Investigation of Architects' Adoption and Use of Smart Green Building Design Strategies in High-Rise Office Design in Abuja, Nigeria

Olutope Adeniyi Adewole, Ayokunle A Akinmoladun, Wemimo Iyetunde Omoniyi, Essien Sunday Akpan

Caleb university, Imota, Albania

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ABSTRACT

The rapid expansion of high-rise office developments in Abuja, Nigeria, presents sustainability challenges, necessitating the integration of 'green' passive design strategies with 'smart' building automation systems to reduce energy consumption and environmental impact. This study investigates the extent, patterns, and determinants of architects' adoption of these smart green design strategies. A structured questionnaire was administered to a sample of 157 registered architects in Abuja, identified through professional registers, to quantitatively assess their knowledge, perceptions, and specification behaviours. Data analysis employed descriptive statistics, reliability tests, and hierarchical regression modelling to test predictors derived from the Technology Acceptance Model (TAM), Diffusion of Innovations, and Institutional Theory. Results reveal a pronounced adoption pattern: near-universal uptake of passive measures (e.g., shading, 92.4%; daylighting, 94.3%) contrasts sharply with limited adoption of integrated smart systems (e.g., advanced BMS, 28.7%; façade integrated PV, 14.6%). While architects reported high perceived usefulness and strong behavioural intentions, regression models indicated that individual cognitive factors were insignificant predictors, explaining negligible variance (R^2=0.046). Instead, the findings robustly indicate that adoption is decisively constrained by institutional and market barriers, primarily high initial cost, client resistance, and concerns over maintenance ecosystems. The study concludes that transcending this intention-behaviour gap requires shifting policy focus from individual architects to the institutional environment, recommending targeted interventions in green finance, mandatory performance disclosure, and specialised capacity building to catalyse mainstream adoption.

Keywords: Smart-Green Strategies, High-Rise Offices, Abuja, Institutional Barriers, Architects' Adoption

INTRODUCTION

Abuja, Nigeria's purpose-built capital city, stands as a powerful symbol of national ambition and rapid urbanisation. Characterised by its meticulous master plan and government investment, the city has evolved into a primary hub for economic and administrative activity (Daramola & Aina, 2004; Heinrich Böll Stiftung Nigeria, 2023). This status has catalysed a sustained construction boom, positioning Abuja as an expanding centre for both public and private office development (Daramola & Aina, 2004). The city's skyline is increasingly punctuated by high-rise structures, which are favoured for their efficient land use, corporate prestige, and concentration of economic functions. However, this vertical growth presents a unique set of environmental and operational challenges that merit specific scholarly and practical attention (Abah et al., 2023).

Unlike low-rise buildings, high-rise offices are defined by their extensive glazed façades, which significantly increase solar heat gain; complex heating, ventilation, and air conditioning (HVAC) demands to service deep floor plates and multiple zones; and limited opportunities for occupant control over their immediate environment (Kalwry & Atakara, 2025). Consequently, these buildings operate on large energy baselines, making their environmental footprint substantially greater and their operational costs more volatile (Kalwry & Atakara, 2025). In an era of climate urgency and economic uncertainty, these building designs becomes a critical determinant of urban sustainability.

Within the ecosystem of the building industry, architects act as the primary decision agents and synthesizers during the early design phases. Their choices regarding form, orientation, envelope, and systems fundamentally lock in a building's performance trajectory long before construction begins (Østergård, Jensen & Maagaard, 2016; Ouldja, Demian & Eftekhari, 2024). They navigate client aspirations, regulatory frameworks, budgetary constraints, and technological possibilities (Ouldja, Demian & Eftekhari, 2024). Therefore, the adoption and integration of smart green building design strategies—an approach that synergistically combines sustainable principles with intelligent technologies for optimisation—are predominantly mediated through the architect's lens (Østergård, Jensen & Maagaard, 2016; Ouldja, Demian & Eftekhari, 2024). Their decisions determine whether these strategies transition from innovative niches to mainstream practice, ultimately shaping the resource consumption patterns and environmental impact of Abuja's built environment for decades to come.

Despite a robust global evidence base demonstrating the multifaceted benefits of smart green design—covering reduced energy and water consumption, lower lifecycle costs, enhanced occupant well-being, and increased asset value—its adoption within the Abuja high-rise office sector remains markedly uneven (Idowu & Abdulrahman, 2023; Ashen, Rimtip & Davou, 2024). A conspicuous gap also exists between the theoretical potential of these strategies and their consistent application in local projects. While some pioneering developments incorporate elements like building automation systems, high-performance glazing, or renewable energy integrations, many others adhere to conventional, less sustainable design paradigms (Orikpete, Ikemba & Ewim, 2023; Alassaf, 2024; Kalwry & Atakara, 2025). This discrepancy points to a research problem, showing a lack of systematic understanding of the factors that influence Abuja-based architects' decisions to adopt or reject these innovative strategies. It raises the question of what exactly explains this patchy adoption landscape, and if the issue is an issue of knowledge, attitude, cost, or regulatory environment.

To investigate this problem, this study employs a quantitative, questionnaire-based methodological approach. This method is deliberately chosen to move beyond anecdotal evidence and capture data at scale (Palazzin, 2012). The objective is to quantitatively measure the prevalence of various smart green strategies, map the attitudes and perceptions of architects towards them, and identify key correlates that predict adoption behaviour across a significant segment of the professional community in Abuja. The research, by surveying a broad sample of architects, aims to construct a representative profile of the current state of practice.

The overarching aim of this research is to investigate the extent, patterns, and determinants of architects' adoption of smart green building design strategies in high-rise office projects in Abuja, Nigeria. This aim will be achieved by addressing three core research questions:

i. What is the level of knowledge, awareness, and formal training that architects in Abuja possess regarding smart green building design strategies?

ii. To what extent, and in what patterns, are specific smart green design strategies (e.g., energy management systems, sustainable materials, passive design techniques) currently being adopted in high-rise office design in Abuja?

iii. What are the predominant drivers (e.g., client demand, environmental ethics, economic benefit) and barriers (e.g., perceived cost, lack of technical expertise, regulatory gaps) influencing the adoption decisions of these architects?

The interpretation of the findings will be guided by an integrated theoretical framework combining three foundational theories. Rogers' Diffusion of Innovations theory will provide a lens to understand how these strategies are communicated and adopted through social systems over time. The Technology Acceptance Model (TAM) will be used to analyse architects' perceptions of the usefulness and ease of use of these strategies, key factors influencing their behavioural intention to adopt them. Finally, Institutional Theory will frame the external pressures—coercive (regulations), mimetic (imitating competitors), and normative (professional standards)— that shape the decision-making environment within architectural firms. Together, these theoretical anchors will provide a comprehensive structure for measuring, analysing, and explaining the complex dynamics of innovation adoption in Abuja's high-rise architectural sector.

