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Application of Energy-Efficient Strategies in Shopping Mall Design: A Case Study of Minna, Niger State, Nigeria

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Abstract

Shopping complexes rank among the most energy-demanding commercial facilities, especially within hot climatic zones where achieving indoor thermal comfort necessitates substantial mechanical cooling and extensive electric lighting. In Minna, Niger State, Nigeria, the conception and operation of retail centres contribute substantially to regional energy requirements, yet the incorporation of energy-conserving design approaches remains underexplored. This research examines the level of awareness, degree of implementation, prospective application of energy-conserving design methods in shopping complexes within Minna, aiming to identify approaches that conserve energy usage while improving environmental sustainability and occupant well-being. was adopted, whereby A mixed method was adopted to execute a descriptive research design utilising a questionnaire and systematic site observations. Descriptive statistical methods and thematic analysis were deployed to analyse the data. Findings demonstrate that while professional consciousness regarding energy-conserving design approaches is remarkably high (93.3%), practical execution within shopping complexes remains irregular, hampered by financial limitations, regulatory shortcomings and client preferences. Participants strongly advocated for early-stage incorporation of passive temperature regulation systems, natural airflow mechanisms, sustainable power technologies, and interdisciplinary cooperation. The research concludes that technical capability, climatic suitability, and professional preparedness for energy conservation already exist in Minna; nevertheless, strengthened regulatory implementation, skill enhancement initiatives, and financial motivations remain necessary to transform these elements into widespread practice. The study recommends compulsory performance-oriented construction regulations, encouragement of sustainable power adoption, and improved utilization of quality indigenous materials to accomplish environmentally responsible, climate-adapted shopping complex designs

Keywords: Energy Efficiency, Shopping mall, Strategies, Minna, Sustainable architecture.

1.0 Introduction

The International Energy Agency (IEA, 2021) characterizes energy conservation as minimizing energy consumption to the lowest feasible level while maintaining living standards, production quality, and economic viability. Energy conservation delivers substantial advantages for structures, particularly Retail Complexes, by reducing utility expenditures, strengthening community resilience, and implementing economically efficient technologies within human settlements. The IEA projects conservation improvement potential ranging between approximately 20% and 50% of aggregate final energy usage (IEA, 2021). Decreasing energy consumption within structures supports climate change mitigation efforts since conventional power facilities combust fossil fuels that emit greenhouse gases contributing to atmospheric contamination (IEA, 2019).

Retail Complexes have evolved considerably in complexity regarding energy usage patterns. The traditional understanding that shopping centres exist exclusively for commercial exchange has become obsolete; contemporary complexes achieve substantial scale in both physical dimensions and activities accommodated within them. Energy-conserving structures are anticipated to fulfil design objectives, encompassing improvement of occupant health and wellness, more efficient utilization of hydro power resources, and reduction of structural environmental effects. Recently, Retail Complexes have emerged as significant urban development hubs that accommodate users while functioning as gathering spaces for diverse population segments pursuing economic and social engagement (Okafor et al., 2021). Consequently, retail complexes demonstrate heightened requirements for thermal regulation, air movement, and cooling due to enclosed structural envelopes. These constructions substantially influence energy usage patterns because of the functions they accommodate (Geissler et al., 2018).

Structures contribute approximately 40% of aggregate energy consumption in Nigeria, with commercial facilities such as Retail Complexes consuming disproportionately substantial amounts because of extensive illumination, environmental control systems, and additional energy-intensive features (Okafor et al., 2021; Krarti et al., 2020). Minna, the administrative centre of Niger State, has undergone notable urban expansion and commercial development, yet lacks contemporary, energy-conserving retail complexes. This circumstance results in dependence on inefficient structures that necessitates travel to alternative urban centres for retail activities, leisure, and social interaction. The convergence of accelerating urbanization, climate-related difficulties, and energy inefficiency presents an urgent challenge demanding innovative architectural responses.

1.1 Objectives of the Study

This study aims to apply energy-conserving approaches in designing a Retail Complex within Minna to reduce energy usage. Specific objectives include: identifying energy-conserving design approaches implemented in retail complexes; determining required energy-conserving design approaches for retail complex application; and proposing architectural design for a retail complex incorporating energy-conserving approaches.

1.2 Study Area

Niger State was established on 3rd February 1976 from the former North-Western State. The State extends between latitude 8°20'N to 9°45'N and longitude 6°15'E to 7°20'E. It shares boundaries with Zamfara State to the north, Kebbi State to the west, Kogi State to the south, Kwara State to the southwest, Kaduna State to the northeast, and the Federal Capital Territory to the southeast. This study focuses on Minna, the state capital, which experiences hot-arid climatic conditions characterized by elevated temperatures and reduced humidity, rendering energy-conserving architectural design essential.

2.0 Literature Review

2.1 Concept of Energy Conservation

The term "energy conservation" carries varying interpretations depending on contextual application. The International Energy Agency (IEA) characterizes energy conservation as approaches for managing and limiting growth in energy usage (IEA, 2015). Scholarly evidence indicates that accelerating temperature increases in urban areas, heightened global warming threats, and climatic shifts represent factors driving increased necessity for energy-conserving structures (Geissler *et al*., 2018).

According to IEA data, structures represent approximately 28% worldwide energy usage and 32% of energy-associated greenhouse gas discharges. Residential areas account for 50–70% of aggregate building energy demand depending on national context (Krarti et al., 2020). Energy conservation constitutes essential components of worldwide initiatives to decrease CO2 discharges, targeting reduction of primary energy usage to between 11% and 20% by 2030 and between 30% and 41% by 2050. Chegut *et al*. (2019) explained that structural energy usage addresses consumption for thermal regulation, air movement, and illumination. Speer et al. (2015) characterized energy conservation as efficient energy utilization supporting economic advancement social progress while enhancing occupant health and wellness with minimal environmental disruption.

2.2 Retail Complex Characteristics

Retail complexes, shopping centres, or commercial plazas represent contemporary adaptations of traditional marketplaces. These structures comprise collections of independent retail establishments, services, parking facilities conceived, constructed, and administered by unified management entities. Additionally accommodate dining establishments, financial institutions, entertainment venues, professional offices, and service stations.

The inaugural shopping centre, Country Club Plaza, was established by the J.C. Nichols organization and inaugurated near Kansas City, Missouri, in 1922. The initial enclosed retail centre, Southdale, opened in Edina, Minnesota, 1956 (Cho et al., 2014). During the 1980s, expansive megaplexes emerged, exemplified by West Edmonton Mall in Alberta, Canada, opened in 1981 featuring over 800 retail establishments, accommodation facilities, amusement areas, and aquatic recreation spaces.

Within Nigeria, retail concepts evolved from traditional marketplace systems. Marketplaces have existed since antiquity that constitute essential elements of every urban or rural settlement. Market significance extends beyond economic functions to encompass social and cultural values (Siddiqui, 2023). Most large-scale retail complexes in Abuja, Nigeria concentrate within central business districts, with primary clusters documented in Lagos and Abuja metropolitan areas.

The table 1 below shows the different shopping malls in Nigeria according to the year of establishment, locations gross area and their primary stakeholders. Orca and Awka mall are the recent mall established in Nigeria.

Table 1. Largest Shopping Malls in Nigeria by Gross Leasable Area

Mall Name	Location	Gross Leasable Area (m²)	Year Opened	Anchor Stores	Primary Stakeholder
Awka Mall	Zik Avenue Anambra State	14,929	2025	Pharmacy Games, Cinemas	Sundry Markets Limited(SML).
Capital Mall	Abuja, FCT	40,000	Under construction	N/A	Churchgate Group

Jabi Lake Mall	Abuja, FCT	26,479	2015	Game, Shoprite	Actis / Duval Properties
Ado Bayero Mall	Kano, Kano	24,136	2014	Shoprite, Game, Filmhouse Cinemas	Beverly Development & Realties Ltd
Orca Mall	Eko Atlantic city, Lagos.	30,000	2025	Showroom	Gilbert chagoury,Ronald chagoury.
Ikeja City Mall	Ikeja, Lagos	22,645	2011	Shoprite, Silverbird	Broll Property Services Limited
Polo Park Mall	Enugu, Enugu	22,530	2011	Game, Shoprite, Hub Media, Max	Persianas Group
Novare Lekki Mall	Lekki, Lagos	22,530	2016	Game, Shoprite	Novare Private Partners
Benin City Shopping Mall	Edo State	13,300	2024	Digital library, Shoprite, Restaurant	Developer of The Palms Mall Chain and Edo state Government
Ibadan Mall	Ibadan, Oyo	18,500	2014	Shoprite	Persianas Group

Source: Authors compilation (2026)

2.3 Energy Usage Patterns in Retail Complexes

Retail complexes consume significant energy for diverse functions encompassing illumination, thermal regulation, air movement, vertical transportation, and retail equipment (Siddiqui, 2023). Raji, Tenpierik, and Dobbelsteen (2017) proposed integrated approaches incorporating structural orientation, facade treatment, strategic landscaping, spatial organization, natural airflow, daylight utilization, and solar shading.

Illumination systems represent major energy consumptions within retail complexes, typically operating extended periods to maintain adequate visibility for commercial activities (Krarti et al., 2020). Environmental control systems sustain comfortable interior temperatures and consume substantial energy, particularly during peak demand intervals (IEA, 2021). Vertical transportation systems within multi-level retail complexes consume significant energy moving individuals and merchandise between floors.

2.4 Energy Conservation Approaches

2.4.1 Efficient Illumination Technologies

LED systems decrease energy consumption by 80% compared to conventional lighting (Hemsath & Alagheband, 2015). Daylight harvesting mechanisms employ sensors measuring natural illumination and adjust artificial lighting correspondingly. Occupancy detectors identify space utilization patterns and modify illumination, automatically extinguishing lights in unoccupied areas.

2.4.2 Environmental Control Systems with Conservation Features

High-performance HVAC units consume less energy while delivering equivalent comfort levels. Variable Refrigerant Flow (VRF) systems employ variable-speed compressors adjusting refrigerant distribution according to thermal requirements. Energy Recovery Ventilation (ERV) systems capture and reuse energy from exhaust air to precondition incoming fresh air (Zhou, 2017). Building Automation Systems (BAS) monitor and regulate environmental control systems with optimizing energy usage.

2.4.3 Sustainable Power Sources

Photovoltaic panels on roofs or facades generate clean electricity and decrease dependence on conventional power networks. Wind turbines and geothermal installations offer additional renewable alternatives. However energy storage systems retain surplus renewable power for utilization during low production periods (Freewan, 2014).

2.5 Passive Thermal Regulation Mechanisms

Passive cooling focuses on managing heat acquisition or dissipation within structures to decrease energy usage and achieve interior thermal comfort. Four passive cooling actions encompass: accumulating cool air or mass within structural envelopes; preventing direct external solar radiation heat gain through shading and structural positioning; extracting accumulated heat through controlled airflow; while retarding heat transfer from external environments through structural envelopes using insulation and double-glazed openings.

3.0 Research Methodology

3.1 Research Design

This investigation adopted combined methodological approaches incorporating qualitative and quantitative techniques. Qualitative components involved comprehensive case examinations and professional discussions, while quantitative elements concentrated on collecting empirical data through structured questionnaires. This strategy provided both detailed descriptive understanding and measurable outcomes supporting evaluation of energy conservation approaches (Day & Gunderson, 2015).

3.2 Population and Sample Selection

The participants are Architectural professionals, Engineering specialists, facility users, construction practitioners, and regulatory officials involved in building standards. Four retail complexes within Minna were selected for examination: Emirate Complex, Obasanjo Centre, Prixair Complex, and IBB Centre. These are the largest, most frequented, and highest energy consumers within the study area.

Applying established sampling formulas, the participant sample was determined as 80 individuals (20 respondents from each complex). Questionnaires were distributed among this population, with 75 returned representing 93.75% response rate.

3.3 Data Collection Instruments

A four-point Modified Likert scale questionnaire was employed, ranging from Strongly Agree (4) to Strongly Disagree (1). The instrument was organized into four segments: participant characteristics, identification of energy conservation approaches, determination of required approaches, and proposed approaches for new retail complexes. Case examination protocols and systematic site observations were additionally conducted.

3.4 Analytical Approach

Quantitative information was examined using descriptive statistical methods encompassing frequency distributions and percentage calculations. Qualitative information from case examinations and discussions was analyzed thematically. Visual representations including graphs, tables, and photographic materials were employed to interpret and present findings.

4.0 Results and Discussion

4.1 Participant Characteristics

Among 75 respondents, 64% were male and 36% female, indicating male-dominated professional environments. Age distribution showed 37.3% aged 26–35 years, 28.0% aged 36–45 years, 18.7% aged 46 and above, and 16.0% aged 18–25 years. Educational qualifications revealed 37.3% with Bachelor's degrees, 24.0% with Master's degrees, 18.7% with Higher National Diplomas, 13.3% with National Diplomas, and 6.7% with doctoral qualifications. Professional categories included architects 36.0%, engineers 32.0%, surveyors 10.7%, and others 21.3%. Experience durations showed 30.7% with 11–15 years, 28.0% with 6–10 years, 21.3% with over 16 years, and 20.0% with 1–5 years. Significantly, 61.3% had previously participated in energy-conserving projects, while 38.7% lacked such experience.

4.2 Awareness Level Regarding Energy Conservation Approaches

The findings in table 2 below with mean score 3.49 is the highest with a frequency of 43 respondents are aware of energy efficiency design strategies in Architecture and 2.85 the lowest with frequency 19 respondents is neutral energy are commonly applied in shopping centres.

Table 2: Awareness and Perceptions of Energy Conservation Approaches

Statement	SD	D	A	SA	Mean Score	Consensus
I am aware of energy efficiency design strategies in architecture.	1 (1.30%)	4 (5.30%)	27 (36.00%)	43 (57.30%)	**3.49**	Agree
Energy efficiency strategies are commonly applied in shopping centres.	6 (8.00%)	18 (24.00%)	32 (42.70%)	19 (25.30%)	**2.85**	Neutral
Energy efficiency significantly affects the performance of shopping malls.	0 (0.00%)	5 (6.70%)	30 (40.00%)	40 (53.30%)	**3.47**	Agree
Environmental factors influence the application of energy-efficient designs.	1 (1.30%)	7 (9.30%)	29 (38.70%)	38 (50.70%)	**3.39**	Agree
Local materials are considered in energy-efficient mall design.	5 (6.70%)	16 (21.30%)	30 (40.00%)	24 (32.00%)	**2.97**	Neutral

Source: Authors' survey (2026)

The results demonstrate elevated awareness (93.3% agreed/strongly agreed) regarding energy conservation design approaches, reflecting well-informed professional communities. However, merely 68.0% concurred that approaches are commonly implemented in retail complexes, indicating disparities between awareness and execution. This aligns with Raji et al. (2017), who noted that while sustainable design knowledge expands in developing nations, practical incorporation remains constrained by financial factors, weak regulatory enforcement, and restricted client requirements.

4.3 Required Energy Conservation Approaches

The findings in table 4.2 shows energy-saving features are essential in shopping mall designs with the highest mean score 3.53 with a frequency of 43 respondents strongly agreed while Natural ventilation can be effectively applied in shopping malls with lowest mean score 3.21 mean score with frequency 30 respondents.

Table 3: Required Energy Conservation Approaches

Statement	SD	D	A	SA	Mean Score	Consensus
Energy-saving features are essential in shopping mall designs.	0 (0.00%)	3 (4.00%)	29 (38.70%)	43 (57.30%)	**3.53**	Agree
Natural ventilation can be effectively applied in shopping malls.	2 (2.70%)	10 (13.30%)	33 (44.00%)	30 (40.00%)	**3.21**	Agree
Passive cooling systems reduce energy consumption significantly.	1 (1.30%)	6 (8.00%)	35 (46.70%)	33 (44.00%)	**3.33**	Agree
Renewable energy use should be mandatory in mall designs.	2 (2.70%)	8 (10.70%)	28 (37.30%)	37 (49.30%)	**3.33**	Agree
Stakeholder collaboration is crucial in implementing energy efficiency strategies.	0 (0.00%)	6 (8.00%)	31 (41.30%)	38 (50.70%)	**3.43**	Agree

Source: Authors' Survey (2026)

An overwhelming 96.0% concurred that energy-saving features are essential in complex designs. The substantial endorsement (84.0%) for natural airflow reflects recognition of its effectiveness in tropical climates where strategic positioning can minimize mechanical cooling. Support for passive cooling systems (90.7%) validates Freewan (2014) and Oropeza-Perez & Østergaard (2018), who demonstrated that shading devices and reflective surfaces dramatically decrease cooling requirements.

4.4 Proposed Conservation Approaches for New Developments

Table 4.5 shows that there are considerable challenges in adopting energy-efficient designs with mean score of 3.00 agreed while 3.53 mean score agreed that energy-efficient features should be integrated into the initial design phase with a frequency of 44.

Table 4: Proposed Conservation Approaches for New Retail Complexes

Statement	SD	D	A	SA	Mean Score	Consensus
Energy-efficient features should be integrated into the initial design phase.	0 (0.00%)	4 (5.30%)	27 (36.00%)	44 (58.70%)	**3.53**	Agree
Architectural layout contributes to improved energy conservation.	1 (1.30%)	5 (6.70%)	28 (37.30%)	41 (54.70%)	**3.45**	Agree
Zoning laws should enforce energy efficiency in commercial building designs.	3 (4.00%)	11 (14.70%)	29 (38.70%)	32 (42.70%)	**3.20**	Agree
There are considerable challenges in adopting energy-efficient designs.	4 (5.30%)	16 (21.30%)	31 (41.30%)	24 (32.00%)	**3.00**	Agree
HVAC energy loads can be minimized through proper architectural planning.	0 (0.00%)	7 (9.30%)	32 (42.70%)	36 (48.00%)	**3.39**	Agree

