Comparative Analysis of Shading Strategies for Energy Efficiency in the Design of a Premium Hospitality Facility in Abuja

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https://doi.org/10.56201/ijemt.vol.12.no8.2026.pg192.205

Abstract
Five-star hotels in tropical climates are highly energy-intensive due to heavy cooling loads from solar heat gain through glazed envelopes. This study investigates shading strategies to enhance energy efficiency for a proposed five-star hotel in Abuja, Nigeria, using a mixed-methods approach combining a survey of 43 building professionals with case studies of three local luxury hotels. Findings reveal high awareness of strategies like brise-soleil (Mean = 3.90) and deep overhangs (Mean = 3.88), yet actual integration remains significantly lower. Key barriers to implementation include regulatory gaps (Mean = 4.62), high initial costs (Mean = 4.37), and expertise shortages (Mean = 4.32), despite strong drivers like daylighting synergy and climate responsiveness (Mean = 4.97). Case studies confirmed that older hotels with deep balconies offer effective passive shading, whereas modern curtain-wall structures suffer from shading neglect. To bridge this gap, the study proposes an architectural design featuring orientation-specific structural envelope features: horizontal brise-soleil and balconies on north/south facades alongside vertical fins on east/west facades. Ultimately, the research demonstrates that adoption is limited by missing enforcement rather than a lack of awareness, recommending mandatory passive-shading standards in Nigeria's building energy-efficiency codes.

Keywords: *shading strategies, energy efficiency, passive design, five-star hotel, Abuja, building envelope.*

1.0 Introduction

The global demand for energy-efficient building design has intensified in response to accelerating climate change, volatile energy costs and mounting environmental concern, with the construction and operation of buildings accounting for a significant share of global energy use and energy-related carbon emissions. Within the commercial sector, high-end hotels are exceptionally dense nodes of consumption; four- and five-star hotels consume more energy than any other hotel category, particularly in tropical regions where cooling demand is substantial (Dibene-Arriola et al., 2021). In these climates the trend toward highly glazed envelopes frequently compromises thermal efficiency, compounded by continuous operation, fluctuating occupancy, extensive service infrastructure and the exacting comfort thresholds international guests expect. Passive architectural interventions, particularly external shading, offer a structurally sound and economically viable way to arrest solar heat gain before it penetrates conditioned space. Attia et al. (2022) found that dynamic shading and electrochromic glazing can cut total annual thermal loads by up to 30%, and Baltazar and Mata

(2023) showed that external shading on hotel glazing can reduce energy needs by up to 45%; Alhuwayil, Almaziad and Mujeebu (2023) further established that well-designed external shading integrated with self-shading envelopes outperforms insulation improvements alone across multiple climates. Within Abuja's Guinea-savannah belt‹ intense solar exposure, prolonged dry seasons and elevated ambient temperatures‹ Adaji, Adekunle and Watkins (2022) confirm that passive interventions including shading are essential to indoor thermal comfort. Despite this, passive shading remains underused or unoptimised in contemporary Abuja developments, which frequently favour highly glazed typologies that disregard local microclimate. Five-star hotels in Abuja consume heavily because of their reliance on mechanical cooling, and sealed, glazed facades exacerbate solar heat gain, producing thermally inefficient buildings. This study addresses that gap by assessing how envelope configurations incorporating shading can optimise energy performance, pursued through objectives that identify the shading strategies known to architects, assess integration levels, barriers and enabling factors, and translate the findings into a design proposal for a five-star hotel in Abuja.

