THE EFFECT OF TECHNOLOGICAL INNOVATIONS ON MANAGING ENERGY COSTS IN STAR-RATED HOTELS IN NAIROBI CITY COUNTY, KENYA

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Hospitality and Tourism Management of Murang'a University of Technology

August, 2026

DECLARATION

Student Declaration

I hereby declare that this thesis is my original work and to the best of my knowledge, has not been presented for a degree award at this university or any other University. I understand what plagiarism is, and I am aware of the university's policy on this. I understand that any false claim regarding this work shall be treated in accordance with the University's Anti-Plagiarism Policy.

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Supervisor's Approval

The undersigned certify that they have read and hereby recommend for acceptance at Murang'a University of Technology a thesis entitled **"The Effect of Technological Innovations on Managing Energy Costs in Star-Rated Hotels in Nairobi City County, Kenya".**

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DEDICATION

I dedicate this thesis to my beloved mother, Juliatta Akue Engolan, whose unconditional love, and prayers have been my greatest source of strength throughout my academic journey. To my dear sisters Beatrice Wambui, Priscilla Angel, Esther Akui, and Brothers Paul Etoto, James Kamau, John Ekeno, Christopher Akori, and Echwa Akui, and my only sister-in-law Christine Apaya. I am deeply grateful for your love, support, and encouragement which have inspired me to persevere through every challenge. To my wonderful nieces and nephews: Malvin Arupe, Trizah Engolan, Veronica Akura, Juliatta Akish, Agnes Muthoni, Bryson Etoto, Njenga Etoto, Zachary Kamau, Daniel Njuguna, Kennedy Muriithi, Jack Mbapai, Delan Kamau, Melvin Emanman, Gael Ekeno Kamau, Rebecca Echwa, Miguel Lopeyok, Alexa Kathure, Claire Lopong'o, Agostinella Lopeyok. I pray that this achievement will inspire you to pursue your dreams with courage, and determination in your generation.

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ABSTRACT

The hotel sector is a heavy energy user, with energy costs being the second-largest expense, after labor. In Nairobi City County, high occupancy levels and high electricity tariffs have compounded energy costs for star-rated hotels. This research examined the effect of technological innovations on managing energy costs in star-rated hotels in Nairobi City County, Kenya. In particular, it explored the effects of energy monitoring, energy management, energy-efficient, and solar energy technologies on managing energy costs. A convergent parallel mixed methods approach was used. A census of the 54 star-rated hotels in Nairobi City County was performed. A sample of 246 was determined using the Yamane formula. Structured questionnaires were distributed to engineering staff, maintenance staff, and electricians (210 with a response rate of 77.2%), and unstructured interviews were held with general managers and accountants (30 with an interview response rate of 83.3%). The quantitative data were analyzed using descriptive statistics (percentages, means, and standard deviations) and inferential statistics (Pearson correlation, simple and multiple regression, and ANOVA). The qualitative data were analyzed thematically. Findings showed that the four types of technological innovations had a positive effect on managing energy costs ($p < 0.01$). Energy-efficient technologies were most correlated with managing energy costs ($r = 0.857$, $R^2 = 0.735$) and LED lighting had the highest adoption rate (82.6%). Energy management technologies had a strong association with managing energy costs ($r = 0.804$, $R^2 = 0.647$). Solar energy technologies had a strong effect on managing energy costs ($r = 0.787$, $R^2 = 0.620$), but low adoption (39.5% for electricity generation) because of their high initial cost (80.0% agreement). Energy monitoring technologies allowed real-time monitoring of energy anomalies, especially in higher-star rated hotels (5-Star-rated). The multiple regression analysis revealed that the combined use of all four technologies explained 71.4% of variance in managing energy costs ($R^2 = 0.714$, $F = 115.58$, $p < 0.01$) with the strongest effect of solar energy technologies ($\beta = 0.348$). The qualitative results revealed that the high initial technology investment cost, lack of technical know-how, infrastructure deficiencies, and difficulty integrating with existing systems were the key barriers, particularly in two-star and three-star hotels. The research findings suggest that all four types of technologies have positive effect on managing energy costs in star-rated hotels. The Diffusion of Innovation theory explains the pattern of adoption with higher-star hotels (5-Star and 4-Star) as innovators and lower-star hotels (2-Star) as laggards. From a Resource-Based View, the technologies serve as valuable, rare and inimitable resources that offer cost competitive advantage. The study advises hotel practitioners to adopt low-cost, high-return technologies initially (LED lighting, smart thermostats), to audit energy needs before investment, to train staff and to investigate financing options for solar technologies. Government should provide tax incentives, offer subsidized loans for lower-star hotels, set up energy consumption standards according to star ratings, mandate energy audits for higher-star hotels, and promote technical training. Future research should engage in longitudinal studies, undertake comparative studies across Kenyan counties, measure return on investment for each technology category.

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ACRONYMS AND ABBREVIATIONS

COVID19	Coronavirus Disease 2019
EEM	Energy Efficiency Measures
HVAC	Heating, Ventilation, Air-conditioning
IHG	Intercontinental Hotel Group
IoT	Internet of Things
IRENA	International Renewable Energy Agency
KWh/m2	Kilowatt-hours per square meter
LED	Light Emitting Diode
RES	Renewable Energy Sources
RETs	Renewable Energy Technologies
SPSS	Statistical Package for Social Sciences

DEFINITION OF TERMS

Energy Cost - Day-to-day expenses incurred in energy used in various hotel operations

Energy Efficient Technologies - Innovations designed to minimize power consumption while maintaining or improving performance, which helps cut energy expenses

Energy Management Technologies - Devices designed to save energy to reduce energy costs

Energy Monitoring Technologies - New technologies that track ongoing energy consumption, process the data through digital systems, and generate insights to identify opportunities for improvement

Internet of Things - An interconnected system of sensor-equipped devices that exchange data over the internet and carry out operations automatically, without direct human involvement.

Payback period - Duration of time energy technological innovation starts to bring in return on investment

Solar Energy Technologies - Devices designed to capture solar rays and transform them into usable power

Star-rated Hotels - Hotel classifications determined by assessing the quality of facilities and services offered, providing travelers with guidance in selecting accommodations that suit their preferences and financial capacity

Technological Innovations - Utilizing different integrations of available technologies to develop practical and beneficial solutions that enhance an organization's competitiveness

Energy use - The quantity and pattern of energy consumed in hotel operations

Automated Appliances - Systems where control technologies mechanically regulate when and how equipment operates to avoid unnecessary energy use without human input.

Efficient equipment - Machines that are designed to consume less energy during operation while delivering the same or better performance

CHAPTER ONE
INTRODUCTION

1.1 Background to the study

The tourism and hospitality sector is one of the major contributors to socio-economic development and contributes significantly to GDP and employment. Globally, it accounted for 4% (USD 3.3 trillion) of GDP in 2022 and recorded a 7.9% increase in new jobs (WTTC, 2022; UNWTO, 2023). In Sub-Saharan Africa, the sector plays a significant role in GDP, with annual growth rates of 5-10, and directly contributing 7.6% of GDP in 2022 and supporting 295 million jobs (WTTC, 2023). The industry in Kenya followed this positive trend and in 2023, it produced around 3 million jobs and the GDP figures were 24 percent higher than in 2019 (Tourism Performance Report, 2024; WTTC, 2024).

Hotels constitute an important part of the tourism industry, playing a major role in the employment and economic revenue (IHG, 2024; Economic Survey, 2024). But they are also one of the most energy-consuming sectors (HES, 2022; Xu & Dan, 2023). International tourism growth has boosted hotel occupancy and growth, with the global occupancy averaging approximately 66% in 2024, Africa at 55 and Kenya registering significant growth rates in room occupancy and bed-nights (WTTC, 2024; Tourism Performance Report, 2024; Economic Survey, 2024). Such development leads to increased energy demand which is addressed by various energy sources (Economic Survey, 2023; Zhang et al., 2024).

Energy is the quantifiable amount of power consumed within an industry, which is typically measured in kilowatt-hours (kWh), or megajoules (MJ) (Miljanic, 2021). It encompasses electricity, fossil fuels, and renewable sources that facilitate daily activities and production processes (IEA, 2023). Energy is one of the key inputs to all goods and services making it a driving force in economic growth and development (Adepoju & Akinwale, 2019; Kenya Vision 2030; Kenya Economic Survey, 2025). Nevertheless, it is a limited and scarce resource (Hassler et al., 2022). The increase in demand on the sources of energy especially fossil energy is caused by the growing population of people and the industrialization process, which, in turn, increases the cost and worsens the environmental situation. Acknowledging these limitations is

crucial in ensuring a productive and efficient performance in energy-intensive industries such as hospitality and tourism (Pang et al., 2024; Adepoju and Akinwale, 2019).

Energy is used in the guest rooms, public areas, and service zones; kitchens, laundries and recreational facilities in the hospitality industry. Electricity has the highest usage since it is used to power the systems such as HVAC and lighting and fossil fuels and renewable sources, especially solar, are commonly used to cook and heat water. This dependence on electricity-intensive systems implies that inefficiencies contribute greatly to the operational costs. Moreover, some of the top energy-consuming and least efficient areas include catering, laundry, and health facilities (X. Xu & Dan, 2023; Shehu et al., 2019; Hotel Energy Solutions, 2023). Hotel consumption of energy depends on the type and nature of hotels. As an example, the five-star hotels use more energy per square meter because of the energy-intensive facilities like spas, swimming pools, 24-hour service, and operating HVAC systems. Energy consumption is also determined by the size of the hotel, the number of rooms, the profile of the customers, their age, and the climate (Shehu et al., 2019). As a rule, higher-rated hotels (4-5 star) are more energy-demanding as compared to lower-rated ones (2 and 3 star) due to the focus on luxury and comfort (Said et al., 2017).

HVAC systems are highest energy consumers, as they provide thermal comfort and air quality, which is especially needed in high-end hotels in which constant operation is required (Hotel Energy Solutions, 2023; Tourkolias et al., 2020). In extreme climates and cities, the complexity of the services and the design differences contribute to the increase in energy use. In the hotel industry, energy consumption varies by the guest rooms, public areas (lobbies, pools, spas), and service areas (kitchens, laundry, offices). The increasing cost of operations has been contributed by high energy consumption coupled with fluctuating energy prices and dependence on fossil fuels. Energy costs can take up to 30 percent of all hotel operating expenses and are increasing, particularly in the areas where outdated building, and inefficient technologies are still in use (Gaturu et al., 2022; Lee et al., 2024).

Rising energy costs strain hotel budgets and reduce profitability, forcing management to pass on the costs to customers, thereby leading to customer complaints (Filimonau

& Magklaropoulou, 2020). Moreover, resulting operational cost leads to the closure of some facilities or the entire hotel altogether, resulting in redundancies (Ugurlu et al., 2022); and overworking of remaining employees, which ultimately leads to employee turnover. In addition, high energy consumption results in negative environmental impacts due to the use of fossil fuels, which results in release of harmful carbon dioxide into the atmosphere (Anwar et al., 2020). In this study, technological innovations refer to the integration of available technologies to develop practical solutions that enhance organizational competitiveness, particularly in energy management (Yayha et al., 2024). Adopting technological innovations remains a priority and the most reliable option for hotels to optimize energy use and reduce energy costs significantly (Economic Survey 2024; Tourism Performance Report 2024). Innovative use of technology increases profitability through energy cost reduction (Kenya Vision 2030).

The hotel sector has adopted the latest technology in various areas of operation such as hotel booking (Economic Survey 2024), storing and managing guests' information, preventing cyber security, and marketing (Tushabe et al., 2023). However, it is facing the challenge of incorporating the latest technological innovations into hotel energy use and management despite the observation that innovative use of technology increases profitability through energy cost reduction, improvement in operational efficiency, helps hotels stand out from the competition, and attracts more eco-friendly customers by being environmentally sustainable. Energy inefficiency in hotels arise from outdated systems, poor insulation, and inconsistent use of energy-saving practices (Salami et al., 2024). This leads to higher energy costs due to energy wastage, which ultimately impacts the environment by increasing greenhouse gas emissions. Addressing these inefficiencies through upgraded and automated energy-saving technologies is crucial for hotels aiming to reduce costs and carbon emissions.

Moreover, the lack of energy monitoring technologies inhibits hotels' ability to track and analyze energy consumption patterns in day-to-day operations to get insights into energy consumption (Oyebode et al., 2024). An imperfect understanding of energy costs prevents hotel operators from making informed decisions about energy management, making it difficult to implement tailored and direct energy-saving measures and accurately budget for energy expenses. This calls for hotels to invest in

energy monitoring technologies to gain an understanding of energy use that will inform decision-making on energy costs. The critical analysis of the literature shows that there is a paradoxical situation when energy-efficient and monitoring technologies have been known to be in place, and their usage in the star-rated hotels in Nairobi is still uneven. This inefficiency cannot be attributed to unawareness (Smitt et al., 2021). Instead, structural factors such as high initial capital requirements, and lack of technical capacity to service the system are found to be even greater determinants of adoption trends (Mathews, 2024). Moreover, the literature has paid significant attention to environmental performance as opposed to financial cost control and created a gap in the knowledge about how the use of technology can be converted into the form of energy cost savings at the hotel scale.

The hotel industry needs to conserve and manage its energy resources and use environmentally friendly, biodegradable products to address the global energy crisis by lowering electricity costs and reducing toxic carbon emissions. Therefore, this study analyzed the effect of technological innovations in managing energy costs in star-rated hotels in Nairobi City County, Kenya. The specific objectives included evaluating the effect of energy monitoring technologies on managing energy cost, assessing the effect of implementing energy management technologies on managing energy costs, determining the effect of adopting energy-efficient technologies on managing energy cost, and examining the effect of solar energy technologies on managing energy cost in star-rated hotels in Nairobi City County, Kenya.

1.2 Problem Statement

Despite the adoption of various operational cost-control measures, energy costs remain among the highest operating expenses in the hotel industry after labor costs. Hotels are highly energy-intensive establishments (Dhirasasna & Sahin, 2021; Shehu et al., 2019) due to continuous use of lighting, heating, ventilation, and Air Conditioning (HVAC) systems, kitchen equipment, laundry operations, recreational facilities, and other guest service functions (Zhang et al., 2024). Increasing energy consumption, inefficient energy utilization, outdated equipment, and insufficient energy monitoring systems continue to escalate hotel operational costs (Sakshi et al., 2020; Nica et al., 2022; Saar & Vaher 2025). The increase in energy costs has significant implications for hotel profitability, operational efficiency, service quality,

and competitiveness (Tourkolias et al., 2020). To offset rising utility expenses, hotels often increase the prices of products and services, reduce operational sections, or minimize staffing levels, which may negatively affect customer satisfaction and employee productivity (Gaturu et al. 2022; Arenhart et al., 2022). In extreme situations, high operational costs may threaten business sustainability (Milojković et al., 2022).

The most controllable hotel expenses are energy costs (Hussain et al., 2020), but there is insufficient literature to address the problem of high energy operating costs in hotels, particularly from a technological perspective (Fang & Partovi, 2022). Technological innovations have increasingly been promoted as effective approaches for improving operational efficiency and reducing energy-related expenses in hotels (Yenidogan et al., 2021). Previous studies have examined energy efficiency practices, guest energy-saving behavior, and the role of technology in improving hotel operations (Sun et al., 2019; Tourkolias et al, 2020; Becken et al., 2023). However, existing empirical literature has not sufficiently addressed the contribution of specific technological innovations toward direct energy cost management in hotels, despite technology's potential to increase hotel operation efficiency and reduce energy costs.

There is limited empirical evidence on how energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies individually and collectively contribute to managing energy costs in star-rated hotels. Although studies conducted in other international contexts have explored technology adoption and energy efficiency (Fang & Partovi, 2022; Paramati et al., 2022), the relationship between these technological innovations and quantifiable energy cost management remains underexplored in Nairobi City County, Kenya.

This gap limits the ability of hotel managers, investors, and policymakers to make informed decisions regarding energy investment, operational budgeting, and sustainable hotel management practices. Therefore, this study seeks to assess the effect of technological innovations in managing energy costs in star-rated hotels in Nairobi City County, Kenya, by examining the effects of energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies on managing energy costs.

1.3 Objectives of the Study.

1.3.1 General Objective of the Study

To assess the effect of technological innovations in managing energy costs in Star-rated Hotels in Nairobi City County, Kenya.

1.3.2 Specific Objectives of the Study

The specific objectives of the study were:

i. To evaluate the effect of energy monitoring technologies in managing energy costs in Star-rated hotels in Nairobi City County, Kenya.
ii. To assess the effect of implementing energy management technologies on managing energy costs in Star-rated hotels in Nairobi City County, Kenya
iii. To determine the effect of adopting energy-efficient technologies on managing energy costs in Star-rated Hotels in Nairobi City County, Kenya.
iv. To examine the effect of solar energy technologies on managing energy costs in Star-rated hotels in Nairobi City County, Kenya.

1.4 Study Hypotheses

H_{01}: Implementing energy monitoring technologies has no significant effect on managing energy costs for star-rated hotels in Nairobi City County, Kenya.

H_{02}: Implementing energy management technologies has no significant effect on energy cost savings in star-rated hotels in Nairobi City County, Kenya.

H_{03}: Adopting energy-efficient technologies has no significant effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya.

H_{04}: Adopting solar energy technologies has no significant effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya.

1.5 Significance of the Study

This research contributes greatly to practitioners, policymakers and academia. For practitioners, it provides evidence-based suggestions to hotel managers in the adoption of cost-effective and sustainable energy technologies to lower operational costs, and to enhance efficiency. On the policymakers' front, the findings are used to guide

industry regulators and national policymakers to formulate specific technological energy management policies and incentives that will ensure efficient energy use in the hospitality industry. The study has an academic contribution to the current body of knowledge by advancing empirical knowledge on the dynamics of energy consumption, and technology adoption in hotels, specifically in the emerging economies, and forms a basis to future research on sustainable management of energy consumption in hotels.

1.6 Scope of the Study

The study was restricted to star-rated hotels (2-star to 5-star) in Nairobi City County to understand the role of technological innovations in managing energy costs specifically energy monitoring, energy management, energy efficient, and solar energy technologies. The target population comprised of the general managers, accountants, electricians, and engineering staff as well as the maintenance staff. This study is confined to the period September 2023 to May 2026.

1.7 Limitations of the study

Limitations are flaws that the researcher is unable to eliminate. First off, the cross-sectional design cannot produce anything; it can only record associations at a specific moment in time. Second, the researcher relied on self-reported data from engineers, electricians, maintenance staff, accountants, and hotel managers, which can be skewed by social desirability or memory bias. Third, the study's richness of qualitative data gathering was constrained by financial and time constraints. Fourth, the researcher's lack of research experience might have affected several aspects of the study's execution.

1.8 Delimitations of the study

Delimitations are restrictions placed on a researcher on purpose. The survey only took into account hotels with ratings ranging from two (2) to five (5) stars; it did not take into account lodges, guest homes, or other types of lodging. The sample was limited to Nairobi City County and did not include other Kenyan counties with a sizable hotel population, such as Mombasa or Kisumu. Only four categories of technological advancements were the focus of the study; other potentially significant technologies, such as wind or geothermal systems, were left out. Last but not least, the study focused

on energy cost control rather than the total accomplishments of environmental sustainability.

1.9 Assumptions of the study

The study was founded on the following assumptions:

i. The respondents (general managers, engineers, accountants, and electricians, as well as maintenance staff) have sufficient knowledge on technological innovations and cost management practices in regards to energy in their respective hotels.
ii. The respondents were honest, truthful and accurate on responding to the questionnaire and interview questions.
iii. The star-rated hotels that have been selected in Nairobi City County are reflective of the star-rated hotels in other urban Kenyan settings.
iv. The data collection tools (questionnaire and interview guide) are valid in that they measure the constructs of technological innovations and energy cost management that are intended.
v. The COVID-19 post-pandemic recovery (2022-2025) is a fairly stable operating environment in which significant data gathering on energy costs can be conducted.

1.10 Contributions of the thesis

This research makes significant contributions to knowledge, practice, and policy in the field of energy management within the hospitality industry, particularly in the context of developing economies. The contributions are organized into four main categories: theoretical contributions, empirical contributions, methodological contributions, practical contributions, and policy contributions.

1.10.1 Theoretical Contributions

This study advances theoretical understanding in the field of energy management in the hospitality industry through the integration and application of two complementary theoretical frameworks: the Resource-Based View (RBV) and the Diffusion of Innovation (DOI) theory.

Integration of RBV and DOI Theories: While previous studies have applied RBV and DOI independently in hospitality research, this study uniquely combines both theories to provide a comprehensive framework for understanding energy technology adoption and its impact on cost management. The integration demonstrates that energy monitoring, energy management, energy-efficient, and solar energy technologies function as strategic resources (RBV) that provide competitive advantage through cost reduction, while simultaneously explaining the differential adoption patterns across hotel categories (DOI). This integrated theoretical lens offers a more robust analytical framework than either theory alone, as it accounts for both the strategic value of technologies and the organizational and contextual factors that influence their adoption.

Extension of RBV to Energy Management: The study extends RBV theory by demonstrating how energy technologies qualify as valuable, rare, and inimitable resources that can generate sustainable competitive advantage in the hotel industry. Specifically, the findings show that solar energy technologies ($\beta = 0.348$) and energy monitoring technologies ($\beta = 0.289$) are particularly valuable resources that enable hotels to achieve lower operating costs. This extends RBV beyond traditional strategic resources (brand reputation, location, human capital) to include technological capabilities in energy management, thereby broadening the theory's applicability in the hospitality context.

Application of DOI in the Hospitality Context: The research provides empirical validation of DOI theory's five adopter categories (innovators, early adopters, early majority, late majority, and laggards) within the hotel industry. The findings confirm that five-star and four-star hotels function as innovators and early adopters of energy technologies, while two-star and three-star hotels tend to be late majority or laggards. This is particularly evident in the adoption of solar energy technologies for electricity generation, where only 39.5% of hotels have adopted the technology, with adoption concentrated among higher-rated establishments. This application of DOI provides a framework for understanding technology diffusion patterns in the hospitality sector and offers insights into how to accelerate adoption among lagging segments.

1.10.2 Empirical Contributions

This study provides new empirical evidence on the relationship between technological innovations and energy cost management in the hotel industry, addressing several gaps in the existing literature.

Contextual Evidence from an Understudied African Urban Setting: The research contributes empirical data from Nairobi City County, Kenya, an understudied African urban environment characterized by high electricity tariffs and unreliable grid supply. Most existing studies on energy management in hotels have been conducted in developed countries or rapidly industrializing Asian economies. By focusing on Kenya, this study provides evidence from a context where energy costs constitute a particularly significant operational burden (accounting for up to 30% of operating expenses) and where the business case for energy technologies is arguably more compelling. The findings therefore extend the generalizability of existing knowledge and provide a baseline for comparative studies across different economic contexts.

Quantification of Technology-Specific Effects on Energy Cost Management: Unlike previous studies that have examined energy efficiency broadly, this research disaggregates technological innovations into four specific categories (energy monitoring, energy management, energy-efficient, and solar energy technologies) and quantifies their individual and combined effects on managing energy costs. The findings reveal that:

i. Solar energy technologies have the strongest effect on managing energy costs ($\beta = 0.588$, $R^2 = 0.592$)
ii. Energy management technologies follow closely ($\beta = 0.568$, $R^2 = 0.540$)
iii. Energy monitoring technologies also show significant effects ($\beta = 0.612$, $R^2 = 0.504$)
iv. Energy-efficient technologies, while still significant, have a relatively lower effect ($\beta = 0.442$, $R^2 = 0.438$)

This disaggregated analysis provides hotel managers with evidence-based guidance on which technologies offer the greatest return on investment and should be prioritized.

Identification of Technology Adoption Patterns and Barriers: The research provides empirical evidence on the specific adoption rates of different energy technologies in star-rated hotels:

i. LED lighting: 82.6% adoption (highest)
ii. Smart energy meters: 75% adoption
iii. Solar water heating: 47% adoption
iv. Solar electricity generation: 39.5% adoption (lowest)

The study also identifies the key barriers to adoption, including high initial capital costs (80.0% agreement), lack of technical know-how, infrastructure deficiencies, and difficulty integrating with existing systems. These findings are particularly valuable for understanding why the gap between awareness of benefits and actual implementation persists, especially among lower-star hotels.

Measurement of Energy Cost Performance Indicators: The study contributes to methodological rigor in energy cost research by utilizing specific indicators to measure managing energy costs, including energy cost per occupied room, energy cost per available room, and energy cost per square meter. This approach moves beyond generalized efficiency outcomes to provide quantifiable financial metrics that are meaningful for hotel managers and investors.

1.10.3 Practical Contributions

The research provides evidence-based, star-rating-specific guidance to hotel practitioners, enabling more informed decision-making regarding technology investments.

Identification of High-Return Technologies: The study identifies which technologies provide the best payback and should be prioritized for investment:

i. LED lighting: widespread adoption (82.6%) with proven cost-effectiveness
ii. Smart thermostats and occupancy sensors: moderate adoption but strong cost-saving potential
iii. Solar water heating systems: substantial savings with relatively lower capital costs compared to PV

iv. Building Energy Management Systems (BEMS): significant energy savings but requires technical expertise

This guidance allows hotel managers, particularly in resource-constrained lower-star hotels, to make staged investments starting with low-cost, high-return technologies and gradually progressing to more capital-intensive solutions.

Understanding of Technology Combinations: The multiple regression analysis reveals that the combined use of all four technology categories explains 71.4% of the variance in managing energy costs ($R^2 = 0.714$, $F = 115.58$, $p < 0.01$). This finding demonstrates that the effect of technologies is amplified when they are used in conjunction, providing a compelling business case for comprehensive rather than piecemeal technology adoption. Hotel practitioners can use this evidence to justify integrated technology investment strategies.

Identification of Adoption Barriers by Hotel Category: The study identifies specific barriers that affect different hotel categories:

i. Two-star and three-star hotels: High initial capital costs, lack of technical skills, limited access to financing
ii. Four-star hotels: Integration challenges with existing systems, need for technical training
iii. Five-star hotels: Full automation and integration, predictive maintenance capabilities

This differentiation enables targeted recommendations that are appropriate for the resources and capabilities of each hotel category.

Implementation Roadmap: Based on the findings, the study provides a practical implementation roadmap for hotel practitioners:

i. Phase 1 (Immediate): Conduct energy audits, install smart meters, implement LED lighting
ii. Phase 2 (Short-term): Install occupancy sensors, smart thermostats, and automated HVAC controls
iii. Phase 3 (Medium-term): Implement Building Energy Management Systems (BEMS)

iv. Phase 4 (Long-term): Invest in solar water heating and PV systems, potentially through financing mechanisms

This phased approach enables hotels to manage cash flow constraints while progressively improving energy performance.

1.10.4 Policy Contributions

The research provides concrete policy guidelines that can accelerate technology adoption and reduce energy costs across the hospitality industry in Kenya and other developing economies.

Financial Incentive Recommendations: The study provides evidence-based recommendations for financial incentives to overcome the high initial cost barrier, including:

i. Tax incentives: Tax rebates or accelerated depreciation for hotels investing in energy technologies
ii. Subsidized loans: Low-interest green financing schemes specifically for lower-star hotels
iii. Energy service companies (ESCOs): Performance contracting models where technology providers finance the investment and are paid from energy savings

These recommendations are supported by the finding that 80.0% of respondents identified high initial cost as a major adoption barrier, indicating that financial incentives would have significant impact on adoption rates.

Regulatory Framework Recommendations: The study recommends:

i. Energy consumption standards: Minimum energy performance standards for hotels, with differentiated requirements by star rating
ii. Mandatory energy audits: Regular energy audits for higher-star hotels (four-star and five-star)
iii. Building codes: Integration of energy efficiency requirements into building regulations for new hotels and major renovations
iv. Reporting requirements: Mandatory public disclosure of energy performance indicators for hotels above a certain size

Capacity Building Recommendations: The research identifies technical skills as a critical barrier, particularly for lower-star hotels. Policy recommendations include:

i. Training programs: Public-private partnerships to provide technical training on energy technologies
ii. Technical assistance: Access to technical experts for hotel operators, particularly in the design and implementation phases

1.10.5 Academic and Research Contributions

Foundation for Future Research: The study establishes a foundation for future research on energy management in hospitality by:

i. Providing a tested theoretical framework (RBV and DOI integration)
ii. Validating research instruments for measuring energy technology adoption and cost management
iii. Identifying research gaps that require further investigation (longitudinal studies, comparative studies, cost-benefit analysis)
iv. Offering a methodology that can be replicated in other contexts

Advancement of Sustainable Tourism Research: The research contributes to the broader field of sustainable tourism by demonstrating the economic case for environmental sustainability. By showing that energy technologies reduce operating costs while also reducing carbon emissions, the study counters the perception that sustainability is a cost burden and demonstrates that it can enhance profitability.

1.11 Organization of the Thesis

This thesis is structured into five chapters organized as follows:

The first chapter establishes the foundation for the entire study. It begins with the background to the study and then presents the problem statement, research objectives, study hypotheses, the significance, and scope of the study. The limitations, delimitations, and the assumptions underpinning the study are also acknowledged. Finally, the chapter presents the contribution of the thesis in detail, and concludes with the organization of the thesis, which provides the overview of the structure of the entire document.

The second chapter provides a comprehensive review of the existing literature relevant to the study, establishing the theoretical and empirical foundations for the research. The theoretical review examines two complementary theories that underpin the study.

The Resource-Based View (RBV) theory, explains the strategic value of energy technologies and their effect on energy costs, while Diffusion of Innovation (DOI) theory explains the variation in adoption patterns across hotel categories. The empirical review critically examines existing studies on each of the four technology categories under investigation. Each empirical review section identifies the gaps in the existing literature that this study addresses. The conceptual framework presents a visual representation of the relationships between the independent variables (energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies) and the dependent variable (managing energy costs)

The third chapter presents the methodological approach and procedures employed to achieve the study's objectives. It includes a description of the research philosophy, the research approach, the research design, the study area, the target population, the sampling frame and sample size, the data collection instruments and piloting of both instruments to assess validity and reliability. Additionally, the validity and reliability of the instruments, the data analytical procedures as well as ethical consideration considered during the research are explored and justified.

The fourth chapter presents the findings of the research, organized in a logical sequence from response rates through demographic characteristics, descriptive statistics, qualitative analysis, correlation analysis, diagnostic tests, regression analysis, and hypothesis testing. The chapter is structured to guide the reader through the data analysis process, with each section building upon the previous one.

Finally, the fifth chapter provides the concluding section of the thesis, synthesizing the findings, drawing conclusions, acknowledging limitations, and making recommendations.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents a literature review of the role of technological innovation in managing energy costs of hotel operations in star-rated hotels. Through reviewing the current state of knowledge on the topic, this chapter establishes the foundation for understanding how technological innovation can be applied to hotel operations to manage energy costs and increase energy efficiency, goals that are both economically and environmentally sustainable for the hospitality industry.

2.2 Theoretical Review

2.2.1 Resource-Based View Theory

Resource-Based View (RBV) theory was initially theorized by Edith Tilton Penrose (1959) and subsequently developed by Barney (1991). RBV assumes that the resources that are valuable, rare, inimitable, and non-substitutable (VRIN) enable firms to attain sustainable competitive advantage and lower costs. Technological innovations are strategic resources in the context of this study, as through the integration of the innovation in the daily operations of the hotel, it can monitor, manage, and enhance energy efficiency (Petrović et al., 2024), and eventually provide management of energy costs. According to this theory, organizations can achieve maximum profitability and a reduction in operating costs as a result of adopting advanced technological innovations.

This study focuses on exploring the role of technological innovations in managing energy costs in star-rated hotels. The RBV is used in this study as an analytical tool to help in analyzing the hotels' potential to adopt technological innovations to minimize expenses related to energy use while enhancing the effectiveness of processes that ensure superior service delivery.

Hotels are energy-intensive buildings and as a result, the RBV emphasizes leveraging energy technological innovations such as energy monitoring technologies, energy-efficient technologies, and solar energy technologies like solar panels, as well as

energy management technologies such as occupancy sensors to manage energy and reduce costs.

Hotels that invest in these innovations can reduce energy operating costs, increase profitability, gain a competitive advantage, increase the quality of services through improvement in operational efficiency, and lead to the hotel's environmental sustainability through the use of clean energy.

One of the most important limitations of the RBV theory is the fact that firms are assumed to be equal in terms of their access to valuable resources. This is not the case in the Kenyan hotel setting, where five-star (5) hotels are in a better position to invest in energy technologies compared to two star (2) hotels. This study solved this shortcoming by making comparisons of the energy cost performance of various star ratings, thus recognizing resource differences.

In this study, the RBV is used to analyze how energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies serve as strategic resources that enable star-rated hotels in Nairobi to manage and reduce energy costs.

2.2.2 Diffusion of Innovation Theory

This theory was developed by Everett Rogers in 1962 (Rogers, 2003) to explain how innovations spread throughout a population over time. Rogers came up with phases to explain the adoption of new agricultural innovations by different farmers at different times. Innovators are willing to experience new ideas; early adopters are leaders in a system who approve new idea by adopting it; early majority consider an innovation decision for long before adopting it; late majority are the skeptical group who only adopt an innovation as a result of peer pressure from the others and finally laggards who adopt an innovation after considering whether the innovation is successfully adopted by other members of the organization. (Kolsi, 2023)

The theory helps to explain the pattern of energy technological innovations adoption in hotels and how the rate of diffusion affects energy conservation and ultimately energy costs performance in different star-rated hotels. It suggests that technological

innovations aimed at managing energy costs will be adopted in phases starting with early adopters, five-star (5) and four-star (4) luxury hotels, and moving through the majority Three star (3) hotels, and laggards, Two star (2) hotels. According to the DOI theory, hotels that adopt energy technologies early can benefit from cost savings and increased market share, while late adopters may experience higher energy costs and potential operational inefficiencies.

While the Diffusion of Innovation theory explain the various categories of adopters of a certain technology, it does not explain the potential effect of external factors like high electricity prices, grid supplies issues, or a lack of government incentives for the introduction of new technologies into the market. These factors may have a major impact upon the adoption rates of innovations beyond the categories explained by Diffusion of Innovation.

In this study, the Diffusion of Innovation theory explains the expected variation in energy technology adoption across two-star (2), three-star (3), four-star (4), and five-star (5) rated hotels in Nairobi, and how this variation affects energy cost management outcomes.

2.2.3 Integration of Resource-Based View and Diffusion of Innovation for This Study

The two theories that are complementary to this study are the Resource-Based View and Diffusion of Innovation. RBV justifies the reasons why hotel management should invest in energy technologies to achieve a competitive advantage by having lower energy costs while DOI details the manner and time when various hotels embrace these technologies, five star (5) hotels are relying on the technology sooner and the two star (2) hotels are lagging behind. These theories offer a complete framework together: Resource Based View is used to analyze the results of energy costs, and Diffusion of Innovation is used to analyze the adoption patterns of star ratings.

2.3 Empirical Review

This section is a critical review of the available empirical literature concerning technological innovations in the area of energy management in the hotel industry. The purpose of this review is to summarize the existing literature, draw main conclusions,

and point to the gaps in the literature, especially in the context of the Resource-Based View (RBV) and Diffusion of Innovation (DOI) theories. The focus is put on the studies that have been published not more than five years ago to make sure that the discussion is relevant and current. The empirical evidence is organized according to the major categories of technological innovations that are applicable in this study energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies.

2.3.1 The Effect of Energy Monitoring Technologies in Managing Energy Costs in Star-rated Hotels

The energy-consuming behavior of the hotel industry requires effective energy monitoring in order to pinpoint inefficiencies and control the cost of the business (Singh, Mishra, & Yadav, 2024). The recent literature highlights the potential of energy monitoring technologies, especially those based on the Internet of Things (IoT) and Artificial Intelligence (AI) to improve energy efficiency and lower the cost of operation in hotels (Gligorijević et al., 2024).

Conventional energy monitoring systems, usually based on manual meter readings, do not give much information on real-time consumption behavior (Adebisi & Ndjuluwa, 2024). This weakness prevents active energy control and the definition of particular spheres of high energy consumption. Nevertheless, this situation has changed with the implementation of smart meters and IoT-based systems, which provide granular and real-time information on electricity, water, and gas usage in different operations of the hotel, such as HVAC, lights, and kitchen appliances (Yousef & Chaer, 2025). Research has demonstrated that the IoT systems can facilitate automated operation according to occupancy and availability of daylight, resulting in massive energy savings in lighting and heating-ventilation systems (Onweh, Al-Habaibeh, & Manu, 2025).

An example of how big chains of hotels use technology to monitor and compare energy use in their properties to save a lot of money and use less energy is digital energy monitoring systems like that of Hilton, LightStay (Ferreira, 2023). These platforms offer practical information, and when used by hotel managers, this information helps them to identify abnormalities, optimize utilization habits, and take corrective measures in a timely manner (Hassan & Eassa, 2025). Incorporation of AI

in HVAC systems also makes the energy control more precise through predictive maintenance and automatic regulation of the energy consumption, resulting in significant energy consumption savings (Haji et al., 2025).

Though the advantages are obvious, the implementation of the modern energy monitoring technology, in particular, those based on the IoT, is hampered by the high initial investment level and the perceived absence of technical skills, especially in smaller or lower-rated hotels (Naumchik et al., 2026). This difference in adoption rates demonstrates a very important gap in the practical use of these technologies, which can be further addressed in terms of the Diffusion of Innovation theory, which explains why some groups of the industry are more likely to implement certain innovations in time (Ho, 2022). According to RBV approach, a hotel that effectively adopts these high-tech monitoring systems will be able to create a distinctive resource, namely high-quality energy intelligence, which will be incorporated into a competitive advantage due to a cost-effective structure and a better sustainability performance (Jerab & Mabrouk, 2023).

While the existing literature provides discussion on the benefits of energy monitoring, there is still a notable gap regarding the absence of these technologies in many hotel establishments. Therefore, more empirical research must be conducted to examine the factors contributing to their non-adoption and the implications this has on energy cost management and operational efficiency of the various hotel segments (2-star to 5-star hotels). Moreover, studies could better identify the application of these technologies with the creation of sustainable competitive advantages as theorized by the RBV, and explore what influences fast or slow diffusion in different hotel settings, as theorized by the DOI.

This study directly responds to the identified gap by examining the various tools of energy monitoring technologies in two-star, three-star, four-star, and five-star hotels in Nairobi City County, Kenya. In contrast to the previous studies that have concentrated on technical results, the present research estimates the reduction of energy cost as the main dependent variable of the research with the help of such indicators as energy cost per occupied room, energy cost per available room, energy cost per square meter. It uses the RBV framework to determine the presence of energy

monitoring technologies as strategic resources to competitive advantage and the DOI framework to describe the adoption patterns of the technologies by hotels of various star ratings. The given study adds to the body of empirical research, where the country of investigation is not the developed world, but Nairobi, an understudied African urban setting with high electricity tariffs and unstable grid supply.

2.3.2 Effect of Energy Management Technologies on managing energy costs in Star-rated hotels

Energy Management Technologies (EnMTs) are extremely significant in the optimization of energy consumption and cost reduction in the hospitality industry (Huang & Anuar, 2026). These technologies actively manage and control energy-consuming equipment within a hotel, such as the HVAC, lighting, and other electrical equipment (Orozco, 2024). The primary goal is to prevent the loss and wastage of energy that results in efficient conservation of the energy and, consequently, the minimization of the cost of operation (Vishwakarma & Kumar, 2023).

EnMTs are integrated with Artificial Intelligence (AI) and IoT to automate systems and devices. The AI-based Building Management Systems (BMS) will be able to understand the energy consumption patterns of a building, anticipate the demand peaks, and automatically tune the building systems, such as HVAC, to ensure the comfort of guests without consuming a lot of energy (Sanjeevi et al., 2025). These intelligent systems have been proven to bring about tremendous savings, and some hotels have registered energy savings of 30 to 40 percent (Singh, Mishra, & Yadav, 2024). Moreover, these systems can predict maintenance needs that reduce wastages of equipments and associated wastages of power (Molęda et al., 2023).

Occupancy sensors, integrated building management system (BMS), smart thermostats, are just but a few of the vital components of modern EnMTs. Smart thermostats that in most cases are linked to hotel databases can be used to regulate the temperatures of the rooms depending on the time of the check-in and checkout of the guests and help to avoid needless use of energy in the rooms that are not occupied by guests thereby saving energy cost per occupied room (Ivanov, 2023). The occupancy sensors installed in guest rooms and common spaces control the light and climate system in a manner that ensures that only the amount of energy that is required is used

(Orozco, 2024). BMS at large scale as used by the DoubleTree by Hilton in Dartford, UK, have been quite effective in saving the energy bill by installing key card lighting and HVAC according to real time usage that ends up in massive cost savings with no effect on the guest experience (Ferreira, 2023).

Regarding RBV, it is possible to discuss the introduction of advanced EnMTs as the development of a valuable, rare, inimitable and non-substitutable (VRIN) resource. When the hotels employ and incorporate such technologies effectively, they stand at a competitive advantage in the shape of low operation costs, superior brand image as environmentally friendly hotel operators and increased guest satisfaction through optimized degrees of comfort (Singgalen, 2024). The theory of the Diffusion of Innovation may be applied to the process of the introduction of EnMTs to all hotels as not all of them will use the innovation at the same pace with early adopters, who are typically large hotel chains with increased financial and technical resources, being first, and smaller hotels may be left out due to the perceived high price and technology (Pett et al., 2024). However, the long-term advantages of modular IoT devices and their increasing availability are gradually contributing to the increased utilization of the industry (Muyeen et al., 2023).

Although the literature indicates that EnMTs are effective, further study is needed on their implementation problems and success factors as it pertains to managing energy costs in large and small hotels of different star ratings.

This study fills the above gap by focusing on the application of the energy management technologies (EnMTs) in two-star (2), three-star (3), four-star (4), and five-star (5) hotels in Nairobi City County, Kenya. In particular, it explores the implementation of smart thermostats, occupancy sensors, and building management systems (BMS), as well as automated HVAC, and measures the impact on energy cost savings based on the indicators of energy cost per occupied room and per square meter. The study utilizes the RBV theory to determine the presence of EnMTs as VRIN resources which give competitive advantage and the DOI theory to describe the patterns of adoption of EnMTs based on the star rating of the hotel. Through the attention to the specific energy conditions in Nairobi including high tariffs and the

lack of reliability in the grid supply, this study offers the empirical evidence in an under-researched African urban environment.

2.3.3 Effect of Adopting Energy-Efficient Technologies in Managing Energy Costs in Hotels

The concept of energy efficiency implies consuming less energy to deliver the same quality and quantity of helpful output of a given service. Technologies that are energy-efficient consume less energy to provide the same service (Shehu et al., 2019). Hotels are intensive regarding their energy consumption because high levels of energy waste can be observed in the poorly insulated building envelopes, lighting, and heating (Quijas et al., 2021). Thus, the adoption of energy-efficient technologies minimizes energy loss and use and offers quality service to the guests, thereby lowering energy spending (Sun et al., 2019; Karvounidi et al., 2024).

Temperature regulation is a critical aspect of hotel guest comfort and satisfaction; however, it accounts for a substantial proportion of hotel energy consumption and operational costs due to inefficiencies in many hotel establishments (Lee et al., 2024). To address this challenge, hotels have increasingly adopted energy-efficient HVAC systems to improve temperature control while reducing energy costs. Studies indicate that efficient air-conditioning systems and chillers enhance energy management by cooling large hotel spaces more effectively, thereby reducing energy cost per available room and per square meter (Simpeh et al., 2022; Li et al., 2020). Similarly, energy-efficient boilers reduce fuel consumption in hot water production, lowering energy costs per guest while minimizing energy waste (Chaudhary et al., 2021). Ventilation systems also contribute to lower operational expenses through improved indoor air circulation and reduced heat loss (Tourkolias et al., 2020).

HVAC systems remain among the largest consumers of energy in hotels, accounting for nearly half of total energy use, particularly when systems are left operating or on standby in unoccupied guest rooms (Shehu et al., 2019). Chillers used in hotel air-conditioning systems alone are estimated to consume approximately 43% of total HVAC energy (Ananth et al., 2021). However, retrofitting conventional chillers with advanced energy-efficient models can reduce energy consumption by up to 38%, leading to significant operational savings. In addition, properly sized HVAC

equipment improves energy efficiency because oversized or undersized units contribute to energy wastage and indoor air quality problems. Regular maintenance, proper installation, and replacement of outdated systems with high-efficiency technologies further enhance HVAC performance and reduce unnecessary energy consumption.

Hotels improve energy efficiency in hot water production by replacing old boilers with high-efficient boilers or heat pumps (Smitt et al., 2021). Furthermore, insulating water heating components such as pipes, storage tanks, and boilers helps retain water temperature for longer periods (Moss et al., 2022), especially in cold conditions, thereby reducing heat loss and lowering operational costs in hospitality buildings.

Energy-efficient building design has become an important strategy for reducing energy consumption and operational costs in hotels. Buildings are among the largest consumers of energy globally, accounting for approximately 45% of total energy use (Shehu et al., 2019). Consequently, improving the energy efficiency of hotel buildings can significantly reduce energy-related costs (Fousteris et al., 2024). Architects and designers, therefore, need to consider spatial planning during the design stage, as building layout and space utilization directly influence energy demand (Kini et al., 2023). Increased floor area and higher heating and cooling requirements are among the major factors contributing to rising energy consumption in hotels.

Building design and orientation also play a critical role in determining energy efficiency (Habibi, 2024). Factors such as climate zone, geographic location, occupancy levels, building materials, equipment usage, and the building envelope—including walls, floors, windows, doors, and roofs—influence overall energy performance. Compact building designs are more energy-efficient due to lower ratio of external surface area to indoor volume, thereby minimizing heat transfer (Xu & Yuan, 2022). In addition, climatic conditions affect energy demand, as hotter regions require greater cooling while colder regions require more heating.

Retrofitting and renovating older buildings are important measures for improving energy efficiency and reducing operational costs. Installation of double-glazed windows and improved insulation systems minimize heat loss during cold seasons and

reduce heat gain during hot seasons (Shao et al., 2020; Shehu et al., 2019). Similarly, the use of effective insulation materials such as stone and brick enhances thermal retention, whereas buildings with extensive glass surfaces may experience greater heat loss or heat gain if appropriate insulation and shading measures are not incorporated. Fixed shading devices can also help reduce overheating in glass buildings (Li & Wu, 2025).

Furthermore, natural lighting through windows reduces dependence on artificial lighting and lowers electricity consumption. However, poorly insulated window frames can contribute to heat leakage, making double-glazed and thermally insulated windows essential for minimizing energy loss (Gaturu et al., 2022). Properly fitted window frames further help reduce unnecessary energy wastage.

Replacement of incandescent bulbs with Light-emitting diode (LED) lighting reduces electricity consumption, lowers bills, increases lifespan, and improves sustainability (Shakir et al., 2024). LED lighting also reduces maintenance needs and carbon emissions (Gaturu et al., 2022).

Despite the comprehensiveness of the literature on technical aspects and the advantages of energy-efficient technologies, several gaps remain. Most studies focus on energy efficiency rather than quantifiable energy cost reduction. There is also limited evidence from African urban areas such as Nairobi. In addition, studies rarely disaggregate energy-efficient technologies into specific categories (LED lighting, efficient HVAC, insulation, and double-glazed windows) to evaluate their individual contribution to cost reduction.

This research addresses this gap by examining energy-efficient technologies in 2 to 5 star-rated hotels in Nairobi City County, Kenya. It focuses on LED lighting, efficient HVAC systems, building insulation, double-glazed windows, and measures their impact on managing energy costs using indicators such as energy cost per occupied room, per available room, and per square meter. It uses the RBV framework to assess whether energy-efficient technologies are strategic resources for competitive advantage and the DOI framework to explain adoption patterns across hotel categories. By focusing on Nairobi, an understudied African urban setting with high

electricity costs and unreliable supply, the study provides empirical evidence on the role of energy-saving technologies in the hospitality industry.

2.3.4 The Role of Solar Energy Technologies in Managing Energy Costs in Star-rated Hotels

Implementation of solar energy solutions is a substantial chance to hotels to save on energy expenses, and minimize dependence on traditional energy sources (Abou et al., 2023). Solar energy is a clean and abundant renewable source that can be utilized with photovoltaic (PV) electricity-generation and solar thermal technologies (Dhirasasna & Sahin, 2021; Yavuz & Yaşarsoy, 2026).

Recent reports point out that there is a trend in the hospitality industry towards the incorporation of solar power. Indicatively, hotels using solar energy have increased significantly in some areas in order to fight the increased electricity prices (Vourdoubas, (2019). PV systems, which are generally placed on rooftops, transform sunlight directly into electricity and any extra energy can be often fed back into the national grid, which also helps to save money (Nwaigwe et al., 2019). Solar thermal systems, however, use solar energy to warm water or heat a room, which is a very cost-effective renewable energy source (Taghipour et al., 2024).

Solar energy is not only beneficial with regard to direct cost savings. By implementing solar technologies, hotels can also make a substantial decrease in their carbon footprint and enhance their image towards the environment and appeal to environmentally conscious customers, thus gaining a competitive advantage (Turktarhan et al., 2023). This is in line with the Resource-Based View (RBV) where the strategic implementation of renewable energy technologies may be viewed as a strong and undistinguishable resource that would add to sustainable competitive advantage (Hossain, Hussain, and Kannan, 2022).

Nevertheless, the shift towards solar energy is not devoid of difficulties. The first impediment found in the literature is the large initial investment cost to equip and install and maintain solar energy systems (Silva et al., 2022). This economic challenge frequently prevents lower-star-rated hotels from implementing these technologies, although they will be cost-effective in the long term and environmentally friendly

(Vella, 2024). This can be explained by the theory of Diffusion of Innovation (DOI) that states that the perceived high cost and complexity may decelerate the pace of adoption among some industry participants (Call & Herber, 2022).

Although the literature continuously highlights the advantages of solar energy in hotels, further empirical studies on new financing strategies and governmental incentives that can address the initial barrier of investment, particularly in small and medium sized hotels, are required. Moreover, research may delve further into the economic sustainability of solar energy systems and their maintenance needs in a variety of hotel settings. To better understand the adoption patterns, the analysis of the factors that affect the rate of adoption of various hotel types and to the RBV, the quantification of the competitive advantages through the integration of solar energy, would be a better insight.

The current study is directly related to the gaps identified since it focuses on the implementation of solar energy technologies in two-star hotels, three-star hotels, four star hotels and five star hotels in Nairobi City County, Kenya. In particular, it explores the deployment of photovoltaic (PV) panels, and solar thermal systems and measures the effect of this on managing energy costs using measures like energy cost per occupied room, available room and square meter. It uses the RBV framework to determine the extent to which solar energy technologies are considered as valuable and inimitable resources to create competitive advantage and the DOI framework to identify the patterns of adoption among hotels by different star ratings, especially the obstacles encountered by lower-rated hotels because of the high initial investment cost. This study offers empirical data on the potential of solar energy to save costs in the hospitality industry by targeting the under-researched African urban environment, Nairobi, where power charges are high, and the power supply is not reliable.

2.4 Knowledge Gaps

Existing literature recognizes energy-saving technologies such as LED lighting, smart thermostats, motion sensors, IoT-based sensors, smart meters, and AI-driven energy monitoring systems as strategic resources that enhance operational efficiency and reduce energy costs in hotels. However, despite this recognition, limited empirical evidence exists on how disparities in access to and adoption of these technologies

influence energy cost performance across different hotel star ratings, particularly in Nairobi City County. Previous hospitality studies have also tended to emphasize general sustainability practices, with insufficient attention given to measurable energy cost indicators such as energy cost per occupied room, per available room, or per square meter. Furthermore, there is limited empirical validation of whether these adoption patterns significantly translate into differences in energy cost outcomes within the Kenyan hotel sector. Therefore, this study seeks to examine how the adoption of advanced energy technologies influences energy cost management across hotels of different star ratings in Nairobi City County.

Existing studies acknowledge that many hotel operators have a limited understanding of energy cost structures, including fixed tariffs, peak-demand charges, time-of-use pricing, and departmental energy consumption patterns (Margetts, 2024; CBRE Hotels Research, 2023). From the Resource-Based View (RBV), inadequate knowledge of energy cost structures limits the development of strategic capabilities necessary for effective energy cost optimization. Furthermore, although some hotels have adopted energy management technologies, the absence of standardized energy cost analytics tools reduces the ability of such technologies to achieve maximum cost-saving benefits. However, limited empirical research has examined how energy cost structures vary across hotel operations and how such variations influence energy cost management, particularly among small and medium-sized hotels. Consequently, further research is required to analyze hotel energy cost structures and their implications for energy cost optimization in the hospitality sector.

Despite the global transition toward renewable energy, the adoption of solar energy technologies within the hotel sector remains relatively low (United Nations, 2022; MDPI, 2023). The Resource-Based View (RBV) identifies solar energy systems as valuable strategic resources capable of generating long-term operational and cost advantages. However, the high initial investment costs associated with solar technologies continue to limit their adoption, particularly among lower-star hotels, which often remain late adopters according to the Diffusion of Innovation (DOI) theory (Emissis, 2024). Although previous studies have discussed the benefits of solar energy technologies, limited empirical evidence exists regarding the adoption of specific solar technologies such as PV and solar thermal systems.

This study addresses the identified research gaps in four ways. First, it applies the Resource-Based View (RBV) to examine how energy monitoring, energy management, energy-efficient, and solar technologies function as strategic resources that contribute to competitive advantage through reduced energy costs among hotels of different star ratings in Nairobi City County. Second, the study applies the Diffusion of Innovation (DOI) theory to explain variations in technology adoption patterns across hotel categories and their influence on energy cost performance. Third, the study measures managing energy costs using specific indicators such as energy cost per occupied room, per available room, and per square meter rather than relying on generalized efficiency outcomes. Finally, the study focuses on Nairobi City County, Kenya, an understudied context characterized by high electricity costs and unreliable grid supply, thereby contributing empirical evidence from a developing urban hospitality environment. By integrating RBV and DOI theories, the study provides a comprehensive framework for understanding the strategic value, adoption patterns, and cost-saving potential of energy technologies within the hotel sector.

2.5 Conceptual Framework

This study assesses the effect of Technological Innovations in managing energy costs in hotels. Hotels consume a significant amount of energy due to lighting, water heating, and the operation of various hotel equipment at high energy costs. Based on the Diffusion of Innovation Theory and Resource-Based View theory, which posits that utilizing technological innovations will provide hotels with a competitive advantage in managing their energy costs. The main concepts explored in this study include energy monitoring technologies, energy management technologies, energy efficient technologies, and solar energy technologies (independent variables) as they relate to the variable of managing energy costs in hotels (dependent variable). Existing literature in the field of energy management in the hospitality industry demonstrates that utilizing technological innovations in managing energy will result in cost savings for the hotels that implement such innovations. The conceptual framework proposes that, when hotels adopt energy-monitoring technologies and implement recommended necessary energy-saving technologies, they can achieve lower energy costs. The framework diagram (Figure 1) illustrates the relationship between technological innovations components, and managing energy costs.

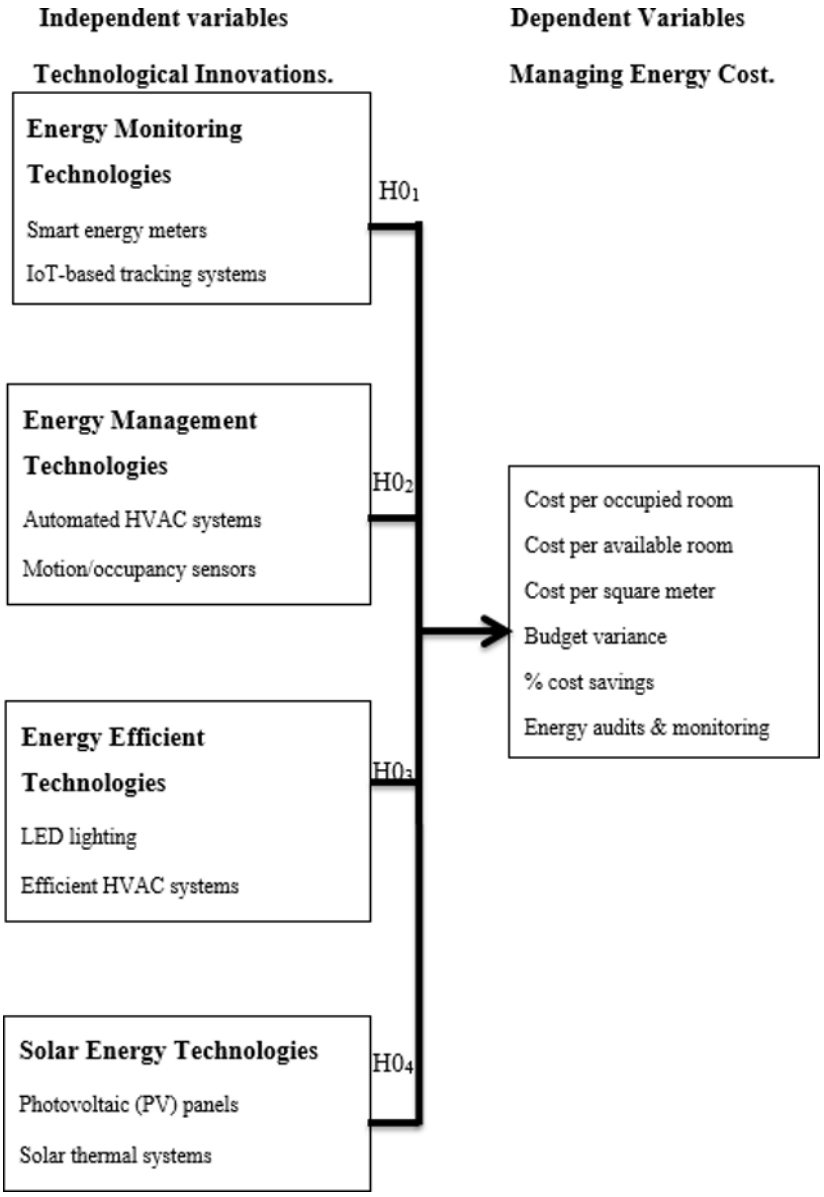


Figure 2.1: Conceptual Framework

2.6 Chapter Summary

This chapter reviewed theoretical and empirical literature on technological innovations and managing energy cost in hotels. The theoretical review examined the Resource-Based View (RBV) and Diffusion of Innovation (DOI) theories. RBV explains how energy technologies serve as strategic resources that provide competitive advantage through cost reduction, while DOI explains adoption patterns across hotel categories, with five-star hotels as innovators and two-star hotels as laggards.

The empirical review covered four technology categories. Energy monitoring technologies (smart meters, IoT systems, AI) enable real-time tracking and anomaly

detection, but adoption is hindered by high costs and technical skill gaps. Energy management technologies (automated HVAC, occupancy sensors, BEMS) reduce energy waste through automation, achieving savings of 30-40%. Energy-efficient technologies (LED lighting, efficient HVAC, insulation) are widely adopted for low-cost options like LED (82.6%) but less for capital-intensive options. Solar energy technologies (PV panels, solar thermal) offer the strongest cost-saving potential but face low adoption (39.5% for electricity generation) due to high initial costs.

Key knowledge gaps identified include: limited evidence from African contexts, insufficient disaggregation of technology types, lack of quantifiable cost indicators (cost per room, per square meter), and inadequate understanding of adoption barriers across hotel categories. The conceptual framework developed in this chapter illustrates the hypothesized relationships between the four technology categories and managing energy costs, guided by RBV and DOI theories.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This section presents the procedures employed to carry out the study. The procedures guide how the study is conducted to ensure the research is systematic, valid, and reliable. It examines the research philosophy, research approach, and research Design (which includes Data Collection Methods & instruments, Sampling procedure, sample size, and technique, Data Analysis, Validity, Reliability of research instruments, and Ethical Considerations.

3.2 Research Philosophy

Research philosophy concerns beliefs and assumptions that guide the research process (Leavy, 2017). Three main worldviews inform researchers' decisions: Positivism, interpretivism, and pragmatism. The study employed a pragmatic paradigm developed in the 20th century by Charles S. Peirce., William James, John Dewey, and George H. Mead (Leavy, 2022) and pragmatism emphasizes the use of useful methods that are practical and work in different contexts in solving the research problem and generates new knowledge (Creswell & Creswell, 2022)

3.3 Research approach

There are three major research approaches; quantitative, qualitative, and mixed methods research approaches (Taherdoost, 2022). This study adopted a mixed methods research approach as elements of qualitative and quantitative research are combined to comprehend the research problem rather than either approach alone (Creswell & Creswell, 2022). A mixed-method approach will best address the research problem since one data source may be insufficient. Moreover, the weaknesses of one method can be offset by the strengths of the other (Creswell & Creswell, 2022).

3.4 Research design

This research design was a convergent parallel mixed-methods study. This method entailed quantitative and qualitative data being collected and analyzed concurrently and then combined to form a holistic picture of the role of technological innovations

in the management of the energy costs in star-rated hotels in Nairobi City County, Kenya.

The design was selected instead of sequential designs (exploratory or explanatory) due to the simultaneous collection of both types of data in the same time frame to facilitate triangulation and cross-validation of results instead of relying on one stage to develop another. Convergent parallel design is especially suitable in situations when the researcher aims to gain complementary quantitative and qualitative information regarding the same phenomenon (Nasiri et al., 2025).

The quantitative element used descriptive survey design to get numerical information on the use and impact of energy monitoring, management, efficient and solar technologies on energy cost management. The qualitative aspect used an exploratory design to understand the perception, experience and problems that the hotel managers are struggling with in the management of the energy costs. This design made it possible to triangulate data and cross-validate the research results and interpret the research problem in a more holistic manner.

3.5 Study Area

The study was conducted in Nairobi City County, Kenya. Find attached in Appendix 1 the map of the study area. This region was chosen because most star-rated hotels are concentrated (Daily Nation, 2020). Furthermore, Nairobi is the hub for many hotel operations with high socioeconomic vigor due to the high population resulting from rural-urban migration (Jackson, 2022). It is also honored as the best in travel by Lonely Planet in 2024 (KNBS, 2023). The growth of Nairobi as an urban center makes it the highest energy resource consumer in providing various hotel services to numerous and varied hotel guests resulting in high energy costs in the hotels. Therefore, there is a need to study the role of technological innovations in managing the resulting costs to promote technologies and consumption patterns that lead to a more sustainable operation in hotels.

3.6 Target population

The unit of analysis was the hotel. A target population is defined as the population to which the researcher wants to extrapolate the findings of the study (Willie, 2024). The

study population included engineering personnel, accountants, electricians, general managers and maintenance staff of the star-rated hotels in the Nairobi City County, Kenya. They were selected due to their expertise and experience in energy consumption, energy costs, and technological advancements in hotels. Table 3.1 shows how the target population is divided into by hotel star rating and the job category.

Table 3.1: Target Population

Hotel Star Rating	General Managers	Engineers	Accountants	Electricians	Maintenance	Total
Two-star	9	9	9	9	9	45
Three-star	15	30	15	30	30	120
Four-star	19	76	19	76	76	266
Five-star	11	66	11	55	66	209
Total	54	181	54	170	181	640

Source: Tourism Regulatory Authority (TRA, 2020) and hotel human resource department

3.7 Sampling Frame and Sample Size

3.7.1 Hotels Sampling Technique.

The study targeted all 54 star-rated hotels in Nairobi City County as listed by the Tourism Regulatory Authority (TRA, 2020). Since the number of hotels was manageable, a census approach was adopted, meaning all hotels were included in the study. The hotels were categorized into four strata based on star rating (2-star, 3-star, 4-star, and 5-star) to ensure representation across different hotel categories. This stratification was important due to the fact that different classifications of hotels were expected to exhibit different levels of technological advancement.

Table 3.2: Sampling Framework Matrix Table for Hotels

Star Rating	Population of Hotels	Sampling Technique
2-Star	9	Census
3-Star	15	Census
4-Star	19	Census
5-Star	11	Census
Total	54	100%

Source: Tourism Regulatory Authority (2020)

3.7.2 Individual Respondent Target Population

The targeted population of the individual respondents consisted of 640 employees from the hotels who hold the positions of general managers, engineers, accountants, electricians, and maintenance staff. As it was not feasible to gather data from all 640 employees, a sample size was determined using Yamane's (1967) formula for finite populations:

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

Where:

n = Sample size to be calculated

N = Total target population size

e = Level of precision (margin of error), set at 0.05 (5%) for a 95% confidence level.

Therefore;

$$n = \frac{640}{1 + 640(0.05^2)}$$

$$n = \frac{640}{1 + 1.6}$$

Therefore, the study sampled 246 respondents. To ensure that each job position and hotel class was fairly represented in the survey as shown in table 3.3, stratified random sampling was utilized to distribute the respondents according to each respective stratum.

Table 3.3: Individual Respondent Distribution by Job Category

Job Category	Target Population	Proportion (%)	Sample Size
General Managers	54	8.4	21
Engineers	181	28.3	69
Accountants	54	8.4	21
Electricians	170	26.6	65
Maintenance Staff	181	28.3	70
Total	640	100	246

3.8 Data Collection Instruments

Both questionnaires and interview guides were utilized to collect both quantitative and qualitative data from different categories of individuals. The questionnaire was administered to engineers, maintenance staff, and electricians due to their technical involvement with the hotel and its energy technologies. The questionnaire asked for information regarding their demographics, as well as their adoption of various energy technologies (energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies) and their effect upon their hotel's energy costs. These questions were asked in accordance with the conceptual framework to ensure that data was collected regarding each of the study's variables. A complete copy of the questionnaire can be found in Appendix IV.

Interviews were conducted with the hotel's general managers and accountants to obtain information regarding their knowledge of the energy management of their hotel, the energy technologies that they have adopted, any challenges that they have experienced, any advantages or disadvantages to those technologies, and their future intentions regarding investing in new technologies to reduce their energy costs. This interview guide provided for in-depth feedback regarding energy management of the hotel that can help to inform the research study. The interview guide is attached in Appendix I.

Each of these research instruments was piloted prior to the actual collection of data from the hotels. This piloting of both questionnaires and interview guides allowed for any issues with those instruments to be corrected before data collection began, improving the effectiveness of those instruments in collecting the necessary data.

3.9 Pilot Study

Prior to the main data collection, a pilot study was conducted to assess the validity and reliability of the research instruments to identify any possible weaknesses in the questionnaire and interview guide. Pilot testing is used to test the research instruments before the study is conducted (Teresi et al., 2022). The instruments were tested for suitability for the research study. According to O'Neill (2022), approximately 10% of the study population was selected for the pilot study. A total of 16 guests were selected from star-rated hotels outside of Nairobi City County but with similar characteristics to hotels that will be surveyed for the main study. These guests will be excluded from the study as a result of being part of the pilot study. Based on the results from the pilot study, certain questions will be revised and some will be eliminated to enhance the effectiveness of the research instruments for the main study.

3.9.1 Validity of the Instruments

Validity is the degree to which the research instrument measures the intended variable (Clark & Watson, 2019). The validity of the research instrument was gauged through the use of encounter validity, content validity, and construct validity. The face validity of the instrument was determined through the researcher's judgment of the suitability of the variables in the research instrument. Further assessments of the confront validity included the use of research instruments used in similar previous research studies and the insights gained from the literature review study. Content validity was determined through the submission of the research instrument to three supervisors for review; suggestions made during this review were incorporated into the instrument. Construct validity was ensured through the definition of each of the variables used in the research instrument to ensure that the research instrument accurately measured the theoretical constructs of the study.

3.9.2 Reliability of the Instruments

Reliability of the data collection instruments refers to the extent to which the results of a study are consistent over time or can be replicated (Zohrabi, 2013). Still another meaning of reliability is the stability of measurements made with a measurement tool over time (Cook & Beckman, 2006). The measurement of the internal consistency of the items that comprise the survey was performed using the Cronbach's alpha statistic.

The level of Cronbach's alpha that was required for this study was a minimum of 0.7, as illustrated in Table 3.4.

Table 3.4: Reliability Statistics Results

Variable	Number of Items	Cronbach's Alpha
Energy Monitoring Technologies	5	0.842
Energy Management Technologies	5	0.776
Energy-Efficient Technologies	5	0.789
Solar Energy Technologies	5	0.811
Managing Energy Costs	5	0.754

3.10 Data analysis

Alem (2020) explains that data analysis is the process of processing and organizing data in a meaningful way. The qualitative data collected from the questionnaires and the Key Informant Interview was analyzed using thematic analysis and presented in table form. The quantitative data that was obtained from the questionnaires was analyzed using descriptive and inferential statistics. The analysis of the data was performed using SPSS 24, a program that can produce both descriptive and inferential statistics. Descriptive statistics such as means, mode, median, percentages and frequencies were used to provide an overview of the data. The Pearson correlation and regression analyses were used to determine the relationship between the different variables in the study. The following multiple regression model was used to determine the coefficients of the independent variables in relation to the dependent variable:

$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \varepsilon$

Where;

$Y = Managing\ Energy\ Costs$

$X1 = Energy\ Monitoring\ Energies$

$X2 = Energy\ Management\ Energies$

$X3 = Energy - Efficient\ Energies$

$X4 = Solar\ Energy\ Technologies$

$\varepsilon = Error\ term$

$\beta 0 = the\ constant\ term$

$Bi\ (1{-}4) = Beta\ Coefficients$

3.11 Diagnostic Analysis

The study performed a series of diagnostic tests to determine if the assumptions of OLS regression had been met before performing the multiple linear regression analysis and testing the hypotheses. The normality of the data was tested to ensure that the data was normally distributed. Additionally, a test for multicollinearity was performed to ensure that the independent variables were independent of one another. Finally, another test was performed to determine if the variance of the residuals was constant across the values of the independent variables.

3.11.1 Normality Test

A normal distribution is symmetrical and has a kurtosis coefficient of 3 or lower. To test the assumption of normality for the data set, the Kolmogorov-Smirnov test will be used to assess the normality of the data. According to Demir (2022), the K-S test is one of the most common normality tests that is used due to the limitations of other normality tests and the ease with which it can be performed in SPSS.

A One-Sample Kolmogorov-Smirnov test will be used to assess the normality of the dependent variable. The Kolmogorov-Smirnov test is a non-parametric statistical test that determines whether a sample of observations is drawn from a specific theoretical distribution, such as a normal, uniform, Poisson or exponential distribution. The hypotheses to be tested are:

H_0: The data is normally distributed (i.e., it does not significantly differ from a normal distribution).

H_a: The data is not normally distributed (i.e., it significantly differs from a normal distribution).

If the p-value associated with the test statistic is greater than 0.05, the null hypothesis will not be rejected and the data will be deemed normally distributed. If the p-value associated with the test statistic is less than or equal to 0.05, the null hypothesis will be rejected and it will be stated that the data deviates from a normal distribution.

3.11.2 Multicollinearity Test

Multicollinearity exists when the independent variables have a high level of correlation with each other. Sileshi (2015) pointed out that if the level of correlation between the variables is too high, it creates problems in the regression model for determining the individual and relative contribution of the independent variables to the outcome. This is less of a concern in research where the goal is to provide predictive values for the dependent variable. However, if the research study intends to determine the effect of the independent variables on the dependent variable, multicollinearity is problematic. The multicollinearity was tested using the variance inflation factor (VIF). A VIF of 10 was used as an indicator of a severe multicollinearity problem. A VIF of less than 5 or a tolerance value of greater than 0.2 are acceptable ranges for multicollinearity to not be a problem in the research study.

3.11.3 Homoscedasticity Test

Homoscedasticity is a condition in which the variance of the error terms in a regression model is approximately equal across all values of the independent variables. Another way of stating this is that the variability of the dependent variable is roughly equal regardless of the values of the independent variables (Saleh & Rosli, 2024). A test for homoscedasticity helps to determine whether the residuals from a regression model have approximately equal variances. If the assumption of homoscedasticity is violated (i.e., if the variances of the residuals from a regression model changes with the independent variables), the condition is referred to as heteroscedasticity (or heteroskedasticity). A test for homoscedasticity was performed in this study to determine whether the assumption of homoscedasticity was met in the regression model.

Ho: The variance in the error term is constant (Homoscedasticity) Ha: The variance in the error term is not constant (Heteroscedasticity)

3.12 Hypothesis Testing

The study utilized multiple regression analysis to test the formulated hypotheses and determine the relationship between the technological innovations and the management of energy costs in the star-rated hotels in Nairobi City County. Multiple regression analysis is appropriate as it enables the examination of the effect of multiple

independent variables on a single dependent variable and establishes the extent to which each variable contributes to the outcome (Weisburd et al., 2021). In this study, the dependent variable was managing energy costs, while the independent variables included energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies. The regression model was used to assess the significance and strength of the relationship between these variables. The hypotheses were tested at a 5% level of significance ($\alpha = 0.05$). The decision rule was based on the p-value obtained from the regression analysis:

i. If p-value ≤ 0.05, the null hypothesis (H_0) was rejected
ii. If p-value > 0.05, the null hypothesis (H_0) was not rejected

This criterion was used to determine whether each independent variable had a statistically significant effect on managing energy costs.

Table 3.5: Hypothesis Summary Table

Objective	**Hypothesis**	**Decision Rule**
To analyze how energy monitoring technologies reduce energy costs in star-rated hotels	H01: Energy monitoring technologies have no significant effect on managing energy costs in star-rated hotels in Nairobi City County	Reject H01 if p-value ≤ 0.05
To assess the role of energy management technologies on energy cost savings	H02: Energy management technologies have no significant effect on managing energy costs in star-rated hotels in Nairobi City County	Reject H02 if p-value ≤ 0.05
To determine the role of energy-efficient technologies in managing energy costs	H03: Energy-efficient technologies have no significant effect on managing energy costs in star-rated hotels in Nairobi City County	Reject H03 if p-value ≤ 0.05
To evaluate the role of solar energy technologies in reducing energy costs	H04: Solar energy technologies have no significant effect on managing energy costs in star-rated hotels in Nairobi City County	Reject H04 if p-value ≤ 0.05

3.13 Ethical Consideration

Ethics are a fundamental basis for carrying out any research effectively and efficiently (Adeoye et al., 2024). First and foremost, Prior approval was obtained from the University and NACOSTI before initiating the research. Moreover, the management and employees in the various hotels were informed about the research with an introductory letter detailing the purpose of the study and their roles as well as how they were identified as participants. In addition, their consent was sought prior to the study (Leavy, 2022). Furthermore, the study participants were ensured that the gathered information will not be shared with any authority at any point in time and that they will be treated with the utmost confidentiality (Creswell & Creswell, 2022), and that all the information will be used for academic purposes only.

3.14 Chapter Summary

This chapter presented the research methodology employed to investigate the effect of technological innovations on managing energy costs in star-rated hotels in Nairobi City County, Kenya.

The study adopted a pragmatic research philosophy and a mixed methods research approach, combining quantitative and qualitative elements to provide a comprehensive understanding of the research problem. A convergent parallel mixed-methods design was used, with quantitative and qualitative data collected simultaneously and analyzed separately before integration.

The study was conducted in Nairobi City County, Kenya, selected due to its concentration of star-rated hotels and high energy costs. The target population comprised 640 employees (general managers, engineers, accountants, electricians, and maintenance staff) from all 54 star-rated hotels. A census approach was used for hotels, and the Yamane formula determined a sample of 246 individual respondents, distributed through stratified random sampling.

Data collection instruments included structured questionnaires administered to 210 technical respondents (engineers, electricians, and maintenance staff) and unstructured interview guides for 36 managerial respondents (general managers, accountants). A pilot study was conducted with 16 respondents from hotels outside

Nairobi to test instrument validity and reliability. Validity was ensured through face, content, and construct validity measures, while reliability was confirmed through Cronbach's alpha coefficients exceeding 0.7 for all variables.

Quantitative data was analyzed using descriptive statistics (percentages, means, standard deviations) and inferential statistics (Pearson correlation, simple and multiple regression, ANOVA) using SPSS 24. Qualitative data was analyzed thematically. Diagnostic tests confirmed that regression assumptions were met: normality (Kolmogorov-Smirnov, $p > 0.05$), multicollinearity (VIF < 10), and homoscedasticity (Breusch-Pagan, $p > 0.05$).

The multiple regression model used was:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where Y = Managing Energy Costs,
X_1 = Energy Monitoring Technologies,
X_2 = Energy Management Technologies,
X_3 = Energy-Efficient Technologies, and
X_4 = Solar Energy Technologies.

Hypotheses were tested at 5% significance level, with null hypotheses rejected if $p \leq 0.05$. Ethical considerations included obtaining university and NACOSTI approval, informed consent, confidentiality assurance, and use of data for academic purposes only.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of the research which are in line with the objectives of the study. The chapter reports the results in a sequential order starting with the response rate, followed by the demographic characteristics, descriptive statistics, and inferential statistic. The final section of the chapter covers the hypothesis testing. Additionally, the chapter includes a detailed discussion of the results.

4.2 Response Rate

The study targeted a total sample of 246 respondents drawn from the staff categories in star-rated hotels within Nairobi City County. Structured questionnaires were administered to 210 technical respondents comprising engineers, electricians, and maintenance staff, while unstructured interviews were conducted with 36 managerial respondents comprising general managers and accountants. Out of the 210 questionnaires distributed, 190 were successfully completed and returned, representing a 90.5% questionnaire response rate. Similarly, 30 out of the 36 targeted interview respondents were successfully interviewed, representing an 83.3% interview response rate. Overall, the study achieved 220 successful responses out of the targeted 246 respondents, resulting in an overall response rate of 89.4%, which was considered adequate for analysis. According to Mugenda (2012), a response rate above 70% is considered very good for research purposes. Table 4.1 presents the response rate summary.

Table 4.1: Research study response rate

Response Category	Targeted	Actual Response	Response Rate (%)
Questionnaires	210	190	90.5
Interviews	36	30	83.3
Total	246	220	89.4

4.3 Demographics Results

This subsection presents the demographic characteristics of the respondents, including their job position, years of experience, gender, hotel star rating. The demographic

analysis is based on the responses from 220 respondents, comprising 190 respondents who completed questionnaires and 30 who participated in interviews. These characteristics of the respondents are important to consider in that they help to provide context for the knowledge and involvement of each of these respondents in the energy management practices of the hotel chains in question. Table 4.2 summarizes the results of this demographic analysis.

Table 4.2: Demographics Results

Factor	Category	Frequency (f)	Percentage (%)
Position	General Manager	15	6.8
	Accountant	15	6.8
	Engineer	70	31.8
	Electrician	60	27.3
	Maintenance Staff	60	27.3
Gender	Male	128	58.2
	Female	92	41.8
Experience	1-5 Years	36	16.4
	6-10 Years	29	13.2
	11-15 Years	55	25.0
	16-20 Years	73	33.2
	Above 21 Years	27	12.3
Star Rating	2-Star	37	16.8
	3-Star	61	27.7
	4-Star	78	35.5
	5-Star	44	20.0

The position of the respondents indicates that engineers formed the largest proportion of the total number of individuals who responded to the questionnaire at 31.8%, followed by electricians and maintenance staff at 27.3% each. The remaining positions within the hotel industry, such as general managers and accountants, each represented 6.8% of the total number of respondents. Such a distribution of individuals according to their positions within the hotels is appropriate for this survey due to the fact that it ensures the representation of individuals from both the technical and management teams within the hotels. Furthermore, because technological innovations were included in the study, it was important to include those individuals who are typically assigned to the operational and maintenance departments. According to Salami et al.

(2024), ensuring that individuals from diverse departments are included in the study will increase the reliability of the study's conclusions.

In relation to gender, the majority of the individuals who responded to the questionnaire were male individuals, making up 58.2% of the total number of respondents. Females, while not the majority of those who responded to the questionnaire, accounted for 41.8% of the total number of individuals. The proportion of male individuals is likely due to the fact that the hotel industry is traditionally male-dominated, particularly in technical and maintenance positions (Yağmur, 2024). However, the inclusion of female individuals within management and accounting departments also indicates that the study was representative of the organization as a whole.

In relation to work experience within the hotel industry, it was found that the largest proportion of individuals who responded to the questionnaire had 16-20 years of experience in the industry (33.2%), followed by those with 11-15 years of experience (25.0%). Individuals with between 1-5 years of experience represented 16.4% of the total number of individuals, those with 6-10 years of experience represented 13.2%, and those with 21 or more years of experience accounted for 12.3% of the total number of individuals who responded. These percentages indicate that the majority of the individuals who responded to the questionnaire have significant experience within the hotel industry; over two-thirds of those who responded have worked within the industry for more than 10 years. Such experience within the hotel industry is important to include in the study as these individuals are likely to have gained an extensive knowledge of the hotel industry and its operations. According to Rouissi (2025), individuals with extensive experience within the hotel industry are likely to contribute insights into those operations that are credible and reliable.

The distribution of the individuals according to the number of stars that their hotels feature indicates that the majority of the hotels from which the individuals in the study were drawn were 4-star hotels (35.5%), followed by 3-star hotels (27.7%), 5-star hotels (20.0%), and 2-star hotels (16.8%). According to Chan, Okumus and Chan (2020), hotels of higher star ratings have higher requirements of their facilities, their services for the customers, and, consequently, their energy requirements. Furthermore,

these higher-rated hotels tend to to use more technological innovations as a means of reducing their energy costs. Therefore, the inclusion of individuals from 3-star and 4-star hotels in particular were beneficial in that they can contribute reliable insights regarding the impact of the technological innovations on energy use in hotels.

4.4 Descriptive Statistics

This section presents the findings of the descriptive statistics. Table data is presented for each of the elements under the study objectives followed by a detailed discussion of each data presentation.

4.4.1 Descriptive Statistics on Energy Monitoring Technologies

The first objective of the study was to analyze how energy monitoring technologies will reduce the costs that star-rated hotels in Nairobi City County spend on energy. The statements within the survey were rated on a five-point Likert scale (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree). The results are presented in Table 4.3

Table 4.3: Descriptive Statistics of Energy Monitoring Technologies

Statement	1	2	3	4	5	Mean	Std Dev
The hotel uses smart energy meters to monitor electricity consumption in real time	2%	5%	18%	45%	30%	3.96	0.98
The hotel uses IoT-based systems to track energy usage across departments	3%	7%	22%	42%	26%	3.81	1.02
Artificial intelligence is used to predict and optimize energy consumption	5%	10%	28%	35%	22%	3.59	1.08
Energy monitoring systems help identify areas of energy wastage	2%	4%	16%	48%	30%	4.00	0.95
Solar tracking systems improve the efficiency of solar energy utilization	4%	8%	26%	38%	24%	3.70	1.05
Average						3.81	1.02

The use of energy monitoring technologies in star-rated hotels receives generally good responses from the study's respondents with a mean score of 3.81 and a standard

deviation of 1.02. This shows that energy monitoring technologies play a significant role in energy management and cost reduction in hotels.

The use of smart energy meters (Mean = 3.96) and the use of systems to identify wastage of energy in hotels (Mean = 4.00) have the highest scores from the study participants. Such a score indicates that hotels have considered and implemented these technologies into their management of energy use in hotels. Studies by Abuimara et al. (2022) have also established that the use of these systems provides better control of energy use and results to a reduction of energy costs.

The use of Internet of Things (IoT) systems for energy management in hotels (Mean = 3.81) is also relatively high, however, the use of artificial intelligence to manage energy in hotels (Mean = 3.59) has a relatively low score. This could be due to the high costs of implementing these technologies in hotels.

The use of solar tracking systems for energy management in hotels (Mean = 3.70) is also relatively low in comparison to other technologies. However, studies by Falcone (2023) also indicate the slow adoption of such technologies, especially in developing economies.

The findings of this study indicate that energy management technologies play a significant role in the control and reduction of energy costs in hotels. However, the low score for the adoption of artificial intelligence in hotels indicates a room for improvement in the industry on the use of such technologies to further control energy costs.

4.4.2 Descriptive Statistics on Energy Management Technologies

The second objective of the study was to assess the role of energy management technologies on energy cost savings in star-rated hotels in Nairobi City County, Kenya. Respondents rated statements on energy management technologies using a five-point Likert scale (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree). The descriptive statistics of the responses are presented in Table 4.5.

Table 4.4: Descriptive Statistics of Energy Management Technologies

Statement	1	2	3	4	5	Mean	Std
Automated HVAC systems are used to regulate heating and cooling efficiently	2%	6%	20%	44%	28%	3.90	0.99
Smart thermostats are used to control temperature based on occupancy	3%	7%	24%	40%	26%	3.79	1.03
Automated lighting systems (e.g., motion sensors) are used to reduce energy consumption	2%	5%	18%	46%	29%	3.95	0.96
Energy scheduling systems are used for high-consumption equipment (laundry, kitchen)	3%	8%	26%	39%	24%	3.73	1.05
Energy management technologies have significantly reduced energy costs in the hotel	2%	6%	22%	45%	25%	3.85	1.00
Average						3.84	1.01

Table 4.4 presents the findings regarding the implementation of energy management technologies in star-rated hotels. The table illustrates that most hotels use energy management technologies, as evidenced by the high mean score of 3.84 (SD = 1.01). Moreover, the high score indicates that the majority of the hotel management team members believe that these technologies play a significant role in the reduction of energy costs of the hotels.

Automated lighting and HVAC control systems have the highest implementation mean scores of 3.95 and 3.90, respectively. Hotels have automated lighting systems to minimize the unnecessary use of energy in unoccupied hotels. Studies by Hossain (2023) show that automation of HVAC systems significantly reduces energy wastage.

Smart thermostats and energy scheduling technologies have a relatively lower mean score of 3.79 and 3.73, respectively. Hotels use these technologies to automate control

of HVAC systems based on the time of operation of the hotel. Still, the relatively lower score for these technologies indicates that hotels may still be in the process of fully integrating and optimizing these technologies into their operations.

Energy management technologies have significantly reduced the energy costs of the hotels, as indicated by a mean score of 3.85. This finding is supported by the results of Mendoza-Pitti (2021), who used similar survey instruments to calculate the mean scores for energy cost reduction by energy management technologies. The study's findings revealed that automated energy systems significantly enhance energy efficiency of hotels.

Energy management technologies significantly contribute to the reduction of energy costs of the hotels. However, the varying scores for each technology indicate that most hotels may require further investment and optimization of these technologies. Overall, hotels that invest in energy management automation technology can better control their energy usage and costs. However, if these technologies are not fully adopted and integrated throughout all departments of a hotel, their full potential cannot be maximized.

4.4.3 Descriptive Statistics on Energy-Efficient Technologies

The third objective of the study was to assess the role of energy-efficient technologies in the management of energy costs in star-rated hotels in Nairobi City County, Kenya. Respondents rated statements on energy-efficient technologies using a five-point Likert scale (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree). The results are presented in Table 4.5.

Table 4.5: Descriptive Statistics on Energy-Efficient Technologies

Statement	1	2	3	4	5	Mean	Std
The hotel uses energy-efficient appliances (e.g., kitchen, laundry)	3%	4%	11%	50%	32%	4.06	0.91
LED lighting is used to reduce electricity consumption	2%	5%	8%	45%	40%	4.18	0.94
The building design supports energy efficiency (insulation, ventilation)	3%	7%	13%	47%	30%	3.97	0.98
The hotel regularly upgrades to energy-efficient equipment	4%	6%	10%	45%	35%	4.05	0.99
Energy-efficient technologies have reduced operational costs	3%	5%	12%	46%	34%	4.05	0.95
Average						4.06	0.95

The descriptive statistics table above reveal that energy-efficient technologies are a critical component in the reduction of energy costs in star-rated hotels. The overall mean score of energy-efficient technologies scoring 4.06 with a standard deviation of 0.95 reveals that the majority of the respondents agreed with the impact of these technologies on the management of energy costs in hotel establishments.

The technology with the highest mean score is the use of LED lighting with a mean score of 4.18. Findings by Riffat, Ahmad, and Shakir, (2024) reveal that LED lighting is one of the most cost-effective energy-efficient solutions for hotels. The following technology with the second-highest mean score is the use of energy-efficient appliances in kitchens and laundry operations with a mean score of 4.06. Such energy-efficient appliances have also been found to be widely adopted by various star-rated hotels in response to the importance of energy efficiency. Beyond energy-efficient lighting and appliances, building designs that incorporate energy-efficient design features such as insulation and ventilation have a mean score of 3.97 indicating their contribution to energy efficiency. The implementation of energy-efficient technologies such as regularly upgrading the equipment in establishments to energy-efficient technologies scores an average of 4.05 indicating the replacement of old equipment with energy-efficient alternatives. Finally, energy-efficient technologies are also found to be effective at reducing the operating costs of the hotels with an average rating of 4.05. These results demonstrate that energy-efficient technologies are critical in

reducing energy consumption and costs for the hotels. In addition, the high mean scores for energy-efficient technologies in star-rated hotels reveal that there have been significant strides made towards the incorporation of energy-efficient technologies into hotels in the Nairobi City County area, in alignment with global trends within the hospitality industry (Engolan, Maina & Mapelu, 2025).

4.4.4 Descriptive Statistics on Solar Energy Technologies

The fourth objective of this study was to evaluate the role of solar energy technologies in the management of energy costs in star-rated hotels in Nairobi City County, Kenya. Respondents rated statements on solar energy technologies using a five-point Likert scale (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree). The results are presented in Table 4.6.

Table 4.6: Descriptive Statistics of Solar Energy Technologies

Statement	**1**	**2**	**3**	**4**	**5**	**Mean**	**Std**
The hotel has installed solar panels for electricity generation	6%	9%	18%	40%	27%	3.83	1.06
Solar systems are used for water heating	5%	8%	15%	42%	30%	3.89	1.04
Solar energy reduces reliance on grid electricity	4%	7%	18%	43%	28%	3.88	1.00
Solar technology has contributed to lowering energy costs	5%	6%	14%	45%	30%	3.94	0.98
The hotel plans to expand solar energy use in the future	3%	4%	12%	47%	34%	4.06	0.96
Average						3.92	1.00

The following table presents the descriptive statistics for each variable related to the use of solar energy technologies in star-rated hotels. The mean score for the survey of star-rated hotels was 3.92 with a standard deviation of 1.00 on each item. These mean scores indicate that, in general, most respondents believe that solar energy

technologies are playing a significant role in the management of energy costs of the hotels that they are associated with. The exception to this role is in relation to the statement that hotels have plans to expand their use of solar energy in the future, as hotels received a mean score of 4.06 for this item. Even though this score is high, it is not as high as the mean score of all other items, indicating that most hotels do not have such plans for the future. However, according to reports on the use of solar and other renewable energy sources in general, though, hotels do have an interest in reducing their energy costs over the long run (Obuseh et al., 2025).

Statements regarding the use of solar energy systems to heat water for the hotels (Mean = 3.89) or the reduction in reliance on grid electricity supply through the use of solar energy (Mean = 3.88) received high mean scores, indicating that hotels are utilizing these technologies to reduce their electricity consumption. These findings are in agreement with the findings of Odoi-Yorke et al.(2023), who indicated that the use of solar energy systems to heat the water that is used in hotels can lead to a reduction of the energy costs of those hotels. Additionally, another statement that received high support was that using solar energy technology has contributed to the lowering of energy costs of these hotels (Mean = 3.94). These findings support the results of studies by Dhirasasna and Sahin, (2021), who found that the adoption of solar energy within hotels can significantly reduce the energy costs of those star-rated accommodations.

Although solar technology adoption is relatively high, the use of solar panels for electricity generation (Mean = 3.83) received the lowest score compared to other solar technologies, suggesting that while solar is being adopted for water heating, the integration of solar electricity generation may still be in the early stages for many hotels. This may be attributed to the high initial capital costs of solar panel installation, as indicated by several respondents during the qualitative portion of the survey.

4.4.5 Descriptive Statistics on Managing Energy Costs

The general objective of the study was to assess how the implementation of energy management technologies, including energy-efficient technologies, energy monitoring systems, and solar energy solutions, influences the management of energy costs in star-rated hotels in Nairobi City County, Kenya. Respondents rated statements on

managing energy costs using a five-point Likert scale (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = Strongly Disagree). The results are presented in

Table 4.7: Descriptive Statistics on Managing Energy Costs

Statement	**1**	**2**	**3**	**4**	**5**	**Mean**	**Std**
The hotel has Experienced a reduction in energy costs over time	3%	5%	12%	48%	32%	4.04	0.94
Electricity expenses have decreased in recent years	4%	6%	10%	50%	30%	3.99	0.96
Energy cost per room has reduced	2%	4%	11%	49%	34%	4.11	0.91
The hotel monitors and controls energy expenses effectively	3%	7%	14%	43%	33%	4.06	0.98
Energy-saving strategies have improved financial performance	4%	5%	13%	47%	31%	4.04	0.94
Average						**4.05**	**0.94**

The descriptive statistics indicate that managing energy costs is a significant priority in star-rated hotels, with an overall mean score of 4.05 (SD = 0.94). This suggests that respondents generally agree that energy management practices have contributed to a reduction in energy costs. Among the individual items, the statement "Energy cost per room has reduced" (Mean = 4.11) recorded the highest score, indicating that many hotels have been successful in reducing energy costs on a per-room basis. These findings also highlight the importance of energy efficiency within the individual guest rooms within the hotel. The guest rooms are often one of the main focuses of hotel operations, and, therefore, are often the rooms that consume the most energy from the hotel. Findings regarding energy efficiency within these guest rooms were revealed by Salami et al. (2024) in their research, indicating that energy-efficient designs of these guest rooms can significantly lower the costs that a hotel experiences in relation to its energy consumption.

The following statement: “The hotel has experienced a reduction in energy costs over time” received a high average rating of 4.04 on a five-point Likert scale. These findings support the suggestions made by other researchers, such as Zhang, Zhao and Fu. (2022), who published research that indicated the impact that energy-saving technologies can have upon a hotel’s finances over time. Additionally, another statement that received high average support from the respondents was: “The hotel monitors and controls its energy expenses” with a mean value of 4.06. Relatedly, the statement “Energy-saving strategies have improved the financial performance of the hotel” also received high support with an average of 4.04.

However, the statement: “Electricity expenses have decreased in recent years” received an average rating of 3.99. While this value is still relatively high, it suggests that while many hotels have experienced a reduction in their electricity expenses, this saving is not experienced by all hotels.

4.5 Qualitative Analysis

This section presents the qualitative findings obtained from interviews with selected participants. The data were analyzed thematically to identify key themes and patterns related to energy cost management in star-rated hotels. The findings complement and explain the quantitative results.

Table 4.8: Summary of Qualitative Responses from the General Managers and the Accountants on Technological Innovations in Energy Management

Questions	Summary of the Main Themes from the Responses
What energy monitoring technologies are used in your hotel?	The majority of interviewees reported the use of smart meters, energy management systems, and IoT-based devices to monitor energy consumption. Some hotels also utilized automated systems for detecting energy wastage, which helps identify inefficient practices. A few respondents mentioned the adoption of artificial intelligence for predictive energy consumption.
How do these technologies help track energy usage?	Interviewees explained that these technologies allow for real-time tracking of energy consumption across various hotel departments. IoT systems were cited as particularly useful for monitoring energy usage in guest rooms, kitchens, and HVAC systems. Smart meters provide detailed consumption data, enabling hotels to pinpoint areas with high energy use and make adjustments. Several interviewees highlighted the role of dashboards that give immediate feedback to managers, making energy management more proactive.
How does the hotel control heating, cooling, and lighting?	The use of automated HVAC systems and motion sensor-based lighting was a common feature within hotels. Many hotels use smart thermostats that automatically adjust to the presence of guests in the rooms. Automated lighting systems are also installed in some hotels to ensure that the rooms are only lit up when necessary. Both of these automated systems significantly reduce the unnecessary consumption of energy by the hotels.
What role do automated systems play in energy management?	Automated systems were also recognized as crucial for energy efficiency in energy-intensive processes such as heating, cooling, and lighting. The automated systems can help to reduce the energy errors that may occur from the workers and ensure that the energy is utilized in an optimal manner. Additionally, the automated systems can help to identify when maintenance is needed for the processes to avoid any energy inefficiencies from the potential failure of the equipment. Finally, several interviewees also mentioned that the automated systems will reduce the labor costs for the facility.

What energy-efficient technologies has the hotel adopted?	The use of LED lighting, energy efficient HVAC systems and appliances in the kitchens and laundry facilities was cited as one of the main methods of reducing energy consumption. A few hotels have also implemented energy efficient windows and improved insulation within their building designs to increase their energy savings. Additionally, some hotels have cited the implementation of energy efficient water heaters and refrigeration systems, especially within the hotels that cater to heavy demands for these services.
How effective Have these technologies been?	Most of the respondents have noticed that energy-efficient technologies have been very effective in reducing the operational costs of the facilities. The electricity and operational costs of the facilities have notably decreased. However, the benefits of implementing energy-efficient technologies are only fully realized with regular maintenance of those technologies and upgrading them periodically to take advantage of the latest technological advancements.
Does the hotel use solar energy technologies?	Most interviewees confirmed the use of solar energy systems, primarily for water heating. A few hotels had started installing solar panels for electricity generation as part of their sustainability efforts. Solar energy was viewed as a viable alternative to grid electricity, especially in reducing peak energy demand and associated costs.
How have they impacted energy consumption?	The interviewees noted that there had been a noticeable impact of implementing solar energy systems in relation to the hotel's reliance upon grid electricity. The solar water heating systems were cited as providing cost savings to the hotel in the provision of hot water. In addition to cost savings, some of the interviewees mentioned that the incorporation of solar energy systems provided an improvement to the sustainability of the hotel, which helped to attract guests that were interested in such sustainability. A few, however, mentioned the challenges in scaling the implementation of solar electricity systems due to their high costs.

How have these technologies affected the hotel's energy costs?	All the interviewees mentioned that due to the various technological innovations that have been introduced into the hotel, including energy-efficient technologies and solar energy systems, the hotel has significantly reduced its energy costs. Most of the guests noted the reduction of electricity bills and operational expenses. The solar energy technologies used the most within the hotel were for heating the water, followed by the installation of energy-efficient appliances and lighting systems.
Which technologies have contributed most to cost reduction?	The use of solar energy systems for heating water and the use of energy-efficient lighting systems (LEDs) were found to be the leading methods of cost reduction for hotels. Additionally, the use of HVAC systems and energy management systems also had a significant impact on the cost of hotels. These systems were found to lead to cost savings for hotels, especially in cases of large hotels with high energy demands.
What challenges does the hotel face in adopting energy technologies?	The main challenges that were identified during the interview process related to the initial investment that would be required to implement such technology, such as solar panels and appliances that would use less energy. Other challenges included the lack of staff with the skills to operate and maintain those new technologies, the resistance to change that is often seen within an organization, and the complexities of integrating new technology with existing technology in the organization.
What factors influence decisions to invest in these technologies?	Decision-makers cited financial savings, long-term cost reduction, and environmental sustainability as key drivers behind investments in energy technologies. Several interviewees mentioned the importance of government incentives and rebates, which made the adoption of energy-efficient technologies more financially feasible. The increasing awareness of climate change and corporate social responsibility were also mentioned as influencing factors.
What improvements would you recommend for better energy cost management?	Interviewees suggested that hotels should focus on integrating energy management systems across all departments for better data accuracy and control. There was also a recommendation for regular staff training on energy-saving practices and the importance of energy-

	efficient technologies. Several respondents called for increased investment in renewable energy sources like solar panels and battery storage systems to further reduce reliance on the grid.

4.6 Correlation Analysis

To determine the relationship between the variables under investigation, Pearson Correlation Analysis was used. The Pearson correlation was utilized to determine the relationships between the variables under investigation, as presented in Table 4.9.

Table 4.9: Correlation Matrix

Variables	**Y**	**X1**	**X2**	**X3**	**X4**
Managing Costs (Y)	1				
Energy Monitoring Technologies (X1)	0.710**	1			
Energy Management Technologies (X2)	0.735**	0.726**	1		
Energy Efficient Technologies (X3)	0.662**	0.643**	0.658**	1	
Solar Energy Technologies (X4)	0.770**	0.684**	0.704**	0.711**	1
n	190	190	190	190	190
Key: Significance at 1%; Significance at 5%					

The results of the correlation between energy monitoring technologies and the management of energy costs exhibit a strong positive and significant correlation ($r = 0.710$, $p < 0.01$). The implementation of technologies like smart meters and internet of things (IoT) based technologies allow hotels to gain better control over their energy costs. Previous research by Tien et al. (2022) confirm the influence of energy monitoring on the reduction of energy costs within commercial buildings.

The results of the study also reveal that there is a strong and significant positive correlation between energy management technologies and the management of energy costs ($r = 0.735$, $p < 0.01$). Energy management technologies allow for hotels to automate many of the systems within the facility to reduce the costs of heating, cooling, lighting, and other energy based processes. The automation of these systems

was previously recognized by Tien et al. (2022) as a means of reducing energy wastage within commercial sectors.

The third technology to examine is the energy efficient technologies and their relationship to the management of energy costs. Energy efficient technologies exhibited a significant positive correlation with the management of energy costs ($r = 0.662$, $p < 0.01$). Technologies like energy efficient appliances, LED lighting, and energy efficient building designs can lead to considerable savings on the energy costs of the hotel. This relationship has been proven through previous research to be true, specifically by Cheekatamarla, Sharma and Shrestha, (2022), who published findings that energy efficient technologies can reduce the energy costs of commercial buildings.

The technology that exhibited the strongest and most significant relationship to the management of energy costs within hotels was the use of solar energy technologies ($r = 0.770$, $p < 0.01$). Technologies using solar power to heat water or generate electricity for the hotel can significantly reduce the energy costs of a property. Furthermore, as hotels increase the use of these technologies, their correlation to the management of energy costs increases as well. These findings support the results of previous research by Dhirasasna and Sahin (2021) into how the adoption of solar energy within hotels can significantly reduce energy expenses.

Finally, it should be noted that the independent variables also exhibit strong correlations with each other. For instance, energy monitoring technologies exhibited a significant positive correlation with energy management technologies ($r = 0.726$, $p < 0.01$) as well as energy efficient technologies ($r = 0.643$, $p < 0.01$). Thus, hotels that implement any form of energy management technology tend to also purchase other technologies to manage their energy costs. Thus, each of the four technologies has been proven through this research study to have a significant impact upon the ability of star-rated hotels to effectively manage their energy costs. Furthermore, the strongest positive correlation was between solar energy technologies and the management of energy costs. Thus, these findings indicate the importance of incorporating renewable energy technologies into the operation of hotels. These findings support the general

trend within the world today towards sustainability and energy efficiency in commercial sectors.

4.7 Diagnostic Analysis

Prior to the estimation of the Ordinary Least Squares (OLS) regression models, diagnostic tests were conducted to assess whether the assumptions of linear regression were met. These assumptions include linearity, multicollinearity, homoscedasticity, and normality. The results of these diagnostic tests are discussed in the subsections that follow.

4.7.1 Normality Test

In order to make inferences from this analysis, the assumption of normally distributed variables is made. To test for normality, both a Kolmogorov-Smirnov and Shapiro-Wilk normality test were performed. The hypotheses that were tested were:

H_0: The data is normally distributed (i.e., it does not significantly differ from a normal distribution).
H_a: The data is not normally distributed (i.e., it significantly differs from a normal distribution).
The results are presented in Table 4.10.

Table 4.10: Kolmogorov-Smirnov test of Normality

Variable	Kolmogorov-Smirnov Statistics	df	Sig.	Shapiro-Wilk Statistic	df	Sig.
Managing Energy Costs	0.207	130	0.074	0.975	130	0.072
Energy Monitoring Technologies	0.213	130	0.066	0.970	130	0.051
Energy Management Technologies	0.198	130	0.083	0.974	130	0.060
Energy-Efficient Technologies	0.222	130	0.058	0.969	130	0.039
Solar Energy Technologies	0.185	130	0.091	0.977	130	0.104
Key: Lilliefors Significance Correction Applied						

The results of the normality tests indicated that each of the variables had insignificant values for both the Shapiro-Wilk and the Kolmogorov-Smirnov tests ($p > 0.05$). Thus, the null hypothesis that the data was normally distributed could not be rejected.

Consequently, the variables were found to be normally distributed (Habibzadeh, 2024). Consequently, using techniques like Ordinary Least Squares (OLS) regression was deemed appropriate for the analysis of these variables.

4.7.2 Multicollinearity Test

The multicollinearity test was essential for determining whether the independent variables were highly correlated with each other. If the independent variables were found to be multicollinear, this would lead to misleading results in the study. The Variance Inflation Factor (VIF) was used to determine the presence of multicollinearity, with a VIF value of 10 or above indicating that the independent variables were multicollinear (Mahmood, 2024). The results of the multicollinearity test are presented in Table 4.11.

Table 4.11: Variance Inflation Factor Test of Multicollinearity

Variables	Collinearity	
	Tolerance	VIF
Energy Monitoring Technologies	0.124	8.064
Energy Management Technologies	0.135	7.413
Energy-Efficient Technologies	0.169	5.926
Solar Energy Technologies	0.211	4.737

The results in Table 16 indicate that there was no issue with multicollinearity, as all the independent variables had VIF values below the threshold of 10. Specifically, Energy Monitoring Technologies had a VIF value of 8.064, Energy Management Technologies had a VIF value of 7.413, Energy-Efficient Technologies had a VIF value of 5.926, and Solar Energy Technologies had a VIF value of 4.737. These results suggest that the independent variables are not highly correlated and that multicollinearity does not pose a problem for the regression analysis. Based on these findings, it was concluded that the data was suitable for running regression analysis, as there were no violations of the multicollinearity assumption.

4.7.3 Homoscedasticity Test

Homoscedasticity suggests that the dependent variable exhibits equal levels of variability for each value of the independent variables (Saleh & Rosli, 2024). To test for homoscedasticity, the study evaluated the variance of residuals in the regression model. A homoscedasticity test was conducted on the error term after running the regression model. If the error term exhibits equal variance across all levels of the independent variables, it suggests a normal distribution of residuals. When there is unequal variability of the residuals, the condition is referred to as heteroscedasticity. The Breusch-Pagan test developed by Breusch and Pagan (1979) was used to test for homogeneity in a linear regression model. According to the test, a probability value greater than 0.05 indicates that the homoscedasticity assumption holds, meaning no violations of the classical linear regression assumptions. The results of the test are presented in Table 4.12.

Table 4.12: Breusch-Pagan Test of Homoscedasticity

Breusch-Pagan/Cook-Weisberg Test for Homoscedasticity	**$Chi^2(3)$**	**$Prob>Chi^2$**
Ho: Constant Variance	0.314	0.800

The results in Table 4.18 indicate an insignificant p-value (greater than 0.05) at the 5% level of significance. This implies that the null hypothesis of constant variance is not rejected, as suggested by Breusch and Pagan (1979). Consequently, there is evidence of homogeneity in the error term, meaning that the assumption of constant variance (homoscedasticity) is satisfied. Therefore, it can be concluded that the assumption of homoscedasticity holds, and there are no violations of the classical linear regression assumptions.

4.8 Regression Analysis

To establish the effect of energy management technologies on managing energy costs in star-rated hotels in Nairobi City County, and to test the study hypotheses, both bivariate and multiple regression analyses were conducted. The criterion for evaluating the results was the significance of the beta coefficients. This section presents the regression findings, including the model summary, ANOVA, and model coefficients for each independent variable, as well as for the multiple regression model.

4.8.1 Effect of Energy Monitoring Technologies on Managing Energy Costs

The first objective of the study examined the effect of energy monitoring technologies on managing energy costs in star-rated hotels in Nairobi City County. To determine the magnitude and significance of the relationship between energy monitoring technologies and energy cost management, a simple regression model was established. The model summary, ANOVA, and model coefficients results are presented in Table 4.13.

Table 4.13: Regression Results for Energy Monitoring Technologies and Managing Energy Costs

Model Summary	**R**	**R Square**	**Adjusted R Square**	**Std.Error of the Estimate**	
	0.710	0.504	0.501	0.315	
ANOVA	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	18.962	1	18.962	191.032	0.000
Residual	18.661	188	0.099		
Total	37.623	189			
Model coefficients	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	1.238	0.245		5.056	0.000
Energy Monitoring Technologies	0.612	0.044	0.710	13.823	0.000
Dependent Variable: Managing Energy Costs					
Predictors: (Constant), Energy Monitoring Technologies					

The model summary indicates a strong positive relationship between energy monitoring technologies and managing energy costs (R = 0.710). The coefficient of determination (R Square = 0.504) depicts the extent to which energy monitoring technologies explain the cost of managing energy costs in the star-rated hotels in Nairobi City County. The high value of the coefficient of determination indicates that energy monitoring technologies have substantially contributed to the improved management of energy costs in the hotels in the area of study.

The value of the adjusted R Square of 0.501 demonstrates that the model remains strong even after adjusting for the sample size used in the study. The ANOVA table results exhibit that the model was statistically significant ($F = 191.032$, $p < 0.05$), indicating that the model exhibited a good fit within the data used to compute the results, implying that energy monitoring technologies have a significant effect on the management of energy costs in the star-rated hotels in the county.

The results of the regression coefficients demonstrate that the energy monitoring technologies used in the star-rated hotels in Nairobi City County have a positive and statistically significant effect on the management of energy costs in the hotels ($\beta = 0.612$, $p < 0.05$). The positive and statistically significant coefficient indicates that if there is a one-unit increase in the use of energy monitoring technologies within the star-rated hotels, there will be a 0.612-unit increase in the management of energy costs within those hotels. The improved use of technologies like smart metering and real-time monitoring of energy costs in these hotels will significantly reduce energy costs in these establishments.

Energy monitoring technologies within the star-rated hotels in Nairobi City County are, therefore, an essential technological innovation that can significantly reduce the costs of energy use within these hotels. The findings of this study are in line with those of Hossain et al. (2023), who also found that using technologies that enable the monitoring of energy use in real time significantly reduce the costs of energy use and improve the energy efficiency of the commercial buildings using these technologies. Based on these findings, the null hypothesis (H01) that posited no significant effect of implementing energy monitoring technologies on the management of energy costs in the star-rated hotels in Nairobi City County, Kenya, was rejected. Thus, it can be concluded from the findings of this study that energy monitoring technologies have a significant positive effect on the management of energy costs in the star-rated hotels in the area of study.

4.8.2 Effect of Energy Management Technologies on Managing Energy Costs

The second objective of the study was to establish the effect of energy management technologies on managing energy costs in star-rated hotels in Nairobi City County. To determine the magnitude and significance of the relationship between the variables, a univariate regression model was established. The model summary, ANOVA, and model coefficients results are presented in Table 4.14.

Table 4.14: Regression Results for Energy Management Technologies on Managing Energy Costs

Model Summary	**R**	**R Square**		**Adjusted R Square**	**Std.Error of the Estimate**
	0.735	0.540		0.537	0.292
ANOVA	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	20.321	1	20.321	220.88	0.000
Residual	17.302	188	0.092		
Total	37.623	189			
Model coefficients	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	1.052	0.198		5.313	0.000
Energy Management Technologies	0.568	0.038	0.735	14.947	0.000
Dependent Variable: Managing Energy Costs					
Predictors: (Constant), Energy Management Technologies					

The model summary shows a strong positive correlation (R = 0.735) between energy management technologies and managing energy costs. The coefficient of determination (R Square = 0.540) indicates that energy management technologies explained 54.0% of the variation in managing energy costs. This means that more than half of the changes in energy cost management among the surveyed hotels were associated with the implementation of energy management technologies such as automated HVAC systems, smart thermostats, occupancy sensors, and energy scheduling systems.

The adjusted R Square value of 0.537 shows the explanatory power of the model is still strong even after adjusting for the number of observations. The ANOVA results show that the regression model is statistically significant ($F = 220.88$, $p < 0.05$), indicating that the model is a good fit for the data. Hence, energy management technologies significantly predict the managing of energy costs.

The results of the regression coefficients indicate that energy management technologies had a positive and statistically significant effect on the managing of energy costs ($\beta = 0.568$, $p < 0.05$). The result implies that if there is a one-unit increase in the implementation of energy management technologies, there will be a 0.568-unit increase in the management of energy costs. Such results show that hotels that implement energy management technologies effectively manage their energy costs. They control energy consumption by automating processes such as heating, cooling, and lighting. Hence, they save energy and money on operational costs.

These findings demonstrate the importance of energy management technologies in the hotel industry as they significantly impact the management of energy costs. The outcomes of this study are in line with the findings of Hossain et al. (2023), who discovered that the implementation of energy management systems significantly reduces the consumption of energy and the operational costs of commercial establishments. Based on these findings, the null hypothesis (H02) that states that there is no significant effect of the implementation of energy management technologies on the management of energy costs in star-rated hotels in Nairobi City County, Kenya, is rejected. Thus, energy management technologies have a significant positive effect on the managing of energy costs in star-rated hotels in Nairobi City County, Kenya.

4.8.3 Effect of Energy-Efficient Technologies on Managing Energy Costs

The third objective of this study sought to determine the effect of energy-efficient technologies on the management of energy costs within the star-rated hotels in Nairobi City County. A univariate regression model was established to determine the significance of the relationship between these two variables. The results of the model summary, ANOVA table, and coefficients are displayed in Table 4.15.

Table 4.15: Regression Results for Energy-Efficient Technologies on Managing Energy Costs

Model Summary	**R**	**R Square**		**Adjusted R Square**	**Std.Error of the Estimate**
	0.662	0.438		0.435	0.335
ANOVA	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	16.479	1	16.479	146.558	0.000
Residual	21.144	188	0.112		
Total	37.623	189			
Model coefficients	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	1.482	0.211		7.027	0.000
Energy Management Technologies	0.442	0.036	0.662	12.106	0.000
Dependent Variable: Managing Energy Costs					

The relationship between energy-efficient technologies and the management of energy costs is demonstrated by the strong positive correlation value of R = 0.662. The coefficient of determination (R Square) of 0.438 indicates that 43.8% of the variation in the management of energy costs in hotels can be explained by the use of energy-efficient technologies such as LED lighting systems, energy-efficient appliances, improvements in insulation, occupancy sensors, and optimized building designs for energy efficiency.

The adjusted coefficient of determination (R Square) of 0.435 indicates that the model remained reliable even if the sample size was taken into account. The ANOVA analysis revealed that the regression model was statistically significant ($F = 146.558$, $p < 0.05$), indicating that the regression model was a good fit to the data collected from the hotels. This means that energy-efficient technologies were significantly associated with the management of energy costs in these hotels. This relationship indicates that the improvements in energy efficiency resulted in significant reductions in the energy costs of hotels.

The results of the regression coefficients indicate that energy-efficient technologies had a positive and statistically significant effect on the management of energy costs in hotels ($\beta = 0.442$, $p < 0.05$). This indicates that an increase of one unit in the implementation of energy-efficient technologies in hotels results in a 0.442 unit increase in the management of energy costs. This effect means that hotels that implement energy-efficient technologies such as efficient lighting systems, appliances, insulation systems, and operational designs experience a reduction in the energy they consume.

Although energy-efficient technologies have a relatively lower explanatory power compared to energy monitoring and energy management technologies, their impact on hotel energy costs is still major. These technologies directly impact the energy costs of hotels by reducing the amount of energy that gets wasted during energy consumption at the point of use by the facilities.

The findings are consistent with Obuseh et al. (2025), who found that energy-efficient technologies significantly reduce operational energy costs in commercial facilities by lowering consumption intensity and improving system performance. Therefore, the null hypothesis (H03), which stated that adopting energy-efficient technologies has no significant effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya, was rejected. The study concludes that energy-efficient technologies have a significant positive effect on managing energy costs in star-rated hotels.

4.8.4 Effect of Solar Energy Technologies on Managing Energy Costs

The fourth objective of the study was to establish the effect of solar energy technologies on managing energy costs in star-rated hotels in Nairobi City County. To determine the magnitude and significance of the relationship between the variables, a univariate regression model was established. The model summary, ANOVA, and model coefficients results are presented in Table 4.22.

Table 4.16: Regression Results for Effect of Solar Energy Technologies on Managing Energy Costs

Model Summary	**R**	**R Square**		**Adjusted R Square**	**Std.Error of the Estimate**
	0.770	0.592		0.590	0.286
ANOVA	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	22.273	1	22.273	272.597	0.000
Residual	15.350	188	0.082		
Total	37.623	189			
Model coefficients	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	1.362	0.178		7.651	0.000
Solar Energy Technologies	0.588	0.035	0.770	16.551	0.000
Dependent Variable: Managing Energy Costs					
Predictors: (Constant), Solar Energy Technologies					

The model summary indicates a very strong positive relationship between solar energy technologies and managing energy costs (R = 0.770). The coefficient of determination (R Square = 0.592) shows that solar energy technologies explained 59.2% of the variation in managing energy costs. This suggests that the adoption of solar technologies such as solar photovoltaic systems, solar water heating systems, and solar-powered auxiliary systems substantially contributed to improved energy cost management in the surveyed hotels.

The adjusted R Square value of 0.590 indicates that the model remained highly reliable even after adjusting for the sample size. The ANOVA table demonstrates that the regression model is statistically significant ($F = 272.597$, $p < 0.05$). This implies that the model fits the data very strongly and that solar energy technologies are a significant predictor of the management of energy costs in hotels. Thus, the investment in solar energy technology has played a major role in the reduction of energy expenses incurred by the hotels.

The regression coefficient results show that solar energy technologies had a positive and statistically significant effect on managing energy costs ($\beta = 0.588$, $p < 0.05$). This implies that a one-unit increase in the adoption of solar energy technologies resulted in a 0.588-unit improvement in managing energy costs. In practical terms, hotels that increasingly adopted solar technologies were more likely to reduce dependence on conventional grid electricity, lower fuel or electricity bills, and improve long-term energy cost savings through renewable energy generation.

Compared to energy monitoring technologies, energy management technologies, and energy-efficient technologies, solar energy technologies demonstrated the highest explanatory power (59.2%), suggesting that renewable energy adoption may offer the greatest direct financial impact on hotel energy cost reduction. This may be because solar technologies not only improve efficiency but also directly substitute expensive external energy sources, especially in energy-intensive hotel operations such as water heating, lighting, and supplementary power supply.

These findings are consistent with Odoi-Yorke et al. (2023), who found that solar energy technologies significantly reduce electricity costs and improve operational sustainability in hospitality establishments by lowering dependence on conventional energy systems. Therefore, the null hypothesis (H04), which stated that adopting solar energy technologies has no significant effect on reducing energy costs in star-rated hotels in Nairobi City County, Kenya, was rejected. The study concludes that solar energy technologies have a significant positive effect on managing energy costs and represent one of the most impactful technological innovations for energy cost reduction in star-rated hotels.

4.8.5 Multiple Regression

To test the hypotheses and assess the combined effect of multiple energy management technologies on managing energy costs, a multiple regression analysis was conducted. The null hypothesis was rejected if the significance value was less than 0.05 at the 5% level of significance. Conversely, a significance value greater than 0.05 led to failure to reject the null hypothesis. The overall multiple regression model adopted to test the study hypothesis was presented as:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \epsilon$$

Where:

$Y = Managing\ Energy\ Costs$

$X1 = Energy\ Monitoring\ Technologies$

$X2 = Energy\ Management\ Technologies$

$X3 = Energy\ Efficient\ Technologies$

$X4 = Solar\ Energy\ Technologies$

$\epsilon = Error\ Terms$

$\beta 0 = Constant\ Term,$

$\beta 1, \beta 2, \beta 3, \beta 4 = Beta\ Coefficients$

The model summary, ANOVA, and model coefficients results are presented in Table 4.23.

Table 4.17: Multiple Regression Results

Model Summary	**R**	**R Square**		**Adjusted R Square**	**Std. Error of the Estimate**
1	0.845	0.714		0.708	0.241
ANOVA	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig**
Regression	26.863	4	6.716	115.58	0.000
Residual	10.760	185	0.058		
Total	37.623	189			
Model Coefficients	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
(Constant)	0.324	0.071		4.536	0.000
Energy Monitoring Technologies	0.282	0.055	0.289	5.130	0.000
Energy Management Technologies	0.267	0.057	0.242	4.649	0.000
Energy-Efficient Technologies	0.196	0.063	0.206	3.107	0.000
Solar Energy Technologies	0.324	0.061	0.348	5.309	0.000
Dependent Variable: Managing Energy Costs Predictors: (Constant), Energy Monitoring Technologies , Energy Management Technologies, Energy-Efficient Technologies, Solar Energy Technologies					

The multiple regression analysis examined the combined effect of energy monitoring technologies, energy management technologies, energy-efficient technologies, and solar energy technologies on managing energy costs in star-rated hotels in Nairobi City County. The model summary indicates a strong positive relationship between the combined technological innovations and managing energy costs (R = 0.845). The coefficient of determination (R Square = 0.714) shows that the four technological innovation variables jointly explained 71.4% of the variation in managing energy

costs. This also implies that the use of these technologies has had a major influence upon the management of energy costs for these hotels. Furthermore, the adjusted R Square value of 0.708 demonstrates the reliability of the model after adjusting for the number of predictors. The ANOVA test results indicate that the model was statistically significant ($F = 115.48$, $p < 0.05$), indicating that the model is a good fit for the management of energy costs within star-rated hotels. These findings indicate that the technological innovations had a major influence upon the ability of those hotels to manage their energy costs.

Moreover, the regression coefficients indicate that all of the variables had positive and statistically significant effects upon the management of energy costs within the hotels. More specifically, the use of energy monitoring technologies ($\beta = 0.289$, $p < 0.05$) had a statistically significant effect upon improving the management of energy costs. Additionally, the use of energy management technologies ($\beta = 0.242$, $p < 0.05$) also had a statistically significant positive effect upon energy cost management. Furthermore, energy-efficient technologies ($\beta = 0.206$, $p < 0.05$) also had a statistically significant positive effect upon energy cost management. Finally, the implementation of solar energy technologies ($\beta = 0.348$, $p < 0.05$) had the strongest effect upon managing energy costs within these hotels.

These findings indicate that each of these technological innovations had some effect upon energy cost management for the hotels; however, the implications of their combined use is even stronger. As such, these findings suggest that the adoption of solar energy technologies is the most influential factor in managing energy costs for star-rated hotels, followed by energy monitoring technologies, energy management technologies, and energy-efficient technologies. Thus, these findings help to indicate the importance of the use of a variety of these technologies within hotels to manage their energy costs effectively. Overall, these findings help to confirm that the use of various technological innovations helps to reduce energy costs and enhances the management of these costs within the hotels being assessed.

4.9 Hypothesis Testing

This section presents the results of hypothesis testing conducted to determine the significance of the relationships between the study variables. The hypotheses were

tested using appropriate statistical techniques, with decisions based on the established significance level.

Table 4.18: Summary of Hypothesis Testing

Hypothesis	Criteria and Method	P-Value	Reference Table	Conclusion
H01:Energy monitoring technologies have no statistically significant effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya.	Simple linear regression model. Reject H_0 if p-value < 0.05 or t-statistic > 1.96.	0.000	Table 4.18	Null hypothesis rejected
H02: Energy management technologies have no statistically significant effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya.	Simple linear regression model. Reject H_0 if p-value < 0.05 or t-statistic > 1.96.	0.000	Table 4.19	Null hypothesis rejected
H03:Energy-efficient technologies have no statistically significant effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya.	Simple linear regression model. Reject H_0 if p-value < 0.05 or t-statistic > 1.96.	0.000	Table 4.20	Null hypothesis rejected

H04: Solar energy technologies have no statistically significant effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya.	Simple linear regression model. Reject H_0 if p-value < 0.05 or t-statistic > 1.96.	0.000	Table 4.21	Null hypothesis rejected

4.10 Chapter Summary

This chapter presented the analysis, results, interpretation, and discussion of findings from the study on the effect of technological innovations on managing energy costs in star-rated hotels in Nairobi City County, Kenya.

The study achieved a high response rate of 89.4% (220 out of 246 respondents). The demographic profile showed that engineers (31.8%) formed the largest respondent group, males (58.2%) were the majority, most respondents had 16-20 years of experience (33.2%), and 4-star hotels (35.5%) contributed the highest number of responses.

Descriptive statistics revealed that all four technology categories had positive effects on managing energy costs. Energy monitoring technologies had a mean score of 3.81 (SD = 1.02), energy management technologies had a mean of 3.84 (SD = 1.01), energy-efficient technologies had the highest mean of 4.06 (SD = 0.95), and solar energy technologies had a mean of 3.92 (SD = 1.00). LED lighting had the highest adoption rate (82.6%), while solar electricity generation had the lowest (39.5%).

Qualitative analysis from 30 interviews with general managers and accountants revealed that while respondents acknowledged the benefits of energy technologies, challenges including high initial costs, lack of technical skills, and integration difficulties hindered adoption, particularly in lower-star hotels. Smart meters, automated HVAC, LED lighting, and solar water heating were identified as the most effective technologies.

Correlation analysis showed significant positive relationships between all independent variables and managing energy costs. Solar energy technologies had the strongest correlation ($r = 0.770$, $p < 0.01$), followed by energy management ($r = 0.735$), energy monitoring ($r = 0.710$), and energy-efficient technologies ($r = 0.662$).

Diagnostic tests confirmed that regression assumptions were met: normality (Kolmogorov-Smirnov, $p > 0.05$), multicollinearity (VIF < 10, ranging from 4.737 to 8.064), and homoscedasticity (Breusch-Pagan, $p = 0.800$).

Simple regression analysis revealed that all four technologies significantly affected managing energy costs ($p < 0.01$). Energy monitoring ($\beta = 0.612$, $R^2 = 0.504$), energy management ($\beta = 0.568$, $R^2 = 0.540$), energy-efficient ($\beta = 0.442$, $R^2 = 0.438$), and solar energy technologies ($\beta = 0.588$, $R^2 = 0.592$).

Multiple regression analysis showed the combined effect of all four technologies explained 71.4% of the variance in managing energy costs ($R^2 = 0.714$, $F = 115.58$, $p < 0.01$). Solar energy technologies had the strongest effect ($\beta = 0.348$), followed by energy monitoring ($\beta = 0.289$), energy management ($\beta = 0.242$), and energy-efficient technologies ($\beta = 0.206$).

Hypothesis testing confirmed that all four null hypotheses were rejected at $p < 0.01$, concluding that energy monitoring, energy management, energy-efficient, and solar energy technologies each have a significant positive effect on managing energy costs in star-rated hotels in Nairobi City County, Kenya.

CHAPTER FIVE
CONCLUSION, RECOMMENDATIONS AND FUTURE WORK

5.1 Conclusion

The following are the conclusions that can be drawn from the results that were outlined above for each of the objectives. The level of significance for all of the hypotheses statements is 0.05.

5.1.1 Objective 1: Energy Monitoring Technologies

The results of the study indicate that the implementation of energy monitoring technologies can play an important role in the management of energy costs for star-rated hotels ($\beta = 0.612$, $p < 0.01$). Hotels that adopted IoT monitoring and smart meters were able to identify energy anomalies early and quickly rectify them, resulting in cost savings. But the adoption rate differs according to star rating. Innovators/early adopters (five- and four-star hotels) have adopted sophisticated monitoring techniques, whereas laggards (two- and three-star hotels) still use simple manual processes. It is in line with the Diffusion of Innovation (DOI) theory. The main deterrent for further adoption, especially for lower-star hotels, is the initial cost. Hence, H01 was rejected.

5.1.2 Objective 2: Energy Management Technologies

This study shows the adoption of energy management technologies has a positive effect on managing energy costs in star-rated hotels ($\beta = 0.568$, $p < 0.01$). Automated HVAC control, occupancy sensors and building energy management systems led to reduced energy costs per room occupied. Automation eliminates errors and optimizes energy use, especially in high-energy-consuming processes. But the use of advanced technologies such as digital thermostats connected to a database is low, and mostly in higher-star hotels. This is consistent with the Resource-Based View (RBV) as energy management technologies are valuable, rare and potentially inimitable resources that create competitive advantage by reducing costs. Hence, H02 was rejected.

5.1.3 Objective 3: Energy-Efficient Technologies

The study found that the adoption of energy-efficient technologies has a positive effect on energy cost management in star-rated hotels ($\beta = 0.442$, $p < 0.01$). Hotels with

greater LED lighting, efficient heating, ventilation and air-conditioning, and building insulation have lower energy costs per occupied room and per square meter. Adoption rates are not uniform: low-cost, high-return technologies (LED lighting, 82.6%) are adopted but capital-intensive technologies (heat recovery, double glazing) are less adopted. This finding confirms the DOI theory, where five-star and Four-star hotels are the innovators and Two-star hotels are the laggards. From an RBV, energy-efficient technologies are valuable resources for strategic advantage. So the null hypothesis H03 was rejected.

5.1.4 Objective 4: Solar Energy Technologies

The study found that the use of solar energy technologies significantly reduces energy costs ($\beta = 0.588$, $p < 0.01$) in star-rated hotels. Solar energy technologies were most effective ($\beta = 0.348$) and had the highest explanatory power ($R^2 = 0.592$) among the four technologies. But adoption levels are low (39.5% for electricity) and there is a large gap between recognition of benefits and action. Five and four star hotels have been the first to adopt, but two and three star hotels have not adopted solar technologies due to high upfront capital cost (80.0% agree), insufficient roof space and lack of financial support. Solar technologies are valuable and potentially inimitable resources from an RBV standpoint, but only hotels with adequate financial conditions can obtain this resource. Thus, H04 was rejected.

5.2 Recommendations

This section presents recommendations based on the study findings and conclusions. The recommendations are intended to guide stakeholders in improving energy cost management and promoting the adoption of sustainable energy technologies in star-rated hotels.

5.2.1 Recommendations to Hotel Practitioners

Hotel practitioners ought to shift their awareness to systematic implementation of energy technologies, both in the short-term and long-term strategic investments. To begin with, hotels, particularly two- and three-star hotels, should implement cost-effective energy monitoring, including smart meters and simple IoT systems. Such tools can help identify energy inefficiencies early and give data in real-time to make decisions on how to eliminate unnecessary energy loss.

Second, hotel managers ought to gradually invest in automated energy management systems such as occupancy sensors and HVAC control systems. In cases where full automation is not financially viable, a step-by-step approach to implementation must be established, beginning with high impact areas like the guest rooms and common areas.

Third, hotel practitioners need to focus on low-cost and high-payoff energy-saving technologies including LED lighting, efficient HVAC systems, and insulation. With more capital intensive technologies (e.g. heat recovery systems) then hotels should take a long-term investment approach, incorporating them into renovation and upgrading plans.

Fourth, hotel owners ought to consider the collective or innovative financing models (e.g., partnerships, leasing arrangements, or energy service companies) to overcome the high initial costs of solar energy technologies. Considering the high cost-cutting effect of solar, hotels must consider it as a strategic investment and not optional upgrade.

Lastly, hotel managers ought to create internal capacity and awareness through training of hotel staff on the energy-saving measures and to integrate energy management in the day to day operations of the hotel. This will make sure that the technological investments are put to good use and maintained through time.

5.2.2 Recommendations to policymakers

Policymakers are key to solving structural and financial limitations that restrict the use of energy technologies in the hospitality industry. First, governments ought to initiate financial incentives like tax rebates, subsidies or low interest green financing schemes to reduce the high initial costs of implementing energy monitoring, management and solar technologies, especially on small and medium scale hotels.

Second, policymakers ought to formulate and implement sector-specific energy efficiency standards and regulations on hotels. These standards have the potential to

promote the minimum levels of adoption of energy-saving technologies and to create a level playing field among the various categories of hotels.

Third, it is necessary to create public-private partnerships (PPPs) that can promote investment in the renewable energy infrastructure, particularly, solar energy systems. These partnerships may assist hotels to surmount financial and technical limitations. Fourth, governments are encouraged to invest in capacity-building programs and technical support, and move towards hotel operators, particularly in lower-star categories, to make them more well-informed about available technologies and their economic advantages.

Fifth, policymakers must encourage development of new financing schemes like pay-as-you-save models or green credit facilities so that advanced technologies can be more affordable to financially constrained hotels.

Finally, national and local governments are to facilitate the campaign of awareness and demonstration project to close the gap between the awareness of the benefits and actual implementation of energy technologies.

5.3 Future Work

Based on the results and some constraints of this research, the following suggestions are proposed concerning the areas of future research:

Longitudinal study. A longitudinal study that would monitor the costs of energy over a 3-5 years period since the technology is adopted would cause the causation and gauge the cost saving over time much more accurately than a cross-section study.

Comparative cross-county study. Duplicate this study in Mombasa (coastal climate), Kisumu (lake region), Nakuru and other counties in Kenya to determine regional differences in adoption, energy tariffs, climate impacts on HVAC demand and cost performance.

Cost-benefit analysis. Carry out extensive cost-benefit studies of each category of technology (LED lighting, HVAC upgrades, solar PV, solar thermal, BEMS, building

insulation) including calculations of payback periods, ROI, net present value, and internal rate of return.

Environmental impact study. Monitor carbon footprint, greenhouse gas emissions (tCO2e) and other environmental sustainability outcomes that emanate as a result of energy technology implementation in hotels.

Study of technical skills gap. Research the technical skills and training necessary to implement IoT-based monitoring, BEMS programming, AI-based energy analytics, and solar system maintenance to guide more specific capacity-building programs.

Guest perception study. Investigate the perception of the guests of environmentally friendly hotels with energy efficiency and solar power and determine whether green certifications impact on the booking and the desire to pay higher prices.

Policy effectiveness study. Test the effectiveness of current government policies (tax incentives, energy regulations, and building codes) with regard to the adoption rates and energy cost performance in the hospitality industry.

Change management study. Examine organizational and behavioral drivers that support or inhibit effective technology implementation in hotels, such as resistance to change, leadership support, and staff engagement strategies.

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APPENDICES

Appendix 1: Interview Guide for Hotel General Managers and Accountants

I am Mercy Amathe Engolan, a Murang'a University post-graduate student studying for a Master's in Hospitality and Tourism Management. Am working on a research entitled "The Effect of Technological Innovations in Managing Energy Costs in Star-Rated Hotels in Nairobi City County, Kenya." I kindly request you to respond to the few questions on technological innovations and Managing Energy costs. The data obtained will be treated with the highest level of confidentiality and will be used for academic purpose only.

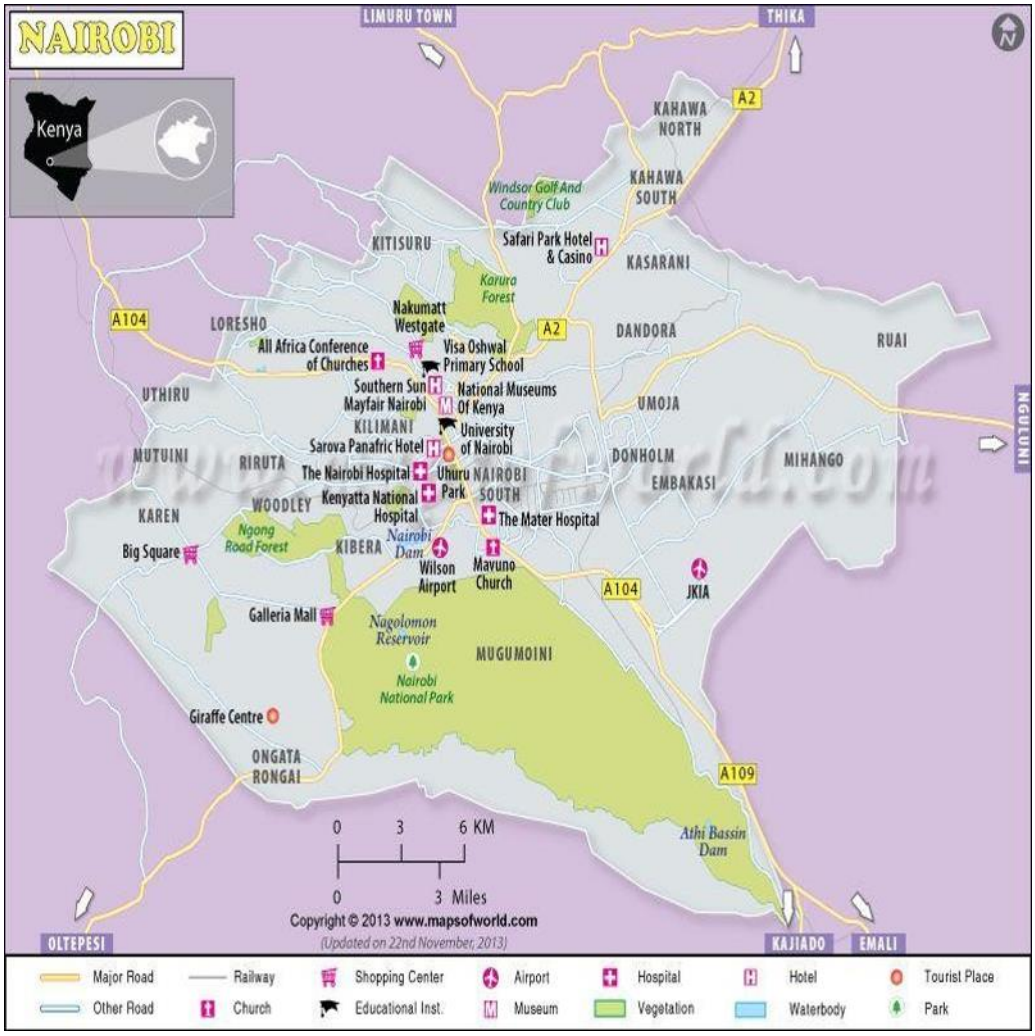
Name of the hotel…….. Gender: M/F……

Date:……..... Time: From……to……

1. Can you describe the technological innovations your hotel uses to monitor energy consumption?
2. How does your hotel use energy consumption data generated from the systems
3. How effective do you think these technologies are in improving energy management?
4. What automated systems does your hotel use to reduce energy consumption?
5. Which automated technologies have contributed most to energy savings?
6. What operational changes have resulted from adopting these technologies?
7. How significant are energy costs in your hotel's operational expenses?
8. In what ways have technological innovations affected your energy costs?
9. What challenges does your hotel face in managing energy costs despite adopting the technologies
10. What technologies could further improve energy efficiency and reduce energy costs?
11. Is there anything else you would like to add regarding energy technologies and managing energy costs?

Thank you for your time and valuable insights. Your participation is greatly appreciated.

Appendix 2: Map of the Study Area



Appendix 3: Research Questionnaire

I am a master's student of Hospitality and Tourism conducting a study on "The role of technological innovations in managing energy costs in star-rated hotels in Nairobi City County, Kenya" to complete my master's thesis. This study aims to gather insights into how technological innovations are influencing energy management and energy cost reduction in star-rated hotels

You are kindly requested to respond to the following statements. Your responses are important as this survey is part of the master research study. I therefore value your cooperation very highly. Your responses will be treated with the utmost confidentiality and only be used for research purposes.

Thank you in advance for your kind cooperation

Part One: Background Information

1. **What is your age range?**

   ☐ 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56+

2. What is your gender?

   ☐ Male ☐ Female ☐ Other ☐ Prefer not to say

3. What is your highest level of education?

   ☐ High School ☐ Diploma ☐ Undergraduate Degree ☐ Postgraduate Degree

4. How long have you worked in the hotel industry?

   ☐ Less than 1 year ☐ 1-5 years ☐ 6-10 years ☐ 11-15 years ☐ 16+ years

5. How would you describe the star rating of your hotel?

   ☐ 2-Star Hotel ☐ 3-Star Hotel ☐ 4-Star Hotel ☐ 5-Star Hotel

6. How would you describe the size of your hotel?

   ☐ Small (1-50 rooms) ☐ Medium (51-150 rooms) ☐ Large (151-300 rooms)

   ☐ Very large (300+ rooms)

7. How many years has your hotel been in operation?

   ☐ Less than 1 year ☐ 1-5 years ☐ 6-10 years

   ☐ 11+ years

Part Two: Technological Innovations

This part focuses on technological innovations and contains four sections

Section One: Energy Monitoring Technologies

Rate your level of agreement with the items of energy monitoring technologies on a five-point scale where ***"1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree".***

Questionnaire Items	**1**	**2**	**3**	**4**	**5**
Artificial intelligence improves the accuracy of hotel energy consumption monitoring.					
Our hotel monitors energy consumption through meter readings					
AI systems help identify unusual or excessive energy consumption patterns in hotel operations.					
IoT devices enable real-time monitoring of energy usage across hotel facilities.					
Smart meters help identify high-energy consumption areas within hotels.					
Energy analytics systems support the identification of opportunities for reducing energy costs.					
Integrating AI, IoT, and smart metering improves the effectiveness of our hotel energy monitoring.					
Digital energy monitoring technologies improve energy management decision-making in our hotel.					

Section Two: Energy Management Technologies

Rate your level of agreement with the items of energy management technologies on a five-point scale where ***"1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree".***

Statements	**1**	**2**	**3**	**4**	**5**
Occupancy sensors in HVAC systems reduce energy use in unoccupied guest rooms.					

Programmable thermostats help reduce unnecessary heating and cooling energy consumption.					
Motion sensor lighting reduces electricity use in corridors and common areas.					
Key-card-controlled room lighting helps prevent energy wastage in guest rooms.					
BEMS dashboards help optimize energy use through automated control of building systems.					
BEMS automated scheduling reduces energy consumption during low occupancy periods.					
Automated kitchen equipment with energy-saving modes reduces electricity consumption.					
Timers installed on kitchen appliances help control unnecessary energy use.					
Programmable laundry machines help reduce electricity consumption.					
Load-sensing laundry dryers help optimize energy use during drying operations.					

Section Two: Energy Efficient Technologies

Rate your level of agreement with the items of energy efficient technologies on a five-point scale where ***"1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree".***

Questionnaire Items	**1**	**2**	**3**	**4**	**5**
Heating, ventilation, and air-conditioning systems are properly maintained and optimized for energy efficiency.					
High-efficiency boilers, heat pumps, and chillers are installed to reduce energy consumption.					
Insulated building materials help reduce heating and cooling energy use.					
Retrofitting older structures with energy-efficient measures has improved overall energy performance.					
LED lighting is used to reduce electricity consumption.					

Energy-saving film on glass windows improves energy efficiency in space heating and cooling					

Section Three: Solar Energy Technologies

Rate your level of agreement with the items of solar energy technologies on a five-point scale where ***"1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree".***

Questionnaire Items	**1**	**2**	**3**	**4**	**5**
Our hotel has integrated solar technologies to reduce energy costs.					
Solar energy contributes significantly to lowering our electricity bills.					
The use of photovoltaic systems in the hotel has reduced electricity costs.					
Solar panels help to lower the hotel's dependence on grid electricity.					
Solar thermal systems have reduced the cost of water heating in the hotel.					
The hotel saves energy costs through the use of solar-powered water heating systems.					
Hybrid solar systems (PV/T) improve overall energy cost efficiency in the hotel.					
The integration of solar technologies has reduced the hotel's overall energy expenses.					
Solar cooling systems help to lower air conditioning costs in the hotel.					
The adoption of solar technologies has reduced peak electricity demand charges in the hotel.					
Solar energy systems provide long-term financial savings despite initial installation costs.					
Solar technology systems operate reliably and reduce reliance on conventional energy sources.					

Management encourages the use of solar technologies to optimize energy expenditure.					

Part Three: Managing Energy Costs in Star-Rated Hotels

This section focuses on managing energy costs

Rate your level of agreement with the items of managing energy costs on a five-point scale where ***"1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree".***

Questionnaire Items	**1**	**2**	**3**	**4**	**5**
The hotel has experienced a reduction in annual energy costs.					
Electricity expenses in the hotel have decreased over time.					
Fuel costs for hotel operations have reduced.					
Monthly energy bills have declined in the hotel.					
The energy cost per occupied room has decreased.					
The energy cost per available room has reduced.					
The energy cost per guest has decreased.					
The energy cost per square meter of hotel space has reduced.					
The hotel has achieved measurable energy cost savings over time.					
The trend in energy costs over the last five years shows a decline.					
There is minimal variance between budgeted and actual energy costs.					
Energy costs are a significant portion of our hotel's operating expenses.					

Thank you for your participation!

Appendix 4: List of Star-rated Hotels in Nairobi City County Kenya.

5-Star hotels	
No	Hotel Establishment
1.	Crowne Plaza Nairobi Airport
2.	Dusit D2
3.	Fairmont The Norfolk
4.	Hemingway's Nairobi
5.	Intercontinental Nairobi
6.	Radisson Blu Hotel Nairobi
7.	Sankara Nairobi
8.	The Boma Nairobi
9.	The Sarova Stanley
10.	Tribe Hotel
11.	Villa Rosa Kempinski
4-Star Rated Hotels	
No.	Hotel Establishment
1.	Carnivore Restaurant
2.	City Lodge Hotel at Two Rivers
3.	Crown Plaza
4.	Eka Hotel
5.	Executive Residency by Best Western
6.	Fairview Hotel
7.	Golden Tulip Westlands
8.	Hilton Garden Inn Nairobi Airport
9.	Hilton Nairobi Limited
10.	House of Waine
11.	Nairobi Safari Club
12.	Ole Sereni Hotel
13.	Pride Inn Lantana Apartments and Suites
14.	Sarova Panafric Hotel
15.	Silver Springs Hotel
16.	Southern Sun Mayfair Nairobi
17.	The Panari Hotel, Nairobi
18.	Weston Hotel
19.	Windsor Golf Hotel and Country Club
3-Star Hotels	
No.	Hotel Establishment
1.	Azure Hotel
2.	Best Western Plus Meridian Hotel

3.	Boma Inn Nairobi
4.	Fahari Gardens Hotel
5.	Ibis Styles Nairobi Westlands
6.	Kenya Comfort Suites
7.	La Masion Royale
8.	Marble Arch Hotel
9.	Ngong Hills Hotel
10.	Pride Inn Raptha Nairobi
11.	Sportsview Hotel Kasarani
12.	The Clarion Hotel
13.	The Heron Portico
14.	Utalii Hotel
15	Villa Leon Guest House
2-Star rated Hotels	
1.	Zehneria Portico
2.	West Breeze Hotel
3.	Town Lodge
4.	Summerdale Inn
5.	Kahama Hotel
6.	Jacaranda Hotel Nairobi
7.	Eton Hotel
8.	Central Park Hotel
9.	After 40 Hotel

Source: Tourism Regulatory Authority (TRA 2020)

Appendix 5: Approval Letter

MURANG'A UNIVERSITY OF TECHNOLOGY
Office of the Director, Postgraduate Studies
E-mail: bps@mut.ac.ke
Website: www.mut.ac.ke
P.O. Box 75-10200
Murang'a, Kenya

Ref: MUT/ARP/PGS/19/2020 /VOL.1 **Date:** 19th December, 2024

Ms. Mercy Emathe
School of Hospitality and Tourism Management,
Murang'a University of Technology,
P.O. Box 75-10,200
Murang'a.

Dear Ms. Emathe,

RE: APPROVAL OF RESEARCH PROPOSAL AND SUPERVISORS.

I am pleased to inform you that the Directorate of Postgraduate Studies on 11th December, 2024 considered and approved your Master research proposal entitled ***"The role of Technology innovations in managing energy cost in star-rated hotels in Nairobi County, Kenya."*** and appointed the following as supervisors:

1.Dr. Juliana Maina - Murang'a University of Technology

2.Dr. Isabella Mapelu - Murang'a University of Technology

You may now proceed with your data collection subject to obtaining research permit from NACOSTI, if required. You should also begin consulting your supervisors and submit through them quarterly progress reports to the Director Postgraduate Studies through your CoD and School Dean. Progress Reports forms can be accessed in the Student Portal.

It is the policy and regulations of the University that you observe deadlines. The guidelines on Postgraduate supervision can be accessed in the post graduate Handbook.

Your responsibilities as a student will include, among others;

i. Maintain regular consultation with your supervisor(s), at least once a month
ii. Submit quarterly reports on time, through your supervisors, CoD, Dