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# ASSESSMENT OF COMPLIANCE OF COMMERCIAL BUILDINGS WITH THE BUILDING ENERGY EFFICIENCY CODE IN KADUNA METROPOLIS

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**ABSTRACT**

*Buildings account for a large share of energy use and emissions, with commercial facilities among the most energy-intensive. This study assesses the level of compliance of shopping malls in Kaduna metropolis with the Nigerian Building Energy Efficiency Code (BEEC). Using a quantitative case-study design, four purpose-built malls (SM1–SM4) were purposively sampled and evaluated via a checklist derived from BEEC and international benchmarks. Walkthrough audits, on-site measurements of Window-to-Wall-Ratio (WWR) glazing, roof insulation, lighting power density, and illuminance were recorded. The results indicate that compliance is inconsistent and often inadequate. None of the SMs had roof insulation. Additionally, all the SMs used single-clear glazing with a Solar Heat Gain Coefficient (SHGC) of approximately 0.78 and a thermal transmittance (U-value) of about 5.8 W/m²K. Several façades exceeded the allowable window-to-wall ratio prescribed by the BEEC, with one orientation reaching nearly 90% WWR. Although three malls met the lighting power density (LPD) limit of 8 W/m², SM3 recorded an LPD of 18.01 W/m². Most HVAC systems in one mall were non-inverter units, with only 22% being inverter types. These deficiencies lead to increased solar gains and cooling loads. Implementing appropriate horizontal shading (between 300 and 900 mm) could reduce cooling demand. Furthermore, switching to inverter HVAC systems can lower compressor energy consumption by up to 50%. Therefore, this study recommends retrofits, including roof insulation, glazing upgrades, shading, HVAC replacement, and improving lighting and controls. To close compliance gaps, it recommends improving verification during permit and construction, requiring post-occupancy monitoring, and offering capacity-building and incentives.*

**KEYWORDS***: Building Energy Efficiency Code; Commercial buildings; Compliance; Energy Efficiency; Kaduna*

## INTRODUCTION

Energy crisis and global warming have been significant issues faced by all developed and developing countries since the 1970s. The building industry accounts for about 40% of total energy consumption and 30% of greenhouse gas emissions, and significant consumption of fossil-fuel-based energy has caused adverse environmental impacts, such as ozone layer depletion, global warming, and climate change (Boyd *et al.,* 2018; Owusu & Asumadu-Sarkodie, 2016). With the continuous development of human society, global energy demand and consumption continue to grow, and the energy problem has become increasingly prominent (Zou, Xu, Sanjayan, & Wang, 2018). In this context, energy conservation has risen to the strategic level of national development, and building energy has become the focus of attention for most countries over the past three decades (Zou *et al.,* 2018).

Many governments have responded by setting building energy efficiency targets and adopting regulatory instruments. The European Union's Energy Performance of Buildings Directive (EPBD) requires all new buildings to meet nearly zero-energy building (NZEB) standards since 2021, integrated with mandatory energy performance certificates to enhance market transparency (Geissler *et al.,* 2018). In the United States, state-level regulatory autonomy results in patchwork adoption of model codes derived from ASHRAE Standard 90.1 and the International Energy Conservation Code (IECC), with leading states such as California implementing advanced standards that incorporate technology evolution and cost-effectiveness assessments (He *et al.,* 2022; Levinson, 2016). Similarly, the United Kingdom aligns Building Energy Efficiency (BEE)within its legally binding net-zero target for 2050, enforcing minimum Energy Performance Certificate (EPC) ratings on privately rented properties and requiring energy performance disclosure to drive market demand for efficiency (Cohen & Bordass, 2015).

Emerging economies have also increasingly recognised the need for tailored energy efficiency policies compatible with local climatic and socio-economic contexts. For instance, Nigeria developed its Building Energy Efficiency Code (BEEC) with a focus on precise, enforceable requirements that support energy-efficient mass housing, given infrastructural and grid constraints (FMPWH, 2017a; Geissler *et al.,* 2018). South Africa and India have introduced analogous codes that tackle rapid urbanisation while aligning with nationally determined contributions to emissions reduction (Yu *et al.,* 2018).

Decisions taken during the design phase strongly influence operational energy use; design choices can therefore reduce building energy consumption and improve building energy performance (Hoes *et al.,* 2009; Wang *et al.,* 2005). Nonetheless, buildings designed to be energy efficient often fail to achieve their expected operational performance, producing a persistent gap between designed and actual performance (Powell, Monaham & Foulds, 2016; Cross, Shelley & Mayer, 2017). Even when energy efficiency measures are economically justified, individuals and firms may not adopt them to the degree that would be expected. This is based on weak enforcement, limited awareness, poor equipment performance, or other barriers (Gerarden *et al.,* 2017; Laustsen, 2008).

The commercial sector is of particular concern. Commercial buildings typically consume much higher energy than residential buildings, often because of longer operating hours, more intensive appliance use and systems that are not designed to respond to variations in demand (Bhatt *et al.,* 2005). Shopping malls, with high occupant densities and extended operating hours, are particularly energy-intensive types of commercial buildings. Given Nigeria's chronic shortage of reliable grid electricity, where peak demand far exceeds generation capacity, energy efficiency in commercial buildings is considered to be one of the most cost-effective means of relieving pressure on the national system while reducing operating costs and greenhouse gas emissions (FMPWH, 2016; Geissler *et al.,* 2018).

Despite the existence of the BEEC and the clear potential benefits of compliance for reduced energy bills, increased thermal comfort, improved indoor air quality, and lower greenhouse gas emissions (Cristino *et al.,* 2021), there is absence of empirical studies that establish the current level of BEE practices in the Nigerian built environment. Without reliable evidence on how BEEC provisions are applied in practice, the true magnitude of lost energy-saving and emissions-reduction opportunities cannot be known. The limited research attention to BEEC compliance in Nigeria, therefore, constrains policymakers, designers, facility managers and other stakeholders from targeting enforcement, incentives, or training where they are most needed.

This study responds to that gap by focusing on commercial buildings, specifically shopping malls. The research seeks to appraise the level of compliance with the Building Energy Efficiency Code. The findings are intended to provide feedback to government agencies, designers, builders, facility managers, and other stakeholders on how to improve building design, enforcement, and operation to realise the energy-saving potential of BEEC provisions.

**International BEEC Best Practices**

The international BEEC were carefully compiled from various continents worldwide. The SANS-10400 originates from Africa, while ASHRAE is from North America. It is important to note that many countries without their own codes have widely adopted ASHRAE standards. Other countries, including Nigeria and Brazil, also refer to ASHRAE when developing their own codes. Finally, India's ECBC was selected from Asia, and Brazil's REELCB from South America.

The codes were analysed under seven headings: roof insulation, external wall provision, glass type (fenestration), WWR, hot water supply system, lighting power density, and air conditioning.

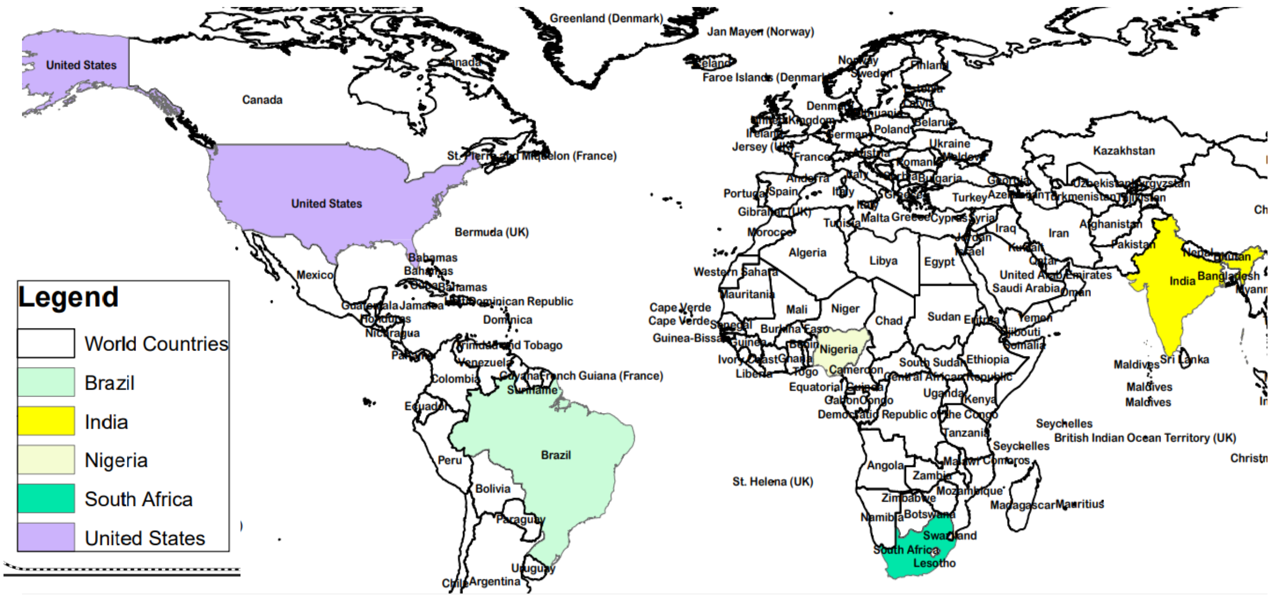


**Figure 1: Location of the various codes on the map**

**BEEC Comparison to International Best Practices**

A review of BEEC from various continents was conducted to identify similarities and differences compared to Nigeria. Although the Nigerian BEEC is only five years old, designers using the code may not have adopted it in their projects. Therefore, it is essential to examine various regulations from regions with climates similar to Nigeria to better understand their standards for measuring building energy efficiency.

While there are similarities in the codes, it can be seen that all the codes have varied provisions. This can be attributed to differences in location and climate. For instance, in warmer climates like Nigeria, more electricity will be used for air conditioning and less for heating. According to CCSP (2008) if the nation's climate warms by at least 1-3°C, the demand for energy used for cooling is expected to increase by about 5-20%, while the demand for energy used for heating is expected to decrease by about 3-15%, and vice versa. The procedure for which the prescriptive energy performance was achieved based on the BEEC as described in Table 1:

**Table 1: BEEC Comparison to International Best Practices**

| S/No | Description | Nigeria (BEEC) 2017 | South Africa (SANS) 2011 | America (ASHRAE) 2016 | Asia (ECBC) 2009 | South America (REELCB) 2006 |
|---|---|---|---|---|---|---|
| 1 | **Roof insulation R-value** | 1.25 | 3.7 | 4.2 | 3.5 | 1.0 |
| 2 | **External walls** | Concrete block | Brickwork | Highly insulated, lightweight construction | Concrete block or any approved material with at least U-0.44; R-2.1 | Any approved construction material with an R-value of 3.0 |
| 3 | **Glass type** | Single clear SHGC – 0.78 U-value – 5.8 | Single clear SHGC – 0.78 U-value – 5.8 | Single low-performance glass SHGC – 0.4 U-value – 3.4 | SHGC – Max. 0.25 | SHGC – 0.87 |
| 4 | **Window-to-wall ratio** | 20% | Varies per Orientation Average 30% | As per design, building or 24-30% whichever is lower | Varies per location, average 30% | 20% |
| 5 | **Hot water** | Not regulated | 50% from non-electrical resistive heating | Electrical resistive heating | Electrical resistive heating | Not regulated |
| 6 | **Lighting W/m² - Office** | 8 | 5 | 9.9 | 16.1 | 9.7 |
| 7 | **Air-conditioning** | Inverter split unit COP 3 | Split unit COP 2.5 | Varies according to the size of the building (Split: COP 3.8) | Specify max energy consumption per space | Min COP of 3.0 |

From the analysis in Table 1, it can be concluded that the ASHRAE and ECBC standards are the most stringent regarding roof insulation (R-Value of 4.2 m²K/W) and fenestration (SHGC of 0.25), respectively. Additionally, ASHRAE and SANS recommend updating glass types to include performance glass. This type of glass helps moderate the effects of solar heat gain, consequently reducing the cooling load. Furthermore, performance glass is effective even when a higher Window-to-Wall Ratio (WWR) is required (FMPWH, 2017a).

While the Nigerian BEEC and Brazilian REELCB impose a stringent WWR of 20%, the lighting power density requirement of South African SANS (5 W/m²) is deemed the most rigorous among all the codes. However, the BEEC and REELCB codes do not include any requirements for lighting controls. For example, occupancy sensors in spaces with transient occupancy, such as restrooms, meeting rooms, and storerooms, can significantly reduce energy consumption, enhancing the building's overall energy efficiency.

Both the Nigerian BEEC and South African SANS regulate only split unit air conditioning systems, whereas ASHRAE and ECBC provide flexible prescriptive performance assessments. These codes recommend different air conditioning units tailored to various types and sizes of buildings. For instance, the ASHRAE split unit has a Coefficient of Performance (COP) of 3.8, while the packaged AC unit boasts a COP of 4.1.

The Nigerian BEEC only mandates that external walls be made of concrete blocks without any insulation requirements. Walls lacking insulation absorb and transmit heat into building spaces, resulting in a higher cooling load. In contrast, ASHRAE, ECBC, and REELCB have minimum requirements for exterior walls. ASHRAE advocates for highly insulated lightweight construction materials, while ECBC and REELCB specify materials with U-values equivalent to R-values of 2.1 m²K/W and 3.0 m²K/W, respectively. Similarly, ASHRAE and ECBC require electrical resistive heating for hot water supply in buildings. However, SANS mandates that 50% of water be heated from non-electrical sources.

**Types of energy efficiency compliance approaches**

Energy efficiency requirements can be established in various ways, with the main types including prescriptive, trade-off, model buildings, energy frame, and performance compliance approaches. The commonest of these are the prescriptive and the performance approach.

**Energy performance approach**

Performance-based BEECs that regulate the whole building performance, including all fixed services, allow the designer to optimise solutions, tailor them to specific circumstances, and use innovative products. It better reflects potential energy savings but depends on high-quality modelling, reviewer capacity and robust QA to avoid optimistic assumptions and "gaming" (Lu *et al.,* 2022). But they are also more complex to apply, require more information and are usually computerised calculations. Although a pass/fail criterion is applied for the final output (energy use per $m^2$ or similar), many intermediate parameter values feed this. It is easier to make mistakes (or hide an incorrect figure) and more challenging to understand, apply, and check. Building control staff need expertise and time to check data and calculations (Liu *et al.,* 2010).

**Prescriptive approach**

Prescriptive compliance requires meeting technical criteria (e.g., minimum insulation, HVAC efficiencies, lighting power densities), and it is widely used where simplicity and enforceability are priorities (e.g., ASHRAE 90.1, China's regional standards). Prescriptive BEECs that provide specific requirements for the building envelope and some or all of the fixed equipment are easy to apply by designers and builders, require relatively little information, and are relatively easy to check by reviewers and inspectors, particularly if equipment and materials have been tested and certified (Liu *et al.,* 2010). Its strengths lie in clear, verifiable checkpoints since prescriptive BEECs stipulate the minimum acceptable, a pass/fail criterion for one parameter per component can usually be applied. Prescriptive rules are inherently rigid and often promote over-specification. They also fail to account for system interactions and occupant behaviour—factors that have been demonstrated to cause significant deviations between predicted and actual energy use (Almeida *et al.,* 2020; Fernandes *et al.,* 2021; Satola *et al.,* 2020). An on-site inspection is required to ensure that materials have been installed correctly.

Minimum energy efficiency requirements apply to all climatic zones in Nigeria. Energy efficiency interventions are specified based on bioclimatic (climate-adaptive) principles described in the National Building Energy Efficiency Guideline (BEEG).

**Commercial Building Energy Consumption**

A commercial building is one in which at least 50 per cent of its floor space is used for commercial activities (Upcounsel, 2021). Commercial buildings can fall under different types, such as offices, shopping malls, hospitals, schools, warehouses, hotels, etc. At the same time, energy need varies across different commercial buildings. Space heating/cooling accounts for one-quarter of the total energy use in commercial buildings in 2012 (EIA: Use of Energy Explained, 2018). Only five building types consume over 50% of energy: Merchandise (e.g., malls and stores) 15%, Offices 14%, Education 10%, Health Care 8%, and Lodging (e.g., hotels) 6%.

For this research, only shopping malls/stores will be considered. Shopping malls were chosen because they have higher operating hours, which makes them consume far more energy when compared to other commercial buildings. For that reason, the malls generally require more operating energy due to high occupant intensity, extensive electrical load usage, and the need for more energy to maintain comfort conditions inside the building compared to residential buildings and office buildings.

## MATERIALS AND METHODS

This study adopted a quantitative research approach using a case study design. The case study was utilised to assess the compliance of commercial shopping malls with the BEEC in Kaduna metropolis. Using purposive sampling, four purpose-built shopping malls (SM1–SM4) were selected against an explicitly stated criteria: i. accessibility to the mall, ii. all the malls must fall under "Band A" electricity supply (>20 hours/day), iii. availability of metered energy bills, iv the malls were constructed/retrofitted within the last ten years, and use of similar building materials. Literature was extensively reviewed to derive a well-labelled checklist from BEEC and international benchmarks.

Data collection consists of a combination of walkthrough audits, on-site measurements and interview schedules with the facility managers. Walkthroughs recorded orientation, floor area and systems data captured included window-to-wall ratio (WWR), glazing type, roof insulation, HVAC make/model (COP), lighting inventories and appliance ratings.

Measured metrics included area and sizes of spaces using measuring tape, as well as lighting power density (LPD, $W \cdot m^{-2}$) and illuminance (lux meter) used for measuring the intensity of light in an area. The measuring tape is used to measure the sizes and distances between spaces or surfaces, as shown in Figure 2. The measuring tape in this context was used to determine the floor area, wall areas, window areas, and the length of shading devices, where available. The lux meter, as shown in Figure 3, consists of light receptors, a unit of lux, a photometric value, a power switch, an auto record key, reading keys, etc. The instrument measures parameters such as lux, that is, lumen per square meter, with measuring ranges between

0.1 and 200,000 lux with a sampling frequency of 2 times per second. The lux meter ascertains the intensity of light in the building spaces.

Compliance decisions were made by comparing observed metrics against BEEC clause thresholds and global benchmarks. The results are presented in tables. The checklist and measurement procedures were piloted to ensure validity and replicability.


**Figure 2: Measuring Tape**


**Figure 3: Energy Lux meter**

## RESULTS AND DISCUSSION

### Compliance of Buildings to BEEC

The BEEC requirements aim to reduce energy consumption in buildings while maintaining occupant comfort and productivity. This study used a prescriptive compliance strategy. During the survey, a list was utilised to assess each item's compliance. Table 2 illustrates the shopping malls' code compliance.

**Table 2: Building energy efficiency code compliance**

| Description | Roof Insulation ($m^2K/W$) | External Walls | Glass Type | Lighting Density ($W/m^2$) | Air Condition | Window to Wall Ratio | | | | Shadings Provision |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | North | South | East | West | |
| **BEEC** | 1.25 | Sandcrete Blocks | Single Clear | 8 | 100% Inverter type | ≤ 20 % for all orientations | | | | WWR >20% |
| **SM 1** | No | Sandcrete Blocks | Single Clear | 5.18 | 22% | 17% | 2% | 7% | 7% | OK |
| **SM 2** | No | Sandcrete Blocks | Single Clear | 7.36 | 0% | 0% | 0% | 1% | 90% | West |
| **SM 3** | No | Sandcrete Blocks | Single Clear | 18.01 | 0% | 77% | 4% | 34% | 2% | North |
| **SM 4** | No | Sandcrete Blocks | Single Clear | 6.88 | 0% | 11% | 0% | 7% | 7% | OK |

Table 2 shows that seven (7) items were evaluated to determine the level of compliance for each of the items. These factors are the window-to-wall ratio, shading, lighting power density, air conditioning, roof insulation, exterior walls, glass type, and lux level. Sections 4.1.1 through 4.1.6 explain how each item complies with BEEC.

**WWR and shadings**

The results presented in Table 2 indicate that both SM1 and SM4 have a window-to-wall ratio (WWR) within the Building Energy Efficiency Code (BEEC) limit. However, SM2 has a WWR that exceeds the limit in the west direction (90%), while SM4 surpasses the limit in the north (77%) and east (34%) directions. Additionally, SM3 exceeds the maximum allowable WWR of 20% in the east direction, but no shading has been provided for that direction. This may be due to the fact that the WWR in the east direction is not significantly above the maximum allowable limit of 20%.

The result, therefore, implies that the absence of appropriate shading devices can contribute to the increased cooling loads in the buildings, high risk of overheating, and difficulty controlling the external environment (solar radiation). Wong, (2008); Al-Tamimi and Fadzil, (2012) indicated that a building that provided shading can record up to 2.62-3.24% savings using 300mm deep horizontal shading on windows. Shading depth of 600mm led to a 5.85-7.06% cooling load reduction. An increase in shading device depth to nearly 900mm lowered the cooling demand by 8.27-10.13%.

**Lighting Power Density (LPD)**

The LPD should not exceed 8 W/m$^2$ for any gross floor area, according to BEEC. According to the results in Table 2, SM 1 (5.18 W/m$^2$), SM 2 (7.36 W/m$^2$), and SM 4 (6.88 W/m$^2$) all have lower LPD than the maximum of 8 W/m$^2$. Only SM 3 (18.01 W/m$^2$) exceeds the specified maximum LPD by more than twofold. The use of energy-inefficient lamps and the provision of more than the required number of lamps leads to higher LPD. The result implies that energy-inefficient lamps consume more energy and produce less light, thereby increasing the lighting energy consumption cost. As a result, using lighting controls like occupancy sensors in places like stores and restrooms can help reduce energy consumption. It is worth noting that the Nigerian BEEC is one of the strictest in terms of LPD, only the South African SANS-10400-XA (5 W/m$^2$) is stricter. REELCB and ASHRAE 90.1 are closer to BEEC with 9.7 and 9.9 W/m$^2$, respectively, while ECBC has nearly double the LPD of BEEC at 16.1 W/m$^2$.

**Air conditioning (Inverter type)**

In this study, the types of air conditioners utilised by the malls were ascertained through the manufacturers and the model of the air conditioner. Through these, the COP can be determined and also whether it is an inverter or non-inverter type. From Table 2, SM 2 with 13 Air Conditioning Units (ACU), SM 3 with 5 ACU, and SM 4 with 4 ACU all had no single inverter type. SM 1 only has 2 ACU representing 22 % inverter type. Unlike the inverter ACU, the use of a non-inverter ACU has several disadvantages, including the working of the compressor. The compressor in a non-inverter ACU works at full speed or stops completely when the set temperature is attained. Inverter type, however, with the help of its frequency compressor, constantly adjusts its speed based on room temperature and the desired temperature. Therefore, as the compressor consistently keeps turning ON and OFF when the set temperature is reached, it consumes a lot of energy in the process of starting each time. Where an Inverter ACU is employed, it can regulate or adjust its speed and save up to 50% energy compared to a non-inverter ACU.

**Roof insulation**

For this study, the material used for the insulation was checked and recorded in the checklist. From the BEEC, it is recommended that all roof constructions include a layer of insulation with a thermal resistance of not less than 1.25 m2K/W (R-value). 3.70 m2K/W, 4.20 m2K/W, and 3.50 m2K/W are recommended in SANS, ASHRAE, and ECBC, respectively. However, none of the shopping malls has roof insulation. The absence of Roof insulation across all buildings increases thermal conductance and transmittance into the buildings, thereby increasing cooling demand.