2.0 Shading Strategies as a Design Tool

Shading devices intercept and deflect direct solar radiation before it reaches the envelope, and are classified by configuration, orientation and function. Horizontal devices‹ overhangs, canopies and horizontal louvres‹ are most effective on south- and north-facing elevations and can raise shading performance by up to 20% relative to unshaded facades (Ibrahim et al., 2023). Vertical devices‹ fins and brise-soleil‹ are best deployed on east and west facades to counter low-angle radiation (Khidmat et al., 2022). Egg-crate devices, combining horizontal and vertical elements in a grid, provide the best performance among typologies studied in hot-humid climates, improving efficiency by up to 17% (Leu & Boonyaputthipong, 2023; Chan et al., 2022). Green walls and vegetated shading add cooling through evapotranspiration, with a review of 647 case studies finding cooling-demand reductions up to 51% and urban-heat-island mitigation up to 5 °C (Santamouris et al., 2022). Collectively, shading has been shown to cut cooling loads between 3% and 27.7% depending on climate, orientation and configuration (Ayoobi & Mehdizade, 2025; Yi et al., 2024). The systematic review of energy-efficiency strategies in office buildings by Erebor, Ibem, Ezema and Sholanke (2021) reinforces shading's established place within the design toolkit, identifying 29 distinct strategies across pre-building, building and post-building phases, with envelope interventions the most frequently reported‹ confirming shading's recognised, if comparatively under-reported, role, a gap the hotel-specific focus of this study addresses.

2.1 Abuja's Solar Geometry and a Classification of Strategies

Because shading is governed by solar geometry, the design response is climate- and orientation-specific rather than generic. At Abuja's latitude of about 9.07° N the midday sun stands high, so horizontal devices shade the north and south elevations effectively, while the low, raking morning and afternoon sun on the east and west demands vertical fins or egg-crate screens (Figure 1). Table 1 sets out the climatic parameters that make external, orientation-specific shading decisive here.

Table 1: Climatic characteristics of Abuja relevant to hotel shading

Climatic parameter	Characteristic in Abuja	Implication for shading
Latitude	≈ 9.07° N	High solar altitudes near midday; low sun morning and afternoon
Climate belt	Guinea savannah; intense solar exposure	Year-round solar-control demand on hotel envelopes
Temperature	Elevated ambient temperatures, prolonged dry season	High cooling loads sustained across the year
Sun path	High midday sun on N/S; low raking sun on E/W	Horizontal devices for N/S; vertical fins for E/W
Solar control	Cooling loads reduced 3–45% with external shading	External, orientation-specific shading is decisive

Source: compiled by the authors from Adaji et al. (2022) and the cited solar-geometry literature.

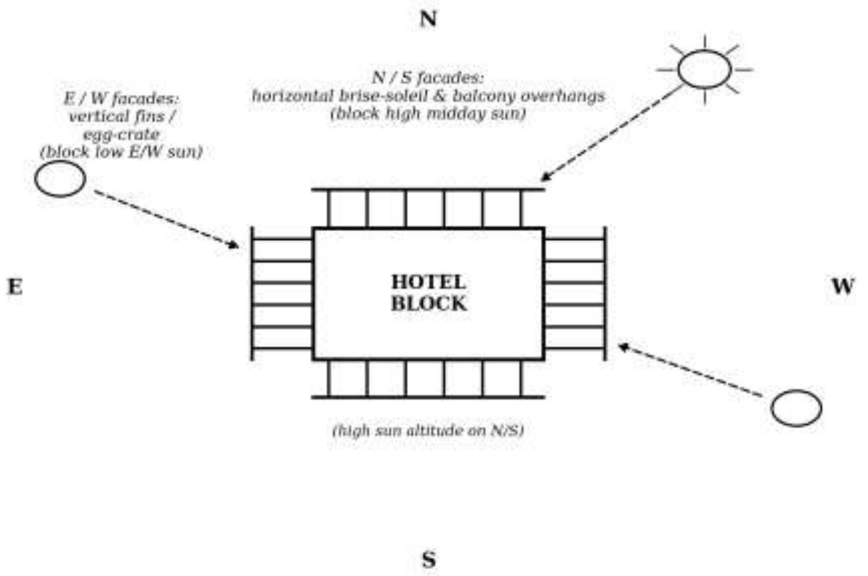

Figure 1: Orientation-specific shading at Abuja's latitude: horizontal brise-soleil and balconies on the north and south facades for the high sun, vertical fins or egg-crate screens on the east and west for the low sun
Source: Authors' construction (2026).

The strategies assessed in this study fall into four families‹ horizontal, vertical and screen, dynamic, and vegetative and site‹ set out in Table 2 and Figure 2. The families differ markedly in cost and permanence, from a structural balcony that shades for the life of the building to a dynamic electrochromic system with a continuing cost and maintenance burden, a difference the results show to be decisive.

Table 2: A classification of the hotel shading strategies assessed

Shading family	Working principle	Strategies assessed in this study
Horizontal	Block the high midday sun (N/S facades)	Deep overhangs & canopies; balconies; atrium skylights with mesh; poolside pergolas
Vertical & screens	Block low east/west sun and diffuse glare	Brise-soleil (sun breakers); facade patterning
Dynamic	Adjust to sun position and sky conditions	Automated louvres; retractable awnings; electrochromic glass
Vegetative & site	Shade and cool through planting and layout	Green walls / vertical gardens; strategic landscaping

Source: Authors' construction (2026).

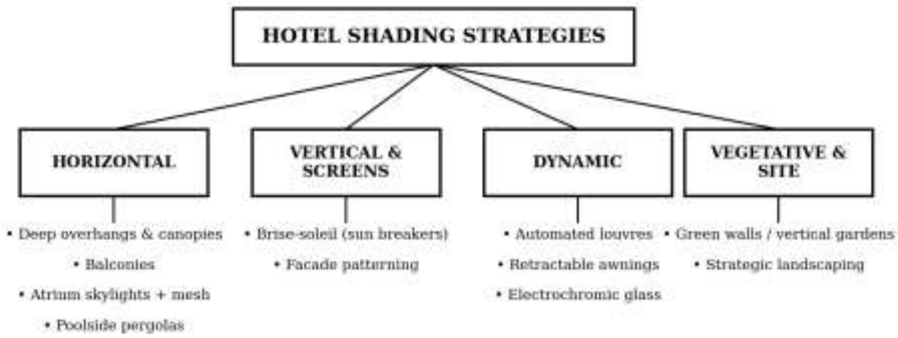

Figure 2: The four shading families and their representative strategies
Source: Authors' construction (2026).

3.0 Methodology

The study adopted a mixed-methods design, combining questionnaire data with case-study observation to build a triangulated understanding of shading integration in Abuja's luxury-hotel sector. The target population comprised registered architects and allied building-industry professionals in the Federal Capital Territory; drawing on ARCON and NIA membership records, the Abuja subset was estimated at about 1,000 practitioners, and the Taro Yamane formula at a 5% margin of error yielded a target of 286 respondents, to be drawn by stratified random sampling across junior, mid-level and senior strata. In practice, 43 completed and usable questionnaires were retrieved and analysed, providing an expert-level sample adequate for the descriptive analysis reported here; the shortfall against the target is acknowledged as a limitation. The instrument assessed knowledge of eleven shading typologies (Section B), their integration (Section C), twelve barriers (Section D) and fourteen enhancing factors (Section E), each on a five-point scale; it was validated by academic experts and its reliability confirmed by a pilot study with all scales meeting the 0.70 Cronbach's-alpha threshold. Three prominent five-star hotels‹ Transcorp Hilton Abuja, Fraser Suites Abuja and Abuja Continental Hotel (formerly Sheraton)‹ were purposively selected and inspected with a structured observation guide. Data were analysed in SPSS version 25 using means, standard deviations and rankings, with the scale mid-point of 3.0 used as the reference.

4.0 Results

Results of the data obtained from the research fieldwork are presented hereafter following analysis in accordance with the study's objectives. The results are presented in two major sections starting with the quantitative questionnaire survey, followed by the qualitative architectural case study assessments. The first section presents the survey results of the sampled building industry professionals across five subsections: demographic profile, professional knowledge of shading strategies, extent of integration of shading strategies, barriers inhibiting integration, and factors that enhance integration levels.

4.1 Knowledge of Shading Strategies

Table 3 and Figure 3 report knowledge of the eleven strategies. Brise-soleil recorded the highest mean (3.90), followed closely by deep overhangs and canopies (3.88), balconies and atrium skylights with shading mesh (both 3.74), and green walls and poolside pergolas (both 3.65). The lowest were retractable awnings (2.95) and electrochromic glass (2.69)، confirming that the most familiar strategies are physically robust and materially common in Nigerian construction, while advanced, technology-driven systems remain least understood.

Table 3: Knowledge of shading strategies (N = 43)

S/N	Shading strategy	Mean	SD	Rank
1	Brise-soleil (sun breakers)	**3.90**	0.693	1st
2	Deep overhangs and canopies	**3.88**	0.762	2nd
3	Balconies	**3.74**	0.563	3rd
4	Atrium skylights with shading mesh	**3.74**	0.242	3rd
5	Green walls and vertical gardens	**3.65**	0.225	5th
6	Poolside pergolas	**3.65**	0.165	5th
7	Facade patterning	**3.18**	0.328	7th
8	Automated louvres	**3.06**	0.758	8th
9	Strategic landscaping	**3.00**	0.654	9th
10	Retractable awnings	**2.95**	0.178	10th
11	Electrochromic glass	**2.69**	0.141	11th

Rankings recomputed from the reported means. Source: Field survey via SPSS v25 (2026).

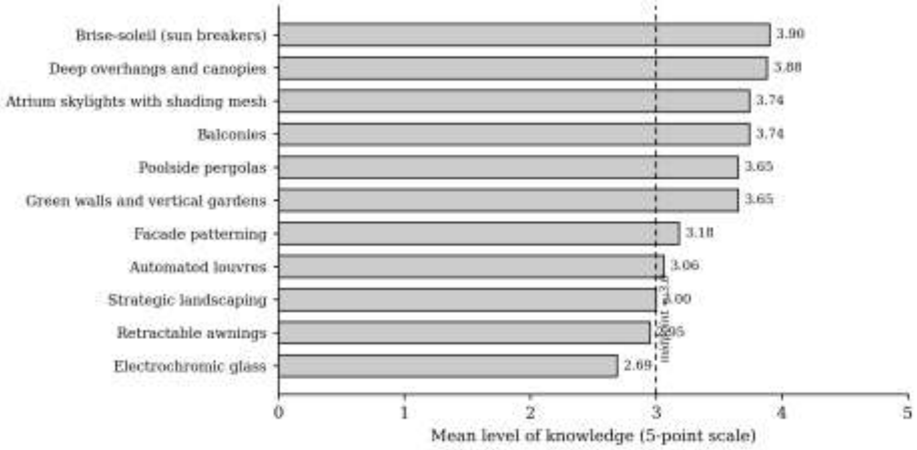

Figure 3: Mean level of knowledge of the eleven strategies (dashed line = 3.0 mid-point)
Source: Authors' analysis (2026).

4.2 Extent of Integration

Table 4 reports integration of the same strategies. Brise-soleil again ranked highest (3.67), followed by green walls and poolside pergolas (both 3.51). Setting knowledge against integration (Table 5, Figure 4) reveals a consistent downward shift for the leading structural strategies: brise-soleil falls from 3.90 to 3.67 (a gap of 0.23) and deep overhangs from 3.88 to 3.46 (a gap of 0.42), with balconies and atrium skylights showing the widest gaps (0.51). Interestingly, a few technology-driven strategies‹ electrochromic glass, automated louvres, facade patterning‹ are integrated slightly more than they are known, but the dominant pattern for the strategy's professionals know best is a clear knowledge-to-integration gap.

Table 4: Integration of shading strategies (N = 43)

S/N	Shading strategy	Mean	SD	Rank
1	Brise-soleil (sun breakers)	**3.67**	0.207	1st
2	Green walls and vertical gardens	**3.51**	0.492	2nd
3	Poolside pergolas	**3.51**	0.086	2nd
4	Deep overhangs and canopies	**3.46**	0.460	4th
5	Automated louvres	**3.37**	0.327	5th
6	Facade patterning	**3.30**	0.289	6th
7	Balconies	**3.23**	0.728	7th
8	Atrium skylights with shading mesh	**3.23**	0.216	7th
9	Strategic landscaping	**3.11**	0.389	9th
10	Electrochromic glass	**3.06**	0.519	10th
11	Retractable awnings	**2.69**	0.091	11th

Rankings recomputed from the reported means. Source: Field survey via SPSS v25 (2026).

Table 5: Knowledge–integration gap across the eleven strategies

Shading strategy	Knowledge	Integration	Gap (K − I)	Know. rank	Integ. rank
Atrium skylights with mesh	3.74	3.23	**+0.51**	3rd	7th
Balconies	3.74	3.23	**+0.51**	3rd	7th
Deep overhangs and canopies	3.88	3.46	**+0.42**	2nd	4th
Retractable awnings	2.95	2.69	**+0.26**	10th	11th
Brise-soleil (sun breakers)	3.90	3.67	**+0.23**	1st	1st
Green walls / vertical gardens	3.65	3.51	**+0.14**	5th	2nd
Poolside pergolas	3.65	3.51	**+0.14**	5th	2nd
Strategic landscaping	3.00	3.11	**−0.11**	9th	9th
Facade patterning	3.18	3.30	**−0.12**	7th	6th
Automated louvres	3.06	3.37	**−0.31**	8th	5th
Electrochromic glass	2.69	3.06	**−0.37**	11th	10th

Gap = knowledge mean − integration mean. Source: Authors' analysis (2026).

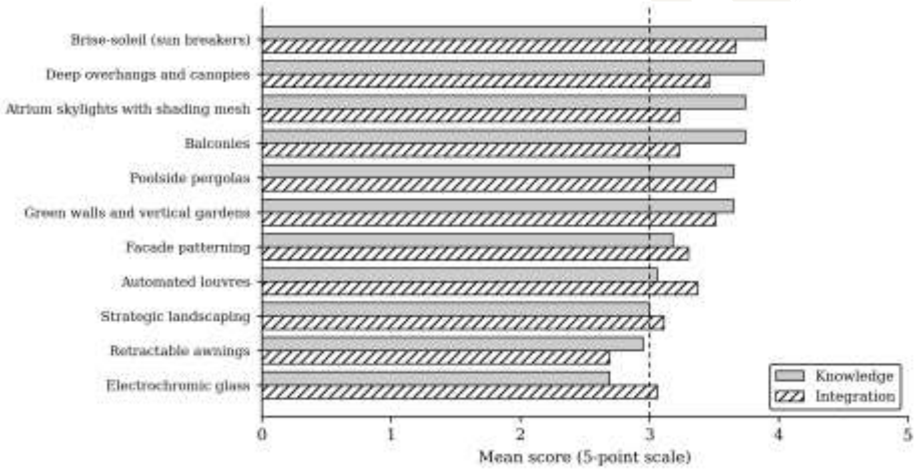

Figure 4: Knowledge (solid) versus integration (hatched) for each strategy
Source: Authors' analysis (2026).

4.3 Barriers Inhibiting Integration

Table 6 and Figure 5 report the twelve barriers, all above 3.70‹ every barrier was perceived as at least moderately significant. Regulatory gaps recorded the single highest mean (4.62), with high initial costs (4.37) and knowledge and expertise gaps (4.32) next. That a regulatory deficiency, rather than cost or awareness, tops the list is the study's key barrier finding.

Table 6: Barriers inhibiting the integration of shading strategies (N = 43)

S/N	Barrier	Mean	SD	Rank
1	Regulatory gaps	**4.62**	0.489	1st
2	High initial costs	**4.37**	0.618	2nd
3	Knowledge and expertise gaps	**4.32**	0.644	3rd
4	Developer priorities	**4.30**	0.637	4th

S/N	Barrier	Mean	SD	Rank
5	Daylighting vs shading trade-offs	**4.27**	0.629	5th
6	Maintenance challenges	**4.25**	0.726	6th
7	Space and functionality trade-offs	**4.20**	0.599	7th
8	Climate variability	**4.18**	0.732	8th
9	Structural constraints	**4.06**	0.736	9th
10	Weather exposure	**4.06**	0.736	9th
11	Facade complexity	**4.00**	0.755	11th
12	Architectural aesthetics	**3.72**	0.908	12th

Rankings recomputed from the reported means. Source: Field survey via SPSS v25 (2026).

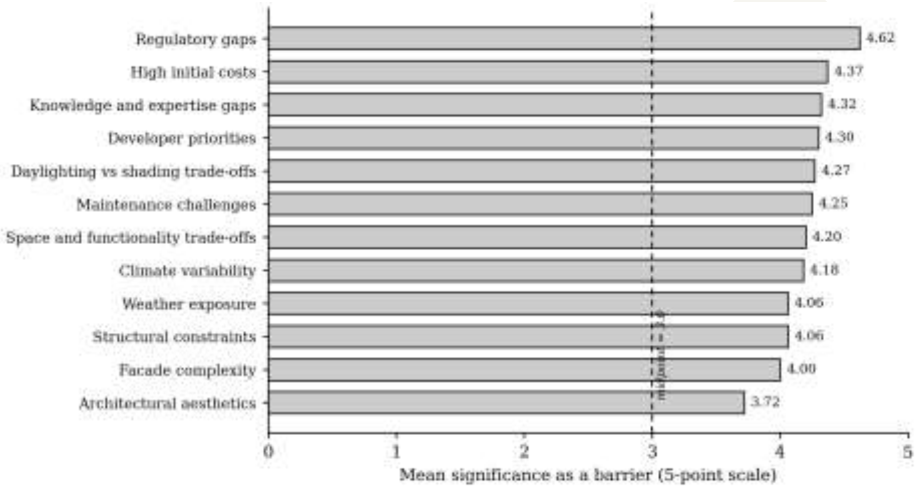

Figure 5: Mean significance of the twelve barriers (dashed line = 3.0 mid-point)
Source: Authors' analysis (2026).

4.4 Factors that Enhance Integration

Table 7 and Figure 6 report the fourteen enhancing factors, every one above 4.75‹ an extraordinarily high consensus. Daylighting synergy and climate responsiveness jointly ranked highest (4.97), followed by green certification incentives (4.95) and urban-heat-island mitigation (4.93). The contrast is instructive: while the barriers are significant but varied, the factors are near-unanimous, indicating that professionals are overwhelmingly convinced of shading's value and are constrained not by doubt but by the absence of structural enablers. Table 8 draws the four objectives together.

Table 7: Factors that enhance the integration of shading strategies (N = 43)

S/N	Enhancing factor	Mean	SD	Rank
1	Daylighting synergy	**4.97**	0.152	1st
2	Climate responsiveness	**4.97**	0.152	1st
3	Green certification incentives	**4.95**	0.213	3rd
4	Urban heat-island mitigation	**4.93**	0.257	4th
5	Brand differentiation	**4.90**	0.293	5th

S/N	Enhancing factor	Mean	SD	Rank
6	Architectural expertise	**4.90**	0.293	5th
7	Adaptive systems	**4.88**	0.324	7th
8	Energy savings	**4.88**	0.324	7th
9	Guest comfort	**4.88**	0.324	7th
10	Innovation in materials	**4.88**	0.324	7th
11	Facade orientation	**4.86**	0.350	11th
12	Supportive codes and policies	**4.83**	0.373	12th
13	Lifecycle value	**4.79**	0.411	13th
14	Architectural integration	**4.76**	0.427	14th

Rankings recomputed from the reported means. Source: Field survey via SPSS v25 (2026).

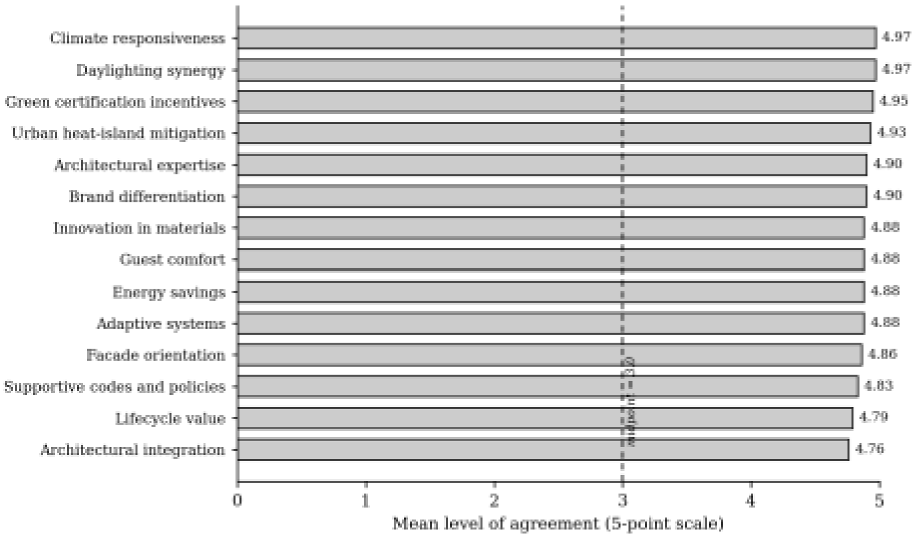

Figure 6: Mean level of agreement on the fourteen enhancing factors (dashed line = 3.0 mid-point)
Source: Authors' analysis (2026).

Table 8: Summary of the leading finding for each research objective

Research objective	Leading item	Mean	Key inference
Knowledge of strategies	Brise-soleil (sun breakers)	3.90	Familiarity centres on robust, buildable fixed devices
Extent of integration	Brise-soleil (sun breakers)	3.67	Integration trails knowledge across the set
Barriers to integration	Regulatory gaps	4.62	Missing enforceable standards, not awareness, is the obstacle
Enhancing factors	Daylighting synergy / climate responsiveness	4.97	Near-unanimous conviction of shading's value

Source: Authors' analysis (2026).

4.5 Case-Study Observations

Physical assessment of the three hotels revealed a clear spectrum of shading integration (Table 9). Transcorp Hilton demonstrated the enduring value of structurally integrated permanent shading: deep concrete balconies along each guest-room wing act as horizontal overhangs, recessed openings reduce gain without added devices, and the H-shaped massing limits the facade exposed to harsh east–west sun‹ though its glazed atrium and lobby rely almost entirely on mechanical cooling. Abuja Continental combined balconies projecting 1,200–1,500 mm, recessed openings forming a double-layered geometric shading effect, and 250–300 mm thermal-mass walls that delay heat transmission‹ a best-practice pairing of solar interception and thermal lag, though weaker on the east and west. Fraser Suites, by contrast, presented a continuous curtain wall with only shallow floor-slab edges and no orientation-specific fins or brise-soleil‹ the clearest physical demonstration of the consequences of inadequate shading.

Table 9: Comparison of shading integration across the three case-study hotels

Hotel	Massing & era	Shading strategy observed	Assessment
Transcorp Hilton	Iconic H-shaped, pre-code	Deep continuous balconies as overhangs; recessed windows; H-massing limits E/W exposure	Strong passive shading; glazed atrium/lobby a missed opportunity
Abuja Continental (ex-Sheraton)	Heavy structural massing, pre-code	Balconies projecting 1200–1500 mm; recessed openings (double-layer shading); 250–300 mm thermal-mass walls	Best-practice solar interception + thermal lag; weaker on E/W
Fraser Suites	Contemporary curtain-wall	Continuous glazing; shallow floor-slab edges only; no orientation-specific fins or brise-soleil	Clearest demonstration of inadequate shading integration

Source: Authors' field observation (2026).

Figure 7: Transcorp Hilton Abuja: massed H-shaped configuration with deep structural balconies

Figure 8: Abuja Continental Hotel: deep structural balconies and recessed openings

Figure 9: Fraser Suites Abuja: continuous curtain wall with only shallow projecting floor-slab edges

5.0 Discussion

The findings present a coherent, mutually reinforcing picture. The most striking pattern is the knowledge-to-integration gap: professionals possess substantial awareness of effective strategies, especially brise-soleil and deep overhangs, yet their physical integration lags that awareness. This aligns with Ibrahim (2023), who found that many five-star hotel concepts in Abuja featured integrated shading at the design stage but a smaller proportion retained it through to construction. Fraser Suites corroborates the gap directly: a contemporary building whose team evidently understood solar control, yet failed to translate that into adequate external shading. The second major finding is the primacy of regulatory deficiency as the dominant barrier‹ regulatory gaps outranked both high initial costs and expertise gaps. This suggests the primary lever is not more technical training but the establishment and enforcement of mandatory passive-design standards, an interpretation the case studies support: Transcorp Hilton and Abuja Continental, both designed before Nigeria's current codes, achieved significant passive shading through architectural form, while Fraser Suites, of the contemporary era, shows the failure of voluntary guidance to drive compliance. The contrast between significant-but-varied barriers (all above 3.70) and near-unanimous enhancing factors (all above 4.75) indicates that the fundamental problem is not a lack of compelling reasons to shade‹ professionals are convinced‹ but a lack of structural enablers, particularly enforcement, that would make ignoring those reasons untenable for developers, consistent with Abdullahi et al. (2022) on regulatory rather than technical barriers to sustainable design in Nigeria. The case evidence also confirms that different orientations demand different geometries: at 9.07° N, horizontal elements suit the north and south, vertical fins or egg-crate systems the east and west, and Fraser Suites' undifferentiated curtain wall was the central design failure. These findings informed the design proposal, in which shading is treated as a structural, permanent feature‹ horizontal brise-soleil and balconies on the north and south, vertical fins and egg-crate screens on the east and west, every element dimensioned by solar-geometry calculation rather than aesthetics alone‹ addressing the cost and regulatory barriers while capitalising on the daylighting, climate-responsiveness and brand benefits respondents overwhelmingly recognised.

6.0 Conclusion and Recommendations

This study investigated the application of shading strategies to enhance energy efficiency in the design of a five-star hotel in Abuja. Professionals possess considerable knowledge of effective strategies‹ brise-soleil and deep overhangs most of all‹ but this is not consistently translated into practice, with a measurable gap across every strategy. Regulatory gaps, high initial costs and expertise deficits are the most significant barriers, while daylighting synergy, climate responsiveness and green certification incentives are the strongest enablers, describing a professional community convinced of shading's value but structurally constrained from implementing it. The case studies confirm that older hotels achieved effective passive shading through form and massing, while a contemporary curtain-wall hotel exhibits the consequences of neglect. The central obstacle is therefore not a deficit of awareness or conviction but the absence of enforceable regulatory standards for envelope solar control. On this basis the study recommends:

1. Incorporating mandatory passive-shading provisions into Nigeria's National Building Energy Efficiency Code and the Federal Ministry of Environment's Green Building Guidelines, with minimum orientation-specific shading depths for commercial hospitality developments;
2. Emphasising the technical dimensioning of shading devices in professional-development programmes to close the expertise gap identified in the barrier analysis; and
3. Incentivising developers through green certification and life-cycle cost-benefit demonstrations to prioritise permanent structural shading over glazing-only solutions.

The design proposal developed from this research, in which shading is embedded as a structural, permanent feature of the envelope rather than an optional add-on, offers a practical demonstration of how these recommendations translate into a commercially viable, climate-responsive luxury hotel for the Federal Capital Territory.

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