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ENERGY-EFFICIENT BUILDING PRACTICES AND OPERATIONAL PERFORMANCE ACROSS STAR-RATED HOTELS IN NAIROBI CITY COUNTY

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ABSTRACT
This study examined the impact of energy-efficient building practices on the operational performance of star-rated hotels in Nairobi City County, Kenya. Hotels are among the most energy-intensive commercial establishments, incurring high operational costs largely driven by lighting, heating, ventilation, and air conditioning (HVAC) systems. The study adopted a descriptive correlational cross-sectional design on 49 star-rated hotels in Nairobi County. Operational managers were purposively selected as respondents because of their direct involvement in implementing and monitoring sustainability practices. Data was collected through structured questionnaires. Both descriptive and inferential statistics were run in the analysis of data. The findings reveal a moderate but consistent adoption of energy-efficient practices such as LED lighting, smart HVAC systems, renewable energy integration, and staff training on sustainable energy use. Hotels reported noticeable reductions in monthly utility bills and overall energy costs. Regression analysis revealed a moderately strong, statistically significant relationship between energy-efficient practices and energy costs ($R = .620$, $R^2 = .384$, $p < .001$). This implies that approximately 38% of the variation in energy costs savings can be explained by the extent of energy efficiency adoption. It can be concluded that energy-efficient building practices significantly contribute to cost savings in star-rated hotels. Hotels should prioritize investment in modern HVAC technologies, energy monitoring systems, and renewable energy sources to enhance sustainability and reduce operational costs.

Keywords:
Energy efficient building practices, operational performance, operational managers, sustainability

INTRODUCTION

The World Travel and Tourism Council (WTTC) highlights the significant role of the hospitality industry in driving global economic growth. In 2024, the Travel & Tourism sector contributed 10% of global GDP, reflecting an 8.5% increase from 2023, which itself had risen 23.2% from 2022. These figures surpass pre-pandemic levels of 9.5% in 2019, demonstrating the sector's recovery and continued expansion (WTTC, 2024). Employment has similarly grown, reaching approximately 348 million by 2024, exceeding the 2019 pre-pandemic level of 334 million (Statista, 2023), with forecasts projecting 449 million employees by 2034, generating 101 million new jobs globally (WTTC, 2025). Despite this positive trajectory, the sector faces persistent challenges, including rising operational costs and environmental pressures related to energy which threaten profitability and long-term sustainability (Yenidogan et al., 2021).

Energy costs constitute a substantial portion of hotel operating expenses, with heating, cooling, lighting, and laundry services accounting for around 80% of total costs (International Energy Agency, 2023). Inefficient energy consumption not only elevates operational expenses but also increases the sector's environmental footprint (Singh

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et al., 2024). Regional and classification-based disparities in energy use are notable: five-star hotels in temperate and tropical regions of Asia, Africa, and Europe consume approximately 429.1 kWh/m² more energy than one-star hotels (Dibene-Arriola et al., 2021). In Africa, hoteliers in Abuja, Nigeria, recognize the importance of sustainable energy management but encounter challenges such as unreliable electricity, costly alternative energy, and limited access to modern energy-saving technologies (Shehu et al., 2019). In Kenya, studies indicate partial adoption of energy-saving measures: ten four- and five-star hotels in Nairobi achieved an average implementation rate of 55.83% over three years (Ogola, 2024), while hotels in Nakuru County have primarily implemented low-cost measures without exploring advanced technologies to enhance operational performance (Nthiga, 2018).
To address these challenges, green building practices offer a promising approach by optimizing resource utilization and promoting energy efficiency (Geng et al., 2019; Prakash et al., 2022). Globally, hotels are increasingly adopting green certification programs such as LEED, BREEAM, Green Star, and Green Globe, which provide structured frameworks for energy conservation, sustainable material use, and environmentally friendly operations (Moramudali & Manawadu, 2018; Serrano et al., 2020; Ronoh et al., 2025). LEED-certified hotels, for example, have demonstrated at least a 25% reduction in energy consumption compared to non-certified hotels (Amiri, Ottelin, & Sorvari, 2019). Further improvements can be achieved through energy-efficient appliances, automated energy management systems, and building retrofits, potentially reducing energy costs by 5–15%, particularly in high-consumption areas such as heating, cooling, and lighting (EHL Insights, 2025; Karvounidi et al., 2024). In the UK, such efficiency improvements could save the hospitality sector up to 4,300 GWh annually (Llanso, 2024).