According to Dabaieh et al (2015), in hot-dry, temperate, and humid and composite climatic regions of the world, roofs contribute up to 60% of the total cooling load of the building reaching inside from the environment. Therefore, the roof component must be designed to be strong enough to withstand all weather conditions (Krüger & Givoni, 2008). Tropical climatic zones need particular consideration to build the appropriate roof designs. In hot and tropical regions, the components of the building envelope, such as the roof, must be designed to minimise discomfort to the occupants. According to Dabaieh *et al* (2015) proper roof design creates little or no daily heat load, such as high thermal capacity roof material.

**External wall**

According to the BEEC, all walls should be built with sandcrete blocks, and as shown in Table 2, all the SMs fulfil this requirement. While SANS and ASHRAE suggest using bricks and highly insulated lightweight materials for construction, only ECBC specifies a U-value of 0.44 W/m²k and an R-value of 2.1 m²k/w. Walls are an essential part of the building envelope that needs careful consideration during design and construction to minimise heat gain and absorption. Properly constructed and insulated walls can greatly reduce the building's energy demand, but the Nigerian BEEC does not mandate minimum insulation standards for walls. Furthermore, wall insulation was not addressed in the design and construction process of the malls, which could lead to higher heat transmittance and conductance through the walls, thereby increasing the buildings' energy needs and requirements.

**Glass type**

The efficiency of glass is measured by its Solar Heat Gain Coefficient and U-value. During the walkthrough survey, the size and type of glass were determined. From Table 2, all the shop units (SMs) have single clear glass in all windows, with an SHGC of 0.78 and a U-value of 5.80 W/m²k. According to the BEEC and SANS standards of South Africa, the glass should be a single layer of clear glass with these same specifications. The Indian ECBC has more stringent requirements for glass, specifying a maximum SHGC of 0.25, followed by ASHRAE standards with an SHGC of 0.40. Although all the malls have glass installed, the type of glass used in the windows affects energy demand. Larger glazing can cause glare and allow excess solar transmittance into the building, increasing cooling loads. Conversely, smaller glazing results in less daylight entering the building, leading to higher artificial lighting demands. Therefore, a balance must be struck between window size, glass type, daylight entry, and cooling requirements. According to Krüger and Givoni, (2008) well-glazed and properly sized openings on the building envelope can reduce overall energy demand overall energy demand.

## CONCLUSION

This study assessed four shopping malls in Kaduna. The findings show that adherence to the BEEC is inconsistent and, in several aspects, insufficient. The evaluation highlights frequent deviations from BEEC requirements: all the malls lacked roof insulation (BEEC R ≥ 1.25 m²K/W), and glazing was uniformly single-pane, with a high SHGC (≈0.78) and a poor U-value (~5.8 W/m²K). Similarly, 50% of the shopping centres exceeded the BEEC window-to-wall ratio (WWR) limit on at least one façade (with one orientation reaching as high as ~90%). Lighting power density generally stayed within the BEEC limit (≤8 W/m²) for three malls (SM1, SM2, SM4), but one (SM3) recorded an LPD of 18.01 W/m², more than twice the code maximum. HVAC systems are mostly non-inverter units, with only 22% of the units in one mall being inverter types, while the other malls had none. This indicates a significant cooling energy requirement.

These shortcomings directly impact the operations of the SMs. For example, the absence of roof insulation, highly transmissive glazing, and oversized unshaded glass areas contribute to increased solar gains and cooling loads. Therefore, installing an appropriate horizontal shading depth of 300–900 mm could lead to greater savings and better insulation, reducing cooling demand by 2% to 10%. Using inverter-type ACUs can cut compressor energy consumption by up to approximately 50% compared with traditional units. This highlights the importance of replacing outdated HVAC systems with inverter models. High LPDs also increase electrical demand and internal heat gains, making the installation of lighting controls and energy-efficient luminaires necessary. Accordingly, policymakers should strengthen permit-stage inspections, implement construction-stage verifications, and mandate post-occupancy commissioning and energy monitoring to close the adoption gap.

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