LITERATURE REVIEW AND THEORETICAL FRAMING

Smart Green in High-Rise Offices

“Smart green” design integrates two interdependent strands. The “green” component comprises well-established passive and active energy-efficiency measures, including orientation and massing choices to reduce solar gains, external shading devices and high-performance glazing to control façade heat transfer, daylighting strategies to reduce electric lighting loads, natural ventilation where feasible, high-efficiency HVAC plant, and water conserving systems and sustainable materials (low-embodied carbon options, recycled materials) (Gil-Ozoudeh et al., 2022). The “smart” component overlays automation, sensing and analytics—BMS (building management systems), sensor networks (CO_2, occupancy, illuminance and temperature), fault-detection and predictive control—to optimise operations and close the gap between design intent and in-use performance (Resync Technologies, 2025). Smart controls can, for example, link daylight sensors to dimmable lighting and couple occupancy detection with demand-controlled ventilation to reduce needless conditioning and ventilation during low occupancy periods. Contemporary reviews and field studies like that of Omer (2008), Gamero-Salinas et al. (2021) and Al Mughairi, Beach & Rezgui (2023), show that integrating automation with good passive and active design can materially improve energy performance and occupant comfort in office buildings when systems are properly specified, commissioned and maintained.

Evidence on Energy, Comfort and Techno-Economic Trade-Offs

Globally, meta-analyses and case studies report high energy savings where passive measures are paired with efficient plant and controls (Bradshaw, 2010; Sun et al., 2012; Amirifard, Sharif & Nasiri, 2019; Taherian & Peters, 2023). Passive shading and daylight optimisation, for instance, reduce cooling and lighting loads, while high-efficiency HVAC and heat-recovery reduce conditioning energy (especially in deep-plan offices) (Silva et al., 2024). Building automation and BMS have been associated with step-changes in operational performance— reported savings range widely in the literature depending on baseline conditions and measurement rigour, but controlled studies highlight savings through scheduling, optimised setpoints and fault detection (Santos, Liu & Jradi, 2022; Bortoff et al., 2024; Van Roosmale et al., 2024). Importantly, savings are conditional as successful outcomes depend on early integration into design, competent commissioning, and ongoing maintenance regimes. Without these, smart systems can underperform or even increase operational risk (e.g., if sensors drift or BMS configurations are poorly maintained) (Bortoff et al., 2024; Van Roosmale et al., 2024). This reveals a core techno-economic trade-off where smart systems add capex and operational complexity but can lower lifecycle costs and improve service if the institutional supports (skilled installers, commissioning and maintenance contracts, performance monitoring) exist (Silva et al., 2024).

In tropical and hot-humid climates—conditions relevant to Abuja—passive strategies have distinctive power. Studies focused on tropical contexts emphasise external shading, façade design and natural ventilation (where appropriate) as highly cost-effective first-order measures, while recommending careful daylighting to avoid glare and overheating (Ndichu, 2017; Gamero-Salinas et al., 2021; Carratt, 2025). Retrofitting automation into such climates has shown benefits, but the literature stresses contextual sensitivity where local climatic patterns, grid reliability, and occupant behaviour meaningfully shape realised savings. Hence, technology transfer from temperate jurisdictions cannot be naive; design and control strategies must be calibrated to tropical diurnal cycles, solar paths and occupant patterns (Gamero-Salinas et al., 2021).

Adoption in Nigeria: Empirical Findings and Patterns

A growing, but still limited, body of empirical work examines green-building awareness and practice in Nigeria. Country and city-level assessments repeatedly identify uneven adoption where small pockets of sophisticated, internationally-oriented projects and larger swathes of mainstream practice where conventional approaches persist (Idowu & Abdulrahman, 2023). Surveys and review articles report recurrent barriers, these reports show perceived high initial cost of green technologies, scarcity of trained local contractors and commissioning agents, weak or inconsistent regulatory incentives, limited access to green finance, and low client willingness to internalise lifecycle savings (i.e., short payback horizons dominate decision calculus) (Yawas, Dan-asabe & Alabi, 2024). Several Nigeria-specific studies and market reports have documented these headwinds and provided ranked barrier lists that place cost and financing near the top, followed by skills and policy gaps (Ashen, Rimti & Davou, 2024; Unegbu et al., 2025). These findings establish that non-technical constraints—finance, supply chains, client preferences, and regulation—are as important as the technology itself in explaining adoption patterns (Unegbu et al., 2025).

Work focused on Abuja specifically indicates both opportunity and inertia. Studies mapping potential for green building adoption in Abuja point to institutional levers (municipal procurement, public-sector demonstration projects and local professional networks) but also note limited policy enforcement and a nascent market for certified projects (Ashen, Rimti & Davou, 2024). Where adoption occurs, it is frequently associated with developer incentives (tenant premium), donor support, or the involvement of internationally linked consultants— all signs that diffusion is path-dependent and uneven (Ganiyu et al., 2020).

Taken together, the literature shows what can be achieved; however, the Nigerian empirical literature explains why those possibilities are not yet widespread. This points to the need for a theoretical frame that links individual architects' cognitions and decisions to firm-level capacities and the wider institutional environment. Three complementary frameworks do this work.

Theoretical Framing

Diffusion of Innovations Framework

Diffusion of Innovations (DOI) theory, pioneered by Rogers, provides a valuable framework for understanding how smart green strategies spread through the community of architectural professionals. This theory characterises adoption decisions according to five key attributes, namely relative advantage (economic or otherwise), compatibility with existing values and practices, complexity of implementation, trialability on an experimental basis, and observability of results (Rogers & Williams, 1983; Adeogun, 2022). DOI further categorises adopters into innovators, early adopters, early majority, late majority, and laggards based on their willingness to embrace new ideas (Rogers, Singhal & Quinlan, 2014).

DOI helps explain the differential adoption rates across various smart green strategies. In Nigeria, technologies perceived as offering clear relative advantage (e.g., energy-efficient lighting with rapid payback) have diffused more rapidly than those with long-term or less tangible benefits (e.g., improved indoor environmental quality) (Adeogun, 2022). The compatibility dimension proves particularly relevant, as strategies that align with existing design processes and aesthetic preferences achieve greater traction than those requiring fundamental workflow changes. DOI's emphasis on social networks and communication channels directs attention to the role of professional associations, continuing education, and project exemplars in spreading innovative practices (Rogers & Williams, 1983; Rogers, Singhal & Quinlan, 2014).

Technology Acceptance Model

The Technology Acceptance Model (TAM) offers a complementary perspective by focusing on individual cognitive processes underlying adoption decisions (Davis, 1989; Silva, 2015). According to TAM, perceived usefulness and perceived ease of use represent the primary determinants of technology adoption (Ajibade, Ibietan & Ayelabola, 2017; Ojeka-John et al., 2025). In the architectural context, perceived usefulness encompasses not only energy performance but also factors such as client satisfaction, regulatory compliance, and professional recognition (Ganiyu et al., 2020). Perceived ease of use includes considerations of technical complexity, integration challenges, and learning curve requirements.

In Nigeria, studies applying TAM principles have found that perceived usefulness exerts stronger influence on adoption intentions than perceived ease of use, suggesting that architects prioritise performance benefits over implementation challenges (Ojeka-John et al., 2025). However, both factors demonstrate significant correlation with actual usage, supporting TAM's core propositions. Recent adaptations of TAM have incorporated social influence processes and facilitating conditions as additional determinants, enhancing the model's applicability to the complex socio-technical context of architectural practice (Ajibade, Ibietan & Ayelabola, 2017; Ojeka-John et al., 2025).