Evidence from Africa illustrates the benefits of sustainability in the hospitality industry (Ronoh et al., 2025); four- and five-star resorts in Marsa Alam, Egypt, have implemented advanced lighting technologies, reducing energy usage while enhancing guest experience (El-Sayed & Abed, 2021). However, research in Kenya remains limited. A study of 70 three- to five-star hotels revealed a focus on monitoring energy bills rather than implementing advanced green solutions, such as renewable energy integration (Omune et al., 2021). Moreover, existing green initiatives tend to emphasize water management, indoor air quality, and environmentally preferred purchasing while neglecting comprehensive energy-efficient building practices and lower-rated hotels (Shekinah, 2021). This narrow focus restricts the generalizability of findings across hotel categories.
Given these gaps, this study sought to examine the impact of energy-efficient practices on operational performance across star-rated hotels in Nairobi City County, addressing both the environmental and economic dimensions of sustainability in the local hospitality sector.

Statement of the Problem

Star-rated hotels in Nairobi City County face high operational costs largely driven by inefficient energy use, which also contributes to environmental degradation. Studies indicate that only 55.83% of energy-saving measures have been implemented over the past three years, reflecting suboptimal adoption of energy-efficient practices. These inefficiencies inflate costs and undermine the long-term sustainability and competitiveness of the sector. Green building practices, particularly energy-efficient interventions such as LED lighting, smart HVAC systems, and building retrofits, have been shown to reduce energy consumption by 5-15% annually. However, there is limited literature on the adoption of energy-efficient practices in Kenyan hotels, with existing studies focusing mainly on basic environmental management and higher-rated hotels, leaving gaps in understanding how advanced energy-efficient practices impact operational performance across the broader hotel sector. This study therefore sought to assess the effects of energy-efficient practices on operational performance in star-rated hotels in Nairobi City County.

Objective of the Study

To evaluate the impact of energy-efficient building practices on operational performance across star-rated hotels in Nairobi City County.

Research Hypothesis

H_0: There is no statistically significant impact of energy-efficient building practices on operational performance across star-rated hotels in Nairobi City County.

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LITERATURE REVIEW

Star-rated hotels are regarded for providing top-quality services and facilities, but they come with a substantial energy cost. They use a lot of energy (lighting, cooking, and HVAC systems) to provide comfort and high-quality service levels (Oluseyi et al., 2016). According to the International Energy Agency (2020), hotels consume approximately 20-30% of the energy consumed in the global commercial building sector, with HVAC systems accounting for more than half of the energy consumed by luxury hotels. Installing energy-efficient appliances, automated building energy management systems, and building retrofits can reduce hotel energy costs by 5% to 15% (EHL Insights, 2025).

The impact of energy-efficient building practices on operational performance has been the subject of numerous studies. Dibene-Arriola et al. (2021) assessed the energy consumption patterns of five-star hotels in temperate and tropical regions across Asia, Africa, and Europe. The study found that premium hotels use 429.1 kWh/m² more annually than one-star hotels. This large energy use demonstrates the potential for savings through the use of energy-efficient systems. Similarly, Becchio et al. (2017) looked into energy-efficient HVAC systems for retrofits in older hotels around the Mediterranean, notably in Matera, Italy. The study used Energy Plus software to simulate alternative HVAC designs with the goal of decreasing heating and cooling loads. The findings demonstrated that energy-efficient HVAC solutions, even when retrofitted into older buildings, can result in significant energy savings. However, the study identified a gap in cost-effectiveness research, particularly in relation to the economic viability of advanced HVAC technologies, such as Polyvalent Heat Pumps, when applied to older hotels. This highlights the relevance of assessing not only energy savings but also the economic practicality of adopting energy-efficient systems within Kenya's hotel sector.

Similarly, O et al. (2024) conducted a case study on three hotels in Lagos, Nigeria: the Lagos Continental Hotel, the Federal Palace Hotel, and the Eko Hotels & Suites. The research showed that retrofitting HVAC systems with Variable Speed Drives (VSDs) and centralized Building Management Systems (BMS) resulted in significant energy savings. However, it did not thoroughly analyze how increased Smart HVAC utilization can lead to more gains in resource efficiency and environmental performance optimization. Furthermore, renewable energy sources are emerging as a viable option for energy savings and environmental conservation in hotels (Vanegas Cantarero, 2020). Mahachi et al. (2015) conceptualized the use of renewable energy at Botswana's Cumberland Hotel and Gaborone Sun, identifying solar and biogas as the most prevalent technologies. Despite the potential, Gaborone Sun was unable to expand its solar installations, and Cumberland Hotel was unable to use biogas owing to resource constraints.

In Kenya, Chomba et al. (2022) evaluated the impact of energy saving methods on customer satisfaction in star-rated hotels in the Mt. Kenya region, which includes Nyeri, Laikipia, Embu, Meru, and Tharaka Nithi counties. The study used a descriptive research design and surveyed 243 respondents from 24 hotels. the study discovered that energy-efficient equipment and daylight optimized building designs improve customer happiness and operational effectiveness. However, the study was primarily concerned with customer views and did not examine the direct impact of these energy conservation initiatives on the hotels' operational performance such as energy cost reductions which this study sought to address.

Conceptual Framework

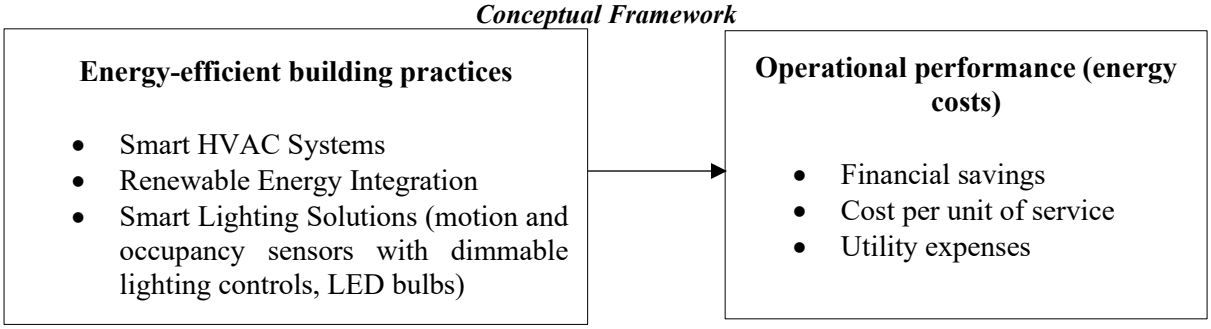

Figure 1: Conceptual Framework

Source: Adopted from LEED practices, certification, and accreditation handbook (Kubba-LEED AP (2009) and modified by the researcher (2025)

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METHODOLOGY

The study was conducted in Nairobi City County, Kenya, focusing on star-rated hotels. A descriptive correlational cross-sectional design was employed, allowing data collection at a single point in time to assess existing trends and relationships without manipulating variables (Setia, 2016). This approach enabled a comprehensive and cost-effective examination of energy-efficient building practices and their impact on operational performance across multiple hotels while minimizing biases associated with longitudinal studies (Babbie, 2016). The target population comprised operational managers from the 52 star-rated hotels in Nairobi (10 five-star, 18 four-star, 15 three-star, and 9 two-star) according to Tourism Regulatory Authority of Kenya (2019) in Musembi (2021). Operational managers were purposively selected for their direct knowledge of sustainability initiatives and operational outcomes. Data was collected using structured questionnaires covering demographics, energy efficient building practices and operational performance, measured on a five-point Likert scale. A pilot study in Mombasa County with six respondents assessed the clarity, relevance, and reliability of the instrument, given its similar hospitality environment to Nairobi (Thabane et al., 2010; Whitehead et al., 2016). Validity was ensured through expert review for face and content validity, while construct validity was supported via literature review (Taherdoost, 2016; Noratiqah Zasali et al., 2023; Middleton, 2019). Reliability was confirmed using Cronbach's alpha, with values above 0.70 indicating internal consistency (Tavakol & Dennick, 2011). Ethical approvals were obtained from relevant authorities, and data analysis was conducted using descriptive statistics to summarize responses, Pearson's correlation and simple linear regression analysis to examine relationships between energy-efficient building practices and operational performance across star-rated hotels in Nairobi City County.

Model's specification

Model: $Y = \beta_0 + \beta_1 X_1 + \varepsilon$

Where:

- Y = Operational performance
- X_1 = Energy-efficient practice(s)
- β_0 = Intercept
- β_1 = Coefficient for the independent variable
- ε = Error term

FINDINGS AND DISCUSSION

Reliability Test

Before the full deployment of the tool, reliability tests were run to detect and resolve any potential reliability issues. Specifically, Cronbach's alpha coefficients were used to establish the reliability of the research tool as summarized in table 1.

Table 1 ***Reliability Test***

Constructs	N of Items	Cronbach's Alpha
Energy efficient building practices	6	.904
Energy costs	5	.919

As shown in Table 1, the reliability of the study constructs indicated high internal consistency. Energy-efficient building practices, assessed through six items, exhibited a Cronbach's alpha of 0.904, while energy costs, measured with five items, demonstrated an alpha of 0.919. These results suggest that the items within each construct consistently measure the intended concepts.

Response Rate

To establish the response rate, descriptive statistics (percentages) were run as summarized in Table 2.

Table 2 Response Rate Matrix

Target	Responses	Percentage
52	49	94%

From Table 2 the response rate of the study was high, indicating effective engagement from participants. Of the 52 targeted respondents, 49 completed the survey, yielding a response rate of 94%. This high participation level suggests that the data are representative of the target population and minimizes potential non-response bias.

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Descriptive Statistics on Energy Efficient Building Practices

Respondents were asked to rate the level to which they agreed or disagreed with some of the statements relating to the adoption levels of energy efficient building practices. A five-point Likert scale was used; 1 = Not at all, 2 = Slightly, 3 = Moderately, 4 = Considerably, 5 = Fully. Standard deviations and means were used to analyze the results.

Table 3 ***Energy Efficient Building Practices***

Statements	N Statistic	Mean Statistic	Std. Deviation Statistic
Our hotel has adopted energy-efficient lighting systems (e.g., LED, motion sensors).	49	3.80	1.080
We have invested in smart HVAC systems (heating, ventilation, and air conditioning).	49	3.57	1.208
We have implemented renewable energy sources (e.g., solar panels, wind energy).	49	3.80	1.099
Our hotel has put in place active energy optimization and monitoring devices.	49	3.82	1.074
We have adopted visible signage and information panels on energy conservation initiatives.	49	3.57	1.041
Our hotel conducts regular training on sustainable energy use.	49	3.94	1.144
Valid N (listwise)	49		

Table 3 shows the descriptive statistics on energy-efficient building practices adopted by hotels. The findings indicate a moderate level of adoption across different measures. On average, respondents agreed that their hotels use energy-efficient lighting (mean = 3.80), smart HVAC systems (mean = 3.57), renewable energy sources (mean = 3.80), energy optimization devices (mean = 3.82), visible energy conservation signage (mean = 3.57), and regular training on sustainable energy use (mean = 3.94). Training scored the highest, showing greater emphasis on staff awareness. Overall, hotels have embraced energy-efficient practices to a fair extent, although the level of implementation differs across specific measures.