Source: Authors' Survey (2026)

Nearly all participants (94.7%) concurred that conservation features should be incorporated during initial design phases, supporting Prieto et al. (2018) who assert that early-stage incorporation proves most economically efficient. The substantial agreement (90.7%) that thoughtful architectural planning can minimize HVAC requirements reinforces that passive design approaches can significantly decrease operational energy demands in hot-arid environments. The moderate agreement (73.3%) regarding challenges indicates that while barriers exist, they are not perceived as insurmountable by most professionals.

4.5 Discussion of Findings

Ceddi Plaza, Abuja: This facility accommodates 55 specialty retail establishments, offices, and service providers within 10,000 m² of commercial space. While the site features appropriate landscaping, illumination and ventilation depend primarily on mechanical systems, relying on three 750kVA standby generators. The structure incorporates blast mitigation features including curved corners and dome skylights, yet proximity to access roads demonstrates inadequate consideration of setback distances.

Jabi Lake Complex, Abuja: This 30,000 m² retail space is strategically situated along Jabi Lake shores, oriented southwest to capture natural views. The lake influences wind patterns, providing enhanced airflow to rear public areas. However, despite natural ventilation potential, the complex depends substantially on mechanical systems featuring extensive chiller installations serving fan coil units. Major circulation areas utilize both natural and artificial illumination through centrally positioned atria permitting light entry via clerestory openings.

5.0 Conclusions and Recommendations

5.1 Conclusions

This investigation examined energy conservation approach implementation in retail complex design within Minna, Niger State. Findings reveal that while professional consciousness regarding energy-conserving design principles is remarkably elevated (93.3%), practical execution remains irregular due to financial considerations, weak regulatory enforcement, and varying client requirements. The research demonstrates strong professional consensus regarding early incorporation of conservation features, dependence on passive cooling and natural airflow, compulsory sustainable power adoption, and multi-sector cooperation.

Within Minna's hot-arid climate, architectural configuration, structural positioning, material selection, and passive design approaches can substantially decrease HVAC requirements, reduce operational expenditures, and improve interior thermal comfort. Technical capability, professional willingness, with climatic suitability for energy conservation already exist within Minna; what remains necessary is deliberate commitment from policymakers, developers, and design communities to transform possibilities into constructed reality

5.2 Recommendations

From the findings, the following recommendations emerge:

i. Early Design Incorporation: Architectural and engineering professionals should prioritize conservation features during initial design phases, optimizing structural positioning, spatial zoning, with envelope configuration to maximize passive cooling, daylight utilization, and natural airflow.

ii. Regulatory Implementation: Government agencies should establish and enforce construction codes mandating minimum energy performance standards for commercial structures, requiring sustainable power incorporation and climate-responsive design.

iii. Sustainable Power Adoption: Developers should integrate photovoltaic systems into retail complex projects, leveraging Minna's abundant solar radiation, supported by tax incentives, subsidies, or favourable financing arrangements.

iv. Capability Enhancement: Continuous professional development programmes should concentrate on practical design, simulation tools, and innovative materials for energy-conserving architecture in hot-arid environments.

v. Stakeholder Cooperation: Multi-sector platforms should unite designers, developers, policymakers, end-users to share effective practices with awareness regarding long-term economic savings and comfort advantages.

vi. Indigenous Material Advancement: Local material production should be strengthened through quality control measures, innovation, and certification systems to encourage specification of climate-appropriate materials reducing embodied energy.

5.3 Contributions to Knowledge

This research provides empirically grounded, context-specific insights regarding energy-conserving commercial building design from a medium-sized Nigerian urban centre, addressing the scarcity of such studies within sub-Saharan African urban contexts. It establishes that professional awareness is elevated (93.3%), challenging assumptions that limited adoption stems primarily from insufficient knowledge, instead directing attention toward structural and market barriers.

The investigation empirically validates the awareness-implementation disparity (68.0% application rate) and strengthens connections between energy conservation approaches and commercial building performance in hot-arid environments. By statistically prioritizing approaches based on professional consensus, it offers evidence-based design priorities for tropical commercial structures. The finding that 81.4% support zoning regulations for energy conservation demonstrates practitioner readiness for formal regulatory mechanisms, providing justification for strengthening construction codes within Nigeria.

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