efficient lighting systems, such as LED bulbs, 51.5% of respondents confirmed their adoption, while 48.5% reported a lack of these systems. This moderate uptake shows that while some office buildings are moving towards more efficient lighting options, nearly half still use conventional, less efficient lighting, which could increase energy consumption. Solar energy appears to be one of the most widely adopted renewable energy sources, with 76.8% of respondents indicating its use as an alternative power source. This high percentage reveals a strong shift towards renewable energy in the buildings surveyed, signaling a commitment to reducing reliance on traditional energy sources.

Energy-efficient HVAC systems have been installed in only 43.6% of the buildings, meaning that 56.4% still rely on potentially outdated and less efficient heating, ventilation, and air conditioning systems. This shows that a majority of buildings may still consume more energy for climate control than necessary, revealing an area for potential improvement in energy efficiency. Smart energy meters or monitoring systems, used to track and manage energy consumption, are present in 50.6% of the buildings, showing an even split between those utilizing monitoring systems and those that are not. Effective tracking will help buildings better understand and optimize their energy usage, so the lack of monitoring in nearly half of the buildings might be a barrier to achieving optimal efficiency.

In terms of building design features that maximize natural lighting, only 49.0% of respondents reported such features in their buildings. This show that many buildings still rely on artificial lighting during daytime hours, potentially increasing energy costs and consumption. A substantial proportion, 61.8%, reported the use of energy-efficient appliances, such as air conditioners, computers, and refrigerators, in their buildings. This adoption rate shows a positive trend towards reducing energy usage through more efficient appliances, although 38.2% still do not widely use these energy-saving devices.

Building insulation has been optimized to reduce energy loss in 56.0% of the cases. This means that just over half of the buildings have implemented

insulation improvements, which are essential for reducing heating and cooling energy requirements, particularly in areas with significant temperature variations.

Regular energy audits, aimed at assessing and improving energy efficiency, are conducted in 66.0% of the buildings. This relatively high percentage show that many buildings are proactive in monitoring and improving their energy performance, which is a positive indication of awareness and commitment to energy efficiency. The use of renewable energy sources, such as solar panels or wind turbines, has been encouraged or implemented in 68.9% of buildings, supporting the finding that a majority are incorporating sustainable energy sources. However, this leaves 31.1% of buildings that have not yet adopted renewable energy options, presenting an opportunity for increased sustainability. Lastly, automatic lighting controls or motion sensors are in place in 46.1% of the buildings to help reduce energy wastage. This adoption rate shows that a little under half of the buildings lack automated lighting controls. Overall, while there is noticeable progress in adopting energy efficiency measures, such as renewable energy sources, energy-efficient appliances, and regular energy audits, other areas particularly HVAC upgrades, natural lighting features, and automatic lighting controls are less widely implemented.

Implication

The data in Table 2 reveal that energy efficiency measures in Dugbe's commercial buildings show a mix of progress and areas for improvement. Energy-efficient lighting systems, such as LED bulbs, are in use in 51.5% of buildings, while the remaining 48.5% still rely on less efficient lighting, showing room for increased adoption. Solar energy is widely used, with 76.8% of respondents reporting its implementation, showing a strong shift towards renewable energy sources. However, only 43.6% of buildings have energy-efficient HVAC systems, showing that over half still use older systems that could be consuming more energy. Smart energy meters are present in 50.6% of buildings, with the rest lacking this technology, limiting their ability to monitor and optimize energy use effectively.

Additional energy efficiency practices include natural lighting features, which are found in just 49.0% of buildings, and energy-efficient appliances used by 61.8% of respondents. Building insulation is optimized in 56.0% of buildings, helping to reduce heating and cooling demands, while 66.0% conduct regular energy audits, reflecting a proactive approach to managing energy efficiency. Renewable energy adoption stands at 68.9%, though 31.1% of buildings have yet to implement such sources. Automatic lighting controls are in place in 46.1% of buildings, showing another area where energy efficiency can be improved. Overall, the data shows that while renewable energy and energy-saving appliances are relatively common, advancements in HVAC systems, natural lighting, and automated controls could further enhance energy efficiency across Dugbe's commercial buildings.

Table 2: Energy Efficiency Measures in Office Buildings

Statement	Yes		No		Total (Freq)
	Freq.	%	Freq.	%	
The building has adopted energy-efficient lighting systems (e.g., LED bulbs)	124	51.5	117	48.5	241
Solar energy is being utilized as an alternative power source in this building	185	76.8	56	23.2	241
Energy-efficient HVAC (heating, ventilation, and air conditioning) systems have been installed in the building.	105	43.6	136	56.4	241
Smart energy meters or monitoring systems are in use to track and manage energy consumption in the building.	122	50.6	119	49.4	241
The building's design includes features that maximize natural	118	49.0	123	51.0	241

lighting to reduce reliance on artificial lighting.					
Energy-efficient appliances are widely used in the building (e.g., air conditioners, computers, refrigerators).	149	61.8	92	38.2	241
The building's insulation (walls, roof, windows) has been upgraded or optimized to reduce energy loss.	135	56.0	106	44.0	241
Regular energy audits are conducted in the building to assess and improve energy efficiency	159	66.0	82	34.0	241
The use of renewable energy sources, such as solar panels or wind turbines, has been encouraged or implemented.	166	68.9	75	31.1	241
Energy-saving measures, such as automatic lighting controls or motion sensors, are in place to reduce wastage.	111	46.1	130	53.9	241

Source: Author's Field Survey, 2024

CONCLUSION AND RECOMMENDATION

This study assessed the influence of occupant behavior on energy consumption and the adoption of energy efficiency measures in selected office buildings in Dugbe, Ibadan. The findings revealed that energy use is primarily driven by excessive reliance on electrical equipment, HVAC systems, and artificial lighting, with behavioral patterns and building size playing significant roles. While there is notable progress in adopting renewable energy and efficient appliances, the uptake of smart energy meters, modern HVAC systems, and automated lighting remains limited. Moreover, a considerable proportion of occupants lack awareness of energy-saving practices, further exacerbating inefficiencies.

To address these challenges, the study recommends a twofold strategy: first, promoting user education to foster energy-conscious behavior among building occupants; and second, encouraging the wider adoption of efficient technologies such as smart meters, LED lighting, and modern HVAC systems. These interventions, combined with supportive policy frameworks and regular energy audits, are essential to achieving sustainable energy management in Nigeria's commercial office sector.

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