Descriptive Statistics on Energy Costs

To capture perceptions on operational expenses, respondents rated statements on energy costs using levels of agreement and disagreement. A five-point Likert scale was used; 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree. Standard deviations and means were used to analyze the results.

Table 4 ***Descriptive Statistics on Energy Costs***

Energy costs	N Statistic	Mean Statistic	Std. Deviation Statistic
Financial savings from energy costs are evident in our hotel.	49	3.94	1.029
Our hotel has realized a reduction in monthly energy utility expenses (electricity, fuel, etc.).	49	4.08	.862

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Our hotel's overall energy costs have decreased overtime.	49	4.10	.872
The cost per unit of service/good delivered in relation to energy use has reduced significantly in our hotels.	49	3.90	.963
Overall, our hotel is cost-effective in its use of energy.	49	4.04	1.172
Valid N (listwise)	49		

Table 4 provides an overview of the descriptive statistics on energy-related costs in hotels. The results indicate that most hotels perceive noticeable financial benefits from energy efficiency measures. Respondents agreed that their hotels experience financial savings from energy use (mean = 3.94), reduced monthly energy bills (mean = 4.08), and a general decline in overall energy costs over time (mean = 4.10). They also noted a reduction in the cost per unit of service delivered relative to energy use (mean = 3.90) and affirmed that their hotels are generally cost-effective in energy utilization (mean = 4.04). These findings suggest that hotels are experiencing tangible cost savings from energy efficiency, with reductions in monthly and overall energy expenses standing out most strongly.

Diagnostics Statistics

Before running inferential statistics (correlation and regression analysis), diagnostic tests were run to establish whether the data obtained met the assumptions of Ordinary Least Squares (OLS).

Normality test

Skewness and kurtosis statistics were used to establish whether the regression residuals were normally distributed as summarized in Table 5.

Table 5 ***Normality Test***

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Energy costs	49	4.0122	.85675	-.931	.340	.301	.668
Overall cost	49	4.0014	.74715	-.801	.340	.420	.668
Valid N (listwise)	49						

From Table 5, energy costs recorded a mean of 4.0122 and a standard deviation of 0.857, with skewness of -0.931 and kurtosis of 0.301, while overall costs had a mean of 4.0014 and a standard deviation of 0.747, with skewness of -0.801 and kurtosis of 0.420. Both variables exhibit skewness values below -0.5, indicating notable negative skew, and although the kurtosis values fall within the commonly accepted range of ±1, the observed skewness deviations suggest asymmetry in the distributions. These results demonstrate that the distributions deviate sufficiently from perfect normality, indicating that the assumption of normality is violated.

Multicollinearity

The multicollinearity tests in Table 6 confirmed the reliability of the regression model. The Variance Inflation Factor (VIF) value for energy-efficient building practices is 1.000, indicating a complete absence of multicollinearity since values close to 1 represent independent predictors. Accordingly, the model can be considered statistically robust and free from multicollinearity problems.

Table 6 Multi-Collinearity Analysis Test for Energy Efficient Building Practices and Operational Performance

	VIF
Energy-efficient building practices and energy costs	*1.000*

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Linearity

Linearity was assessed using scatter plots, which provided a visual representation of the relationship between Energy efficient building practices and operational performance as presented in Figure 1