Institutional Theory Perspective

Institutional theory completes the theoretical triad by emphasising how external pressures shape organizational behaviour through coercive, mimetic, and normative mechanisms (Dang & Pekkola, 2020; Arranz, Sena & Kwong, 2022). Coercive pressures stem from formal regulations and requirements, including building codes,

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zoning ordinances, and environmental mandates. Mimetic pressures result from uncertainty that encourages imitation of perceived leaders or successful competitors. Normative pressures arise from professional standards, educational socialisation, and industry certifications that establish expectations for appropriate behaviour.

Research by Oke et al. (2025) indicates that coercive pressures currently exert limited influence due to weak enforcement of building energy regulations, though recent policy developments suggest increasing stringency. Mimetic pressures appear more influential, particularly through international design firms and multinational corporate clients who introduce global best practices (Adewale et al., 2024). Normative pressures from professional associations like the Architects Registration Council of Nigeria (ARCON) and Nigerian Institute of Architects show potential but remain underdeveloped regarding sustainability standards (Adewale et al., 2024). Institutional theory here helps explain why architects sometimes adopt symbolic rather than substantive green measures, implementing visible strategies that enhance legitimacy without fundamentally transforming practice.

Theoretical Synthesis

Each theoretical perspective offers distinct insights into the adoption process. DOI illuminates the diffusion patterns across technologies and adopters, TAM explains individual decision processes, and institutional theory contextualises these within broader professional and regulatory structures. Rather than operating in isolation, these frameworks intersect in meaningful ways that suggest an integrated theoretical approach for understanding smart green adoption.

An integrated framework recognises that perceived usefulness (from TAM) incorporates institutional influences such as regulatory requirements and client expectations, while perceived ease of use reflects the knowledge infrastructure and professional support systems that facilitate implementation (Ojeka-John et al., 202). Similarly, DOI's adoption attributes are themselves shaped by institutional forces – for instance, relative advantage may be determined by regulatory incentives, while compatibility is influenced by professional norms and standards (Adeogun, 2022).

This theoretical synthesis suggests that comprehensive understanding of adoption requires attention to individual cognition, social diffusion processes, and institutional contexts simultaneously. The integrated framework justifies investigating not only which strategies architects adopt but also how their perceptions of benefits and barriers are shaped by professional networks, regulatory environments, and market conditions specific to the Nigerian context. This approach aligns with recent research emphasising the multi-level nature of sustainability transitions in the building industry, where individual professionals operate within complex socio-technical systems that both constrain and enable innovation (Geels, 2019; Hong, Chan & Ma, 2025).

Gaps in the Literature

Two gaps motivate the present questionnaire study. First, much of the Nigerian literature is descriptive and cross sectional without systematic measurement of individual architects' technology acceptance beliefs or rigorous mapping of adoption patterns specifically for high-rise offices. Second, there is limited work connecting microlevel attitudes to firm-level and institutional constraints in a single analytical model. By operationalising diffusion, TAM and institutional variables in a single instrument and by including objective measures of specification behaviour (counts of projects, checklist of strategies specified), this research seeks to close those gaps and produce evidence that is both diagnostic (what is happening) and explanatory (why it is happening).

METHODOLOGY

Research design

This study adopts a cross-sectional, questionnaire-based survey as its sole primary data source. The design is deliberately quantitative and descriptive-analytical, the questionnaire measures architects' training and objective knowledge, their self-reported specification behaviour for an agreed list of smart-green strategies, and a set of attitudinal and institutional predictors drawn from the Technology Acceptance Model (TAM),

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Diffusion indicators and Institutional Theory. A single, well-structured instrument allows the research to capture prevalence, correlations and predictors across the population of practicing architects in Abuja at one point in time, enabling multivariate testing of hypotheses about drivers and barriers to adoption.

Population and Sampling Frame

The target population were registered architects practising in the Federal Capital Territory (Abuja). The principal sampling frame was the ARCON register together with local professional membership lists (Abuja Chapter of the Nigerian Institute of Architects and local firm lists). ARCON's public materials confirm a national register of practitioners (historically 4,926 as reported for 2021), and subsequent inductions (e.g., 624 inductees reported in December 2023) have increased the national pool; ARCON also publishes current lists of registered firms (Okonta et al., 2025).

However, ARCON does not publish an easily-accessible, up-to-date count for FCT-only architects; therefore, the sampling calculation proceeds transparently using a conservative estimate for Abuja's practising architects. Drawing on the national totals and the concentration of professional practice in the capital, a defensible working population for Abuja was estimated at approximately 550–600 architects. The Yamane sample-size formula was used to determine a statistically defensible sample:

$$n = \frac{N}{1 + N(e)^2}$$

Where N = population size and e = desired margin of error. For N = 555 (midpoint of the working estimate) and e = 0.05 (5% margin of error), the calculation yields:

$$n = \frac{555}{1 + 555\,(0.025)^2} = 233$$

Sampling Strategy and Recruitment Procedures

A stratified sampling approach was applied to improve representativeness across practice types. Strata were defined by firm size (micro: 1–5 staff; small: 6–20; medium: 21–50; large: 51+), and by years of experience (0– 5, 6–10, 11–15, 16+). The sampling frame was assembled from ARCON and the Abuja NIA chapter membership lists, supplemented by professional networks and firm web listings; within each stratum, architects were randomly selected where possible, while purposive oversampling ensured adequate representation of large practice and senior roles (principals/partners) who make specification decisions. Recruitment was multi-modal, a secure online survey link (Google Forms) was the primary instrument, complemented by targeted personalised email invitations, and short in-person recruitment.

Research Instrument

The primary research instrument is a well-structured questionnaire. The questionnaire is modular and logically sequenced from consent to respondent/firm profile to awareness and training (including a 5-item objective knowledge check) to TAM-style attitude scales (perceived usefulness; perceived ease of use) to diffusion and social influence items to adoption/behaviour checklist and frequency questions for a defined list of smart green strategies to drivers and barriers (institutional/facilitating conditions) and then behavioural intention and open comments. Each module maps onto key variables for analysis. Demographic controls and firm attributes (confounders), objective knowledge (covariate), TAM scales (proximate predictors), diffusion indicators (peer exposure, demonstration effects), and institutional variables (regulatory clarity, finance access).

Data Analysis Preparation

For data collection, informed consent was obtained at the survey start and all responses were anonymised for analysis; email addresses were stored separately and only for respondents who opt in. Raw data was exported to Excel, duplicates removed, and responses screened for straight-lining and failed attention checks.

For multi-item scales, missing items were imputed only when missingness was minimal and random—single item mean imputation for isolated misses; multiple imputation for larger patterns where appropriate. Composite scale scores were computed and standardised as necessary. Metadata and a codebook with precise variable labels and value codings were also maintained; and raw and cleaned datasets were documented separately.

The analysis begun with descriptive statistics (frequencies, means, SDs) and cross-tabulations by firm size and training. However, hypothesis testing proceeds with regression models, including OLS for continuous adoption indices, ordered logistic regression for ordinal adoption categories, and logistic regression for dichotomous outcomes. Mediation tests (perceived usefulness → intention → adoption) and moderation tests (e.g., firm size moderating perceived ease → adoption) were conducted using bootstrapped standard errors. Models were controlled for firm size, years of experience and number of high-rise projects. Results were reported with effect sizes, 95% confidence intervals and robust diagnostics.