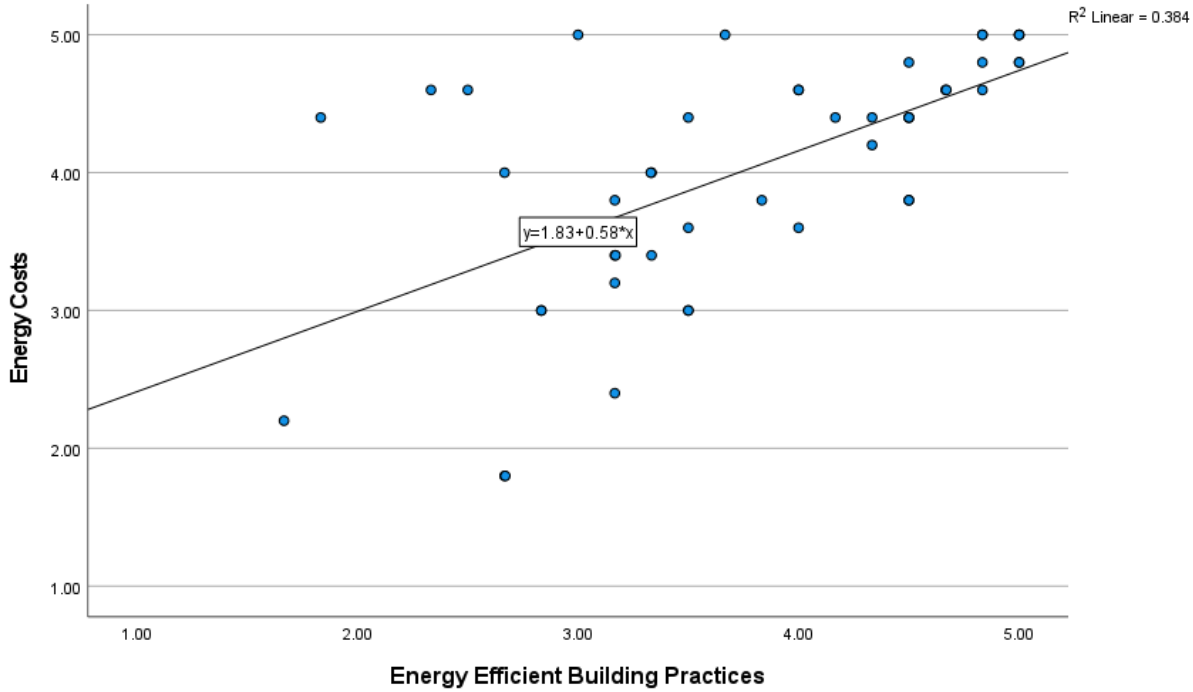

Figure 1: Linearity Plot of Energy Efficient Building Practices and Energy Costs

The scatter plot in Figure 1 illustrates the relationship between energy-efficient building practices and energy costs. The distribution of data points generally follows an upward diagonal trend, suggesting that the relationship between the two variables is approximately linear. This confirms that the assumption of linearity was reasonably met, allowing for the use of Ordinary Least Squares (OLS) regression in subsequent inferential analysis.

Inferential Statistics

Diagnostic tests were conducted to assess the suitability of the data for regression analysis, and the results indicated violations of the normality assumption (Table 3). Multiple transformation attempts, including logarithmic and reflection-based approaches, did not sufficiently normalize the variables. Consequently, relying solely on ordinary least squares (OLS) regression would have risked biased inference. To address this limitation, OLS was supplemented with bootstrapping, a resampling technique that does not assume normality and provides more reliable estimates of standard errors and confidence intervals (Efron & Tibshirani, 1993). In this study, the bootstrap procedure was conducted using a simple random sampling method with 1,000 resamples, applying a 95% percentile-based confidence interval. To ensure replicability, the random number generator was set using the Mersenne Twister algorithm with a fixed seed of 12345. This combined approach enhanced the robustness and reproducibility of the regression estimates despite the distributional challenges in the data.

Energy Efficient Building Practices and Energy Costs

Table 7Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.620	.384	.371	.67952	1.938

The model demonstrates a moderately strong link between energy-efficient building practices and energy costs, as shown in Table 7 (R = .620). This means that hotels that adopt more energy-efficient measures tend to have noticeably lower energy costs. The R^2 value of .384 indicates that about 38% of the differences in energy costs

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can be explained by energy-efficient practices. The adjusted R^2 (.371) confirms the result is reliable, even after accounting for sample size. The standard error of estimate (.67952) shows that the predicted energy costs are, on average, fairly close to the actual values.

Table 8 ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	13.531	1	13.531	29.303	.000
Residual	21.702	47	.462		
Total	35.233	48			

The analysis of variance (ANOVA), as shown in Table 8, revealed that the regression model was statistically significant, $F(1, 47) = 29.30$, $p < .001$. This finding suggests that energy-efficient building practices significantly improved the prediction of hotel energy costs compared to a model with no predictors. Specifically, the regression model explained 38.4% of the variance in energy costs ($R^2 = .384$), while the remaining 61.6% was attributable to other factors outside the model. This indicates that the adoption of energy-efficient practices contributes meaningfully to cost savings, highlighting their practical and economic importance for hotels.

Table 9 Bootstrap for Coefficients

		Bootstrap				
Model	B	Bias	Std. Error	Sig. (2-tailed)	95% CI Lower	95% CI Upper
(Constant)	1.828	-.041	.566	.009	.629	2.884
Energy efficient building practices	.583	.009	.131	.001	.343	.849

The bootstrap analysis further confirmed the stability of the regression coefficients, as shown in Table 9. The unstandardized coefficient for energy-efficient building practices remained consistent with the original estimate ($B = .583$), with only a minimal bias of .009. The standard error increased slightly under bootstrapping ($SE = .131$), but the effect remained statistically significant ($p = .001$). Importantly, the 95% confidence interval (.343 to .849) did not include zero, reinforcing that the effect of energy-efficient practices on energy costs was both reliable and robust across repeated resampling. These findings indicate that the observed relationship is not sample-specific but generalizable within the population.

Correlation Analysis

Table 10 Pearson Correlation

	Energy costs	Energy efficient building practices
Pearson Correlation	1.000	.620**
	.620**	1.000
Sig. (1-tailed)	–	.000
	.000	–
N	49	49
	49	49
Bootstrap Bias	.000	.003
	.003	.000
Std. Error	.000	.101
	.101	.000
95% CI Lower	1.000	.414
	.414	1.000
95% CI Upper	1.000	.809
	.809	1.000

Table 10 presents the Pearson product-moment correlation, revealing a statistically significant, moderately strong, positive association between energy-efficient practices and energy costs, $r(49) = .62$, $p < .001$. This indicates that hotels with higher adoption of energy-efficient practices tend to achieve greater reductions in energy costs. The bootstrap confidence interval for the correlation (.41 to .81) was entirely positive, reinforcing the reliability of this

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relationship. Thus, the findings provide both statistical and practical evidence that energy-efficient practices are consistently associated with improved cost savings.

These findings align with previous studies that have highlighted the potential of energy efficiency in lowering operational costs in hotels. Dibene-Arriola et al. (2021) and Becchio et al. (2017) showed that premium hotels, particularly those in energy-intensive regions, stand to benefit significantly from energy-saving measures, especially through optimized HVAC systems. Similarly, O et al. (2024) reported substantial savings from HVAC retrofits and the integration of Building Management Systems in Nigerian hotels. In the Kenyan context, Chomba et al. (2022) found that energy-efficient equipment enhances customer satisfaction and operational performance, although their study did not directly quantify cost reductions. The present findings therefore extend this body of knowledge by providing empirical evidence that energy-efficient building practices not only improve customer experiences but also significantly reduce operational energy costs in star-rated hotels.

CONCLUSION

The study established that energy-efficient building practices have a significant positive impact on reducing energy costs in star-rated hotels in Nairobi City County. Hotels that implemented measures such as energy-efficient lighting, smart HVAC systems, renewable energy, and staff training reported measurable financial savings. The regression results demonstrated that energy efficiency explains a substantial proportion of the variation in energy costs, confirming its importance as a strategic tool for improving operational performance.

RECOMMENDATIONS FOR FUTURE STUDIES

1) Future research could utilize a Longitudinal Approach: This will help track changes in energy costs and operational performance over time, providing deeper insights into the long-term impact of energy-efficient practices.
2) Future studies should focus on comparative analysis of star-rated hotels with non-star-rated or boutique hotels to determine whether energy efficiency benefits are consistent across different categories.

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