Interpretation Strategy

Finally, empirical findings were interpreted through the combined theoretical frame. Diffusion indicators to read network and firm-level patterning, TAM constructs to explain individual variance, and institutional variables to reveal structural enabling or constraining forces. Incremental R-squared and nested model comparisons quantify the explanatory contribution of institutional variables beyond TAM, clarifying whether individual perceptions or structural levers are the dominant policy targets for accelerating adoption in Abuja.

RESULTS

INTRODUCTION AND RESPONDENT PROFILE

The survey was distributed to registered architects in Abuja, with 198 (85%) initial responses. After applying inclusion criteria (current registration, practice in Abuja, involvement in high-rise office design, and passing an attention check), a final sample of N=157 complete responses was retained for analysis. A comparison of early and late respondents revealed no significant differences in self-rated knowledge (early M=3.90 vs. late M=4.06, t=-1.16, p=.248) or objective knowledge scores (early M=3.66 vs. late M=3.49, t=1.03, p=.307), suggesting a low risk of non-response bias.

The demographic and professional characteristics of the final sample are presented in *Table 1*. The respondents were experienced professionals, with the largest group (34.4%) having 11-15 years of experience. The sample was dominated by Project Architects (26.8%) and Senior Architects (17.8%). Most respondents held a Bachelor's degree (47.8%) or a Master's degree (29.9%) as their highest qualification. The firms represented were predominantly small to medium-sized, with 45.9% employing 1-5 staff and 40.8% employing 6-20 staff.

Table 1: Demographic and Professional Characteristics of Respondents (N=157)

Characteristic	Category	Count	Percent
Current Role	Principal/Partner	27	17.2%
	Director	11	7.0%
	Senior Architect	28	17.8%
Characteristic	**Category**	**Count**	**Percent**
	Project Architect	42	26.8%
	Design Architect	23	14.6%

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	Technical Architect	14	8.9%
	Other	12	7.6%
Highest Qualification	B.Arch / B.Sc Architecture	75	47.8%
	M.Arch / MSc	47	29.9%
	PhD	5	3.2%
	Technical Diploma/ND	22	14.0%
	Other	8	5.1%
Years of Experience	0–5	15	9.6%
	6–10	54	34.4%
	11–15	43	27.4%
	16–20	30	19.1%
	21+	15	9.6%
Firm Size (Staff)	1–5	72	45.9%
	6–20	64	40.8%
	51–150	19	12.1%
	151+	2	1.3%

Regarding firm characteristics, a majority (77/157, 49.0%) reported having no explicit sustainability policy, while only 36 (22.9%) had a formal written policy. The vast majority of firms (127/157, 80.9%) had not formally completed any project certified under a green building standard like LEED or GBCN.

Awareness, Training, and Objective Knowledge

Formal training in smart green design was not widespread. While 53 respondents (33.8%) had completed short CPD workshops, 49 (31.2%) reported having no formal training at all. Only 19 (12.1%) held a certificate in a relevant field, and a mere 5 (3.2%) had pursued postgraduate study (e.g., MSc) in the area.

Despite this, architects rated their personal knowledge highly (M=3.98, SD=0.89 on a 5-point scale). However, results from a five-item objective knowledge test revealed some gap between self-assessed and actual knowledge. The average objective knowledge score was 3.57 out of 5 (SD=1.05). Performance on individual items was mixed (*Table 2*). While knowledge of passive shading was high (86.6% correct), there were notable misconceptions, particularly regarding daylight-linked controls (only 56.1% knew they typically *reduce* energy use) and the comparative efficiency of façade-integrated PV (only 58.0% knew it does *not* always outperform rooftop PV).

Table 2: Performance on Objective Knowledge Test (N=157)

Knowledge Item (Correct Answer)	Percent Correct
Passive external shading reduces cooling load in hot climates. (True)	86.6%
Daylight-linked lighting controls typically increase overall lighting energy use. (False)	56.1%
Knowledge Item (Correct Answer)	**Percent Correct**
A well-commissioned BMS can improve energy performance. (True)	79.6%
Façade-integrated PV panels always produce more energy per m² than rooftop PV in tropical climates. (False)	58.0%

Lifecycle cost analysis (LCCA) typically favors higher initial capex if it leads to lower operating costs. (True)	77.1%

Prevalence and Patterns of Smart Green Strategy Adoption

Adoption of the 22 smart green strategies was highly variable, showing a clear distinction between foundational passive strategies and more advanced, technology-intensive systems.

Table 3: Adoption Prevalence and Mean Frequency of Smart Green Strategies (N=157)

Strategy	% Ever Adopted	Mean Frequency (0-4)
Daylighting design	94.3%	2.10
External passive shading	92.4%	2.11
High-performance glazing	91.7%	1.98
High-efficiency HVAC systems	90.4%	2.01
Solar-informed orientation/footprint	86.0%	1.85
Basic Building Management System (BMS)	73.2%	1.43
Use of thermal mass/insulation	72.6%	1.32
Use of locally sourced sustainable materials	72.6%	1.24
Daylight-linked lighting controls	70.7%	1.34
Rainwater harvesting	60.5%	0.99
Demand-controlled ventilation	59.9%	1.31
Sensor networks for IEQ	52.2%	0.76
Green roofs / roof terraces	49.7%	0.87
Natural ventilation strategies	42.0%	0.89
Rooftop PV installations	42.0%	0.66
Heat recovery systems	38.9%	0.72
Formal lifecycle cost analysis (LCCA)	38.9%	0.64
Commissioning & POE specified	38.2%	0.55
Greywater recycling systems	29.9%	0.51
Advanced BMS features	28.7%	0.55
On-site energy storage (batteries)	18.5%	0.29
Façade-integrated PV panels	14.6%	0.30

As shown in *Table 3*, adoption was highest for passive and design-led strategies such as daylighting design (94.3%), external shading (92.4%), and high-performance glazing (91.7%). The adoption of active and integrated systems was markedly lower. While basic BMS saw some uptake (73.2%), advanced BMS features were rare

(28.7%). Renewable energy strategies, particularly façade-integrated PV (14.6%), and on-site storage (18.5%) were among the least adopted. On average, respondents had worked on 8.9 high-rise projects in the last five years, of which 3.4 (38.2%) incorporated at least two smart green strategies.

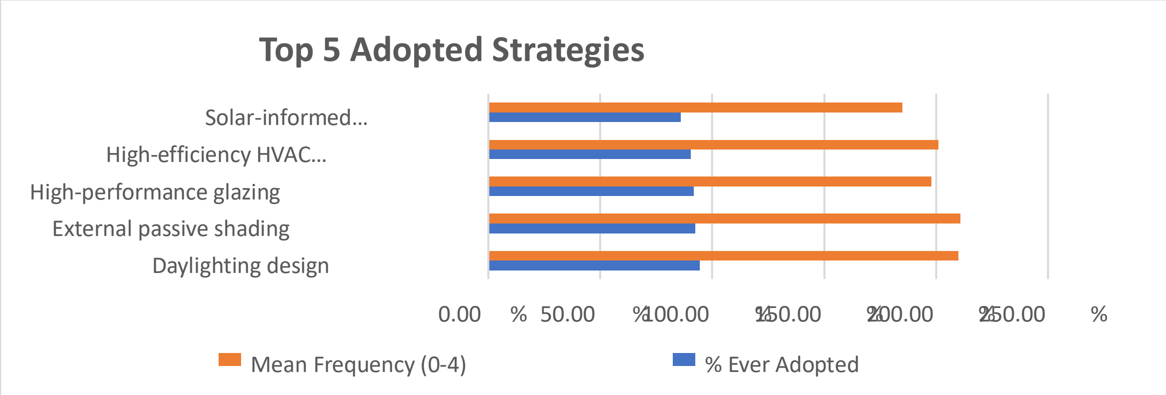

Figure 1: Top 5 Adopted Strategies

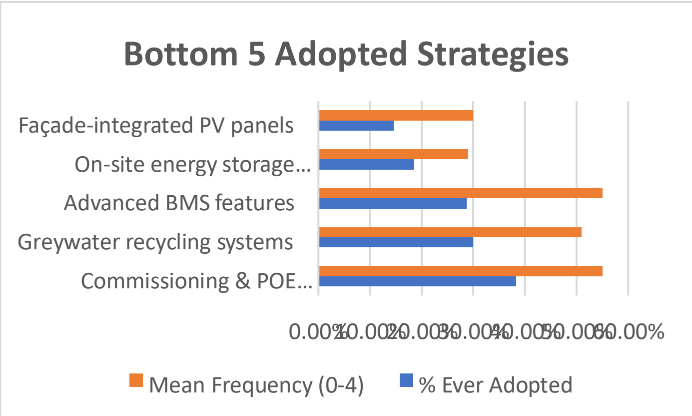

Figure 2: Bottom 5 Adopted Strategies Perceptions, Drivers, and Barriers

The multi-item scales for the theoretical constructs showed mixed reliability. The Perceived Usefulness (PU) scale demonstrated acceptable internal consistency (Cronbach's α = 0.602), with architects agreeing that SGB strategies are useful (M=3.67, SD=0.62). In contrast, the scales for Perceived Ease of Use (PEOU, α=-0.113), Social Influence (α=-0.205), and Facilitating Conditions (α=-0.051) had unacceptably low reliability, indicating that the items did not cohere as unified constructs in this sample. Consequently, these were analysed as individual items.

The most powerful drivers for adoption were *improved occupant comfort and productivity* (M=4.24/5) and *client request or demand* (M=4.18/5). The least influential driver was the *availability of green finance/incentives* (M=2.98/5), highlighting its current limitation in the market.

The analysis of barriers, presented in Figure 3, revealed that financial and risk-related concerns are the most significant impediments. High initial capital cost (capex) was the top-rated barrier (M=4.15/5), followed closely by Concerns about long-term maintenance and operational reliability (M=3.90) and Client unwillingness to pay higher capex (M=3.89).

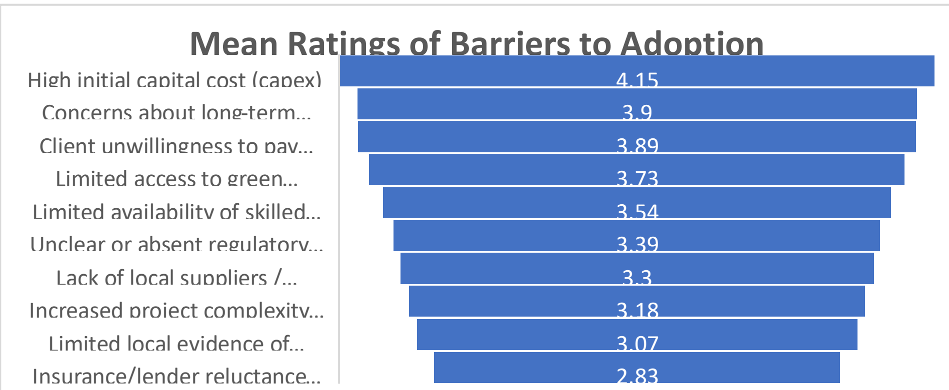

Figure 3: Mean Ratings of Barriers to Adoption

Regression Analyses

A hierarchical multiple regression was conducted to predict the overall adoption index. Control variables (number of projects, firm size, experience, % high-rise work) were entered in Model 1, TAM variables (PU, PEOU) in Model 2, and institutional variables (Facilitating Conditions, mean Barrier score) in Model 3. All variables were standardised. The results are presented in Table 4.

Table 4: Hierarchical Regression Predicting Standardised Adoption Index

Predictor	Model 1	Model 2	Model 3
Controls			
Number of Projects (5yr)	-0.027	-0.038	-0.064
Firm Size	-0.044	-0.056	-0.046
Years of Experience	0.112	0.120	0.142
% Firm Work (High-Rise)	-0.069	-0.052	-0.054
TAM Variables			
Perceived Usefulness (PU)		0.026	0.027
Perceived Ease of Use (PEOU)		0.106	0.103
Institutional Variables			
Facilitating Conditions			0.121
Barrier Score			0.079
Model Fit			
R^2	.014	.026	.046
Adjusted R^2	-.012	-.013	-.005

None of the models were statistically significant, and the addition of theoretical variables did not really substantially improve the explanatory power. The overall models explained a negligible amount of variance in adoption (R^2 Model 3 = .046), and no individual predictor reached statistical significance at $p < .05$.

A subsequent binary logistic regression was performed to ascertain the effects of knowledge, perceptions, and firm characteristics on the likelihood of having adopted a basic BMS. However, the model was not statistically significant, $\chi^2(6) = 6.24$, $p = .397$. None of the predictors were significant, though the odds ratios for PU (OR = 0.723) and objective knowledge (OR = 0.911) suggested a negative, albeit non-significant, relationship with adoption.

Behavioural Intention and Response to Interventions

Despite the current low adoption of advanced strategies, architects expressed strong positive intentions for the future. The vast majority (83.4%) reported being "likely" or "very likely" (score of 4 or 5 on a 5-point scale) to specify at least one smart green strategy in their next high-rise project. Furthermore, 92.4% of respondents stated that the availability of green finance or performance-based guarantees would make them "more likely" or "much more likely" to specify BMS and renewable energy integration. Finally, there was overwhelming interest (89.2%) in attending a subsidised specialist CPD on BMS and high-rise performance systems.

Table 5: Behavioural Intentions and Response to Potential Interventions

Indicator	Response Category	Count	Percent
Likelihood to specify any SGB strategy in next project (1=Very Unlikely, 5=Very Likely)	1 (Very Unlikely)	2	1.3%
	2	4	2.5%
	3 (Neutral)	20	12.7%
	4 (Likely)	51	32.5%
	5 (Very Likely)	80	51.0%
	Total (Likely/Very Likely)	**131**	**83.4%**
Effect of green finance on specifying BMS/Renewables	Much less likely	0	0.0%
	Less likely	1	0.6%
	No change	11	7.0%
	More likely	70	44.6%
	Much more likely	75	47.8%
	Total (More/Much more likely)	**145**	**92.4%**
Willingness to attend specialist CPD	No	3	1.9%
	Maybe — depends on timing	14	8.9%
	Yes — definitely	140	89.2%
	Total (Yes)	**140**	**89.2%**

This strong positive intention stands in stark contrast to the current low adoption rates of complex systems like BMS and renewables, revealing a significant attitude-behaviour gap. This suggests that the barriers identified (high capex, client resistance, maintenance concerns) are perceived as so formidable that they actively suppress action, despite a underlying belief in the value of smart green strategies.

When asked to identify the single most impactful policy or market change, responses were varied. The most frequent suggestions were "Clear energy performance regulations" (18.5%), "Client awareness campaigns" (15.9%), and "Local supplier development & certification" (13.4%). This aligns with the quantitative data, pointing to a desire for stronger regulatory signals, more informed clients, and a more robust local supply chain to mitigate perceived risks.

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Qualitative Analysis

Table 6: Thematic Analysis of Qualitative Open-Text Responses

Theme (Ranked by Frequency)	Frequency (Mentions)	Representative Anonymised Quotes (Accepted)	Representative Anonymised Quotes (Rejected)	Interpretation
Client/Developer Decision Logic	13	"An international client insisted on VRF systems and daylighting after tenant requirements were clarified; client absorbed modest extra capex." "Developer accepted high-performance glazing once the tenant contract guaranteed lower operating bills."	*(Primarily a driver for acceptance; less frequently cited as a direct reason for rejection in quotes.)*	Clients are the primary gatekeepers. Strategies are accepted when the client understands the business case (tenant demand, lease premiums, PR value, operational savings).
BMS / Automation	7	"On a donor-funded civic office, automated BMS with monitoring was accepted because funders required performance guarantees."	"Advanced BMS analytics were rejected by a private developer due to anticipated maintenance costs and lack of local technicians."	Basic automation is accepted under certain conditions (donor/government mandates). Advanced features are rejected due to perceived maintenance burdens and a lack of local technical support.
Performance Evidence / Monitoring	7	"We specified POE and monitoring in a pilot; data convinced the client of energy savings and prompted replication."	"Clients asked for local performance evidence; without it PV proposals were hard to sell."	Local, project-specific performance data is a powerful tool for persuasion. The absence of such evidence is a significant barrier to adoption for newer technologies.
Cost / Capex Concerns	6	"We specified light shelves and atrium daylighting (low capex) — accepted..."	"…expensive PV and storage were rejected due to payback uncertainty." "BMS analytics were seen as an unnecessary capex for many private developers."	Upfront cost is a central concern. Low-capex strategies are more readily accepted. Highinvestment strategies are rejected without a clear and certain return on investment (ROI).
Maintenance / Commissioning	6	"Commissioning was accepted in one	"…but in others it was rejected because the client did not want	Concerns about long-term operational burdens and the reliability of the local supply chain for

Theme (Ranked by Frequency)	Frequency (Mentions)	Representative Anonymised Quotes (Accepted)	Representative Anonymised Quotes (Rejected)	Interpretation
		project as part of contract..."	increased O&M obligations." "We could not find reliable local contractors to service the advanced controls; this stopped adoption."	maintenance and commissioning are major practical barriers to adoption.
PV and Renewables	6	"Rooftop PV accepted for a government office because funding covered capex and there was PR value."	"Façade PV was rejected because of cost, aesthetics and uncertainty under local tariffs."	Renewables are adopted when capex is mitigated (e.g., by funding) or when non-economic benefits (PR) are valued. Novel applications face multifaceted resistance (cost, aesthetics, regulatory uncertainty).
Skills / Training	3		"Professional bodies should expand CPDs — many architects lack formal systems integration training."	There is a recognised skills gap that affects both the specification confidence of architects and the capacity of local contractors, creating a cycle of reluctance.

The qualitative analysis was based on a focused content analysis of 28 optional open-text responses (11 accepted examples, 9 rejected examples, 8 general comments). Themes were identified by counting recurring keywords and concepts across all fields.

DISCUSSION AND COMPARATIVE ANALYSIS

This study set out to investigate the adoption of smart green building (SGB) strategies among architects in Abuja, Nigeria. The results reveal constrained progress, characterised by high awareness and positive intentions but severely limited by a complex web of institutional and market barriers. The findings largely conform to global and regional patterns identified in the literature while highlighting context-specific divergences that are critical for understanding the Abuja context.

Conformity and Divergence with Global and Regional Patterns

The pattern of adoption observed—widespread use of passive, low-capex strategies (daylighting, shading, glazing >90%) and markedly lower uptake of active, integrated systems (advanced BMS 28.7%, renewables 40%)—closely mirrors findings from other emerging economies (Idowu & Abdulrahman, 2023; Ashen, Rimtip & Davou, 2024). This aligns with the Diffusion of Innovations theory, where strategies with high relative advantage (clear energy savings), compatibility (easily integrated into standard design processes), and observability (visible aesthetic or comfort benefits) diffuse most rapidly. As noted in the literature, passive measures like shading are highly cost-effective first-order measures in tropical climates (Ndichu, 2017; GameroSalinas et al., 2021), and their high adoption rate suggests Abuja architects are rationally prioritising these proven, low-risk interventions.

However, where Abuja diverges from more advanced markets is in the near-complete blockage of diffusion for smarter, integrated technologies. The miniscule adoption of façade-integrated PV (14.6%) and advanced BMS analytics (28.7%) is not merely a case of being earlier on the adoption curve; it is a symptom of a fractured ecosystem. This finding powerfully reinforces the literature on Nigerian construction, which identifies nontechnical constraints—finance, supply chains, client preferences—as critical barriers (Unegbu et al., 2025). The qualitative data provides the context, as these strategies are rejected not because they are perceived as useless (PU scores were high), but because they score poorly on compatibility with local client priorities and complexity given the lack of technical support. This emphasises a core tenet of institutional theory, where the adoption decision is not made in a vacuum but is profoundly shaped by mimetic pressures (clients mimicking short-term cost focus) and the absence of strong coercive (regulation) or normative (professional standards) pressures.

The Attitude-Behaviour Gap

The most telling finding is the stark attitude-behaviour gap. Architects possess strong positive intentions (83.4% likely to adopt) and believe in the usefulness of SGB strategies (PU M=3.67), yet their actual adoption of complex systems remains low. This chasm cannot be explained by Technology Acceptance Model (TAM) alone, which focuses on individual perceptions. Instead, it is a classic display of institutional barriers overwhelming individual intent. Architects are caught between their professional knowledge and a market that does not value or support its application. Their positive response to green finance (92.4%) and training (89.2%) is a clear signal that they are aware of the solutions but lack the agency to implement them individually. This aligns with OjekaJohn et al. (2025), who found that perceived usefulness is necessary but not sufficient for adoption in the Nigerian context.

Theoretical Contribution

The regression results were illuminating in their nullity. Combined together, TAM and institutional model explained a negligible amount of variance ($R^2 = 0.046$) in adoption, and no individual cognitive or perceptual factor was a significant predictor. This statistical non-finding is, in itself, a significant finding. It strongly suggests that, individual-level factors are dwarfed by larger structural constraints.

While DOI helps describe the pattern of diffusion and TAM captures the individual intent, Institutional Theory provides the most powerful explanatory framework for the current state of adoption. The barriers are not primarily about a lack of knowledge or negative attitudes among architects; they are about:

a. Weak Coercive Pressures: Unclear regulations and absent enforcement were rated a major barrier.

b. Predominant Mimetic Pressures: Widespread imitation of a cost-focused, risk-averse development model.

c. Underdeveloped Normative Pressures: A lack of strong industry standards or client demand for high performance.

Therefore, a combined model improves explanatory power not by adding variance, but by correctly identifying the locus of the problem. Meaning that interventions must target the institutional and market level, not just the individual architect.

Policy and Practice Recommendations

The following recommendations are directly derived from the study's results and are designed to address the specific barriers identified.

i. Mandate Building Performance Disclosure and Strengthen Energy Codes

The top barrier was 'high initial capital cost,' followed by 'unclear or absent regulatory guidance.' Clients reject strategies due to uncertain ROI and a lack of local performance evidence. Therefore, Abuja Federal Capital Development Authority (FCDA) should develop and enforce a mandatory building energy performance disclosure policy for all new and majorly renovated high-rise offices. This should be coupled with a phased strengthening of the energy efficiency provisions in the building code.

ii. Establish a Green Building Finance Facility

92.4% of architects said green finance would make them more likely to specify BMS and renewables.

'Limited access to green finance' was a top-5 barrier. This evidence calls for the Central Bank of Nigeria (CBN), in partnership with commercial banks and development finance institutions, to establish a dedicated credit facility for green buildings. This should offer reduced-interest loans or partial risk guarantees to developers who meet predefined green criteria (e.g., EDGE or GBCN certification).

This can build on existing CBN intervention funds. Even though it would require collaboration between the CBN, the Nigerian Mortgage Refinance Company (NMRC), and commercial banks, the impact is mitigating the primary barrier of high capex, making SGB strategies financially viable for developers and empowering architects to propose them.

iii. Launch a Targeted Capacity Building Programme

This study clearly shows that 89.2% of architects are willing to attend specialist CPD. The qualitative data highlighted a critical skills gap among both architects ("lack systems integration training") and contractors ("cannot find reliable local technicians"). The Architects Registration Council of Nigeria (ARCON) and the Nigerian Institute of Architects (NIA), in collaboration with COREN and technical universities, should therefore develop and subsidise a certified CPD curriculum focused on BMS commissioning, integrated design, and building performance evaluation.

iv. Foster Client Awareness and Market Transformation

'Client unwillingness to pay' was a top-3 barrier. The qualitative data showed strategies are accepted only when the client understands the business case (tenant demand, operational savings). Therefore, the Nigerian Green Building Council (NGBC) and large property firms should lead a high-profile awareness campaign targeting property developers, institutional investors, and corporate tenants. This should showcase successful local case studies and articulate the business case for green offices in terms of tenant attraction, retention, and lower vacancy rates. This would create mimetic pressure by making green design a marker of market leadership and shifts client demand, which is the most powerful driver of architect behaviour.

Limitations And Future Research

This study, while providing a snapshot of current practices, is subject to several limitations inherent to its methodological approach. Firstly, the reliance on self-reported data introduces the potential for social desirability bias, where respondents may overstate their knowledge, adoption rates, or positive intentions. Additionally, the cross-sectional design captures attitudes and behaviours at a single point in time, which limits the ability to establish causality or observe the evolution of adoption trends. Although checks suggested a low risk of nonresponse bias, the potential for sampling bias remains if responding architects were systematically more interested in sustainability than non-respondents.

These limitations delineate clear pathways for future research. To move beyond self-reported data, in-depth longitudinal case studies of projects that successfully implemented advanced SGB strategies are needed to document the actual decision-making processes, contractual arrangements, and on-site challenges. Furthermore, post-occupancy evaluations and physical performance monitoring of both conventional and green high-rises in Abuja would provide the objective energy and comfort data that this study found was a critical missing link for convincing clients. Finally, a mixed-methods sequel that combines the broad patterns identified here with qualitative interviews would yield deeper causal insights into the complex interplay between architect agency, client demands, and regulatory frameworks.

CONCLUSION

This research set out to answer three core questions regarding the adoption of smart green building strategies in Abuja's high-rise office sector. First, it found that architects possess a high self-rated knowledge but a more moderate objective understanding, with some gaps concerning integrated technologies like advanced BMS and renewables. Second, it revealed a distinct adoption pattern where near-universal uptake of passive, low-capex measures (e.g., shading, daylighting) stands in stark contrast to the severely limited adoption of active, integrated smart systems (e.g., BMS analytics, façade PV). Third, the analysis identified the drivers and barriers, pinpointing client demand and occupant comfort as key motivators, while high initial cost, client resistance, and maintenance concerns emerged as the most formidable impediments.

The central explanatory insight is that while architects' knowledge and positive perceptions are necessary, they are insufficient catalysts for change. Institutional constraints and market failures are decisive in the Abuja context, creating a chasm between intent and action. In conclusion, the path to adopting smart green design in Abuja lies not in waiting for architects to become more knowledgeable or motivated, as they already are. However, it requires a deliberate, multi-stakeholder effort to re-shape the institutional and market environment in which they operate. The immediate levers call for targeted education to build technical capacity, financial incentives to mitigate capex hurdles, and high-profile demonstration projects to provide irrefutable local evidence, thereby moving adoption from isolated exemplars to mainstream practice.

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APPENDIX

Appendix 1: Questionnaire Instrument

Study title: Investigation of Architects' Adoption and Use of Smart Green Building Design Strategies in

High-Rise Office Design in Abuja, Nigeria

Estimated completion time: 10–15 minutes

Definitions (show at top): For this survey, *high-rise office* = building > **8 storeys** or **≥24 m** in height. *BMS* = Building Management System (automation that monitors/controls HVAC, lighting, shading, etc.). Responses are anonymous and used for academic research only.

SECTION 1 — Consent & eligibility

1. Informed consent — "I have read the study information, I understand the purpose of this research, and I consent to my (anonymous) responses being used for academic research and publications. I understand participation is voluntary and I can withdraw before submitting." ○ I consent to participate. ○ I do not consent to participate. *(If no, end survey.)*

2. Are you a registered architect currently practising in Abuja (Federal Capital Territory)?

○ Yes

○ No *(If No, end survey.)*

3. Have you been involved (in any role) in the design or specification of high-rise office projects in the past five years? ○ Yes ○ No

4. Attention check — "Please select 'Often' to confirm you are completing the survey carefully." ○ Never / Rarely / Sometimes / **Often** / Always

SECTION 2 — Respondent & Firm Profile

5. Current role in your firm (Dropdown): Principal/Partner; Director; Senior Architect; Project Architect; Design Architect; Technical Architect; Other (specify).

6. Highest professional qualification : B.Arch / B.Sc Architecture; M.Arch / MSc; PhD; Technical Diploma / ND; Other (specify).

7. Years of professional experience : 0–5; 6–10; 11–15; 16–20; 21+

8. Firm size (number of full-time staff) : 1–5; 6–20; 21–50; 51–150; 151+.

9. Approximately what percentage (%) of your firm's work (by project count) is high-rise office design? (Short numeric answer)

10. Does your firm have an explicit sustainability/green building policy? : Yes — formal written policy; Yes — informal practices only; No.

11. Has your firm completed projects certified (or submitted) under any green building standard (e.g., GBCN, LEED, BREEAM, EDGE)? : Yes — certified; Yes — submitted but not yet certified; No; Don't know / Prefer not to say.

12. Do you have access to in-house MEP or building performance specialists (engineers/energy modellers)? : Yes; No — we outsource; No — not available.

SECTION 3 — Training, Awareness & Objective Knowledge

13. Have you completed formal training specifically on green building design, building performance simulation, BMS, or related topics?: Short CPD / workshop (≤1 week); Certificate course (1–6 months); Postgraduate course (MSc / Graduate diploma); Online MOOC; None.

14. If yes, name the main course or provider and approximate hours. (Paragraph / optional)

15. Self-rated knowledge: How would you rate your personal knowledge of smart green design strategies for high-rise offices? (Linear scale 1–5: 1 = Very low, 5 = Very high)

16. Objective knowledge test — True / False for each statement (Multiple choice grid):

a. Passive external shading reduces cooling load in hot climates. (True / False)

b. Daylight-linked lighting controls (dimming based on daylight) typically increase overall lighting energy use. (True / False)

c. A well-commissioned BMS can improve energy performance compared to an uncommissioned system. (True / False)

d. Façade-integrated PV panels always produce more energy per m^2 than rooftop PV in tropical climates. (True / False)

e. Lifecycle cost analysis (LCCA) typically favours higher initial capex if it leads to lower operating costs over the building's life. (True / False)

SECTION 4 — Perceptions & attitudes (TAM & institutional items) — 1–5 Likert (1 = Strongly disagree … 5 = Strongly agree)

Perceived Usefulness (PU) — four items:

a. Implementing BMS in high-rise offices leads to measurable energy cost savings.

b. b. Smart façade systems (automated shading, adaptive glazing) improve occupant comfort in Abuja's climate.

c. Specifying smart green strategies increases the long-term asset value of office buildings.

d. These strategies significantly reduce operational disruptions (e.g., fewer tenant complaints).

Perceived Ease / Maintainability (PE) — four items (note: last item reverse coded):

e. It is straightforward to find local contractors who can install and commission BMS.

f. Local maintenance teams can reliably maintain advanced building automation systems.

g. Smart systems (sensors, automation) are generally easy to operate for building managers in Abuja.

h. The technical complexity of smart green solutions discourages their use. *(Reverse code for scale.)*

Social Influence (3 items):

i. Clients in Abuja expect architects to propose green/smart features for high-rise offices.

j. Peer architects in my network often influence my specification choices.

k. Developers reward green / smart specifications through higher fees or project opportunities.

Facilitating Conditions & Institutional Pressures (4 items):

l. Access to green finance (preferential loans) would increase the use of smart green strategies.

m. Clearer building energy regulations in Abuja would increase adoption of these strategies.

n. Availability of local suppliers for PV, sensors and controls is sufficient.

o. Insurance and lender requirements influence design choices for energy systems.

SECTION 5 — Current adoption / behaviour (past 5 years)

17. In the past five years, approximately how many high-rise office projects have you personally contributed to (design/specification role)? (Numeric)

18. Of those projects, how many included at least two smart green strategies (e.g., passive + BMS, PV + daylight controls)? (Numeric)

23. For each strategy below, indicate (A) whether you have specified it in any high-rise office project in the past five years (Yes/No) and (B) if Yes, how frequently across projects (Never / Rarely / Sometimes / Often / Always). *(Use grid / repeated blocks)*

List of strategies:

- External passive shading (brise-soleil, fins)
- Orientation/footprint decisions informed by solar analysis
- High-performance glazing (low-e, double/triple as appropriate)
- Thermal mass and insulation strategies for cooling reduction
- Natural ventilation strategies (where feasible)
- Green roofs / roof terraces for cooling & stormwater

management

- Daylighting design (light shelves, atria)
- Daylight-linked lighting controls (dimming/occupancy sensors)
- High-efficiency HVAC systems (VRF, inverter chillers)
- Demand-controlled ventilation (CO_2 sensors)
- Heat recovery systems (AHU energy recovery)
- Building Management System (BMS) — basic (controls HVAC, lighting)
- Building Management System (BMS) — advanced (analytics, fault detection)
- Sensor networks for occupant comfort/IEQ
- Façade-integrated PV panels
- Rooftop PV installations
- On-site energy storage (batteries)
- Greywater recycling / water reuse systems
- Rainwater harvesting / attenuation tanks
- Use of locally-sourced sustainable materials / low-carbon alternatives
- Formal lifecycle cost analysis (LCCA) used during design decision making
- Commissioning and post-occupancy evaluation / monitoring specified in contract

24. Which single strategy have you most often specified in Abuja high-rise offices in the past five years? (Dropdown list of above strategies + None)

SECTION 6 — Drivers & Barriers (1–5 scale)

25. Rate importance of drivers for specifying smart green strategies (1 = Not important … 5 = Very important): expected energy savings; improved occupant comfort; client request/demand; regulatory requirement; marketing/tenant attraction; availability of green finance; professional ethics; peer/industry norms.

26. Rate significance of barriers preventing specification (1 = Not significant … 5 = Very significant): high initial capital cost; client unwillingness to pay higher capex; lack of local suppliers; limited skilled contractors/commissioning agents; concerns about long-term maintenance; unclear/absent regulatory guidance; limited local evidence of performance/ROI; increased project complexity and procurement risk; insurance/lender reluctance; limited access to green finance.

27. For the three barriers you marked most significant above, indicate whether each is Primary / Secondary / Not relevant. (Short paragraph — list barrier and label.)

28. If a single policy or market change would increase adoption the most, which would you choose? : Clear energy performance regulations; Financial incentives / green loans; Mandatory commissioning and POE; Subsidised training & capacity building; Local supplier development & certification; Client awareness campaigns; Other (specify).

SECTION 7 — Behavioural intentions & scenarios

29. How likely are you to specify at least one smart green strategy in your next high-rise office project? (1–5 Likert: Very unlikely … Very likely)

30. If green finance or performance-based guarantees were available to developers, how would that affect your likelihood to specify BMS and renewable integration? (Much less likely / Less likely / No change / More likely / Much more likely.

31. Would you attend a short specialist CPD on BMS and high-rise performance systems if offered free/subsidised? (Yes — definitely / Maybe / No)

SECTION 8 — Project examples & open responses (optional)

32. Brief example of an accepted proposed strategy (2–3 sentences; anonymised).

33. Brief example of a rejected proposed strategy (2–3 sentences; anonymised).

34. Any further comments on opportunities or barriers?

SECTION 9 — Follow-up (optional)

35. Consent to be contacted for a short follow-up interview? (Yes / No)

Appendix 2: Reliability Table (Cronbach's Alpha and Item-Level Means)

Scale	**n items**	**Cronbach's α**	**Mean (itemlevel, average)**	**Notes (item keys)**
Perceived Usefulness	4	0.602	3.69	PU items: energy savings, façade comfort, asset value, operational disruption
Perceived Ease (recoded)	4	-0.113	3.07	PE items: local installability, local maintenance, ease to operate, technical complexity (recoded)
Social Influence	3	-0.205	2.99	client expectations, peer influence, developer rewards
Facilitating Conditions	4	-0.051	2.95	green finance, regulation, local suppliers, insurers/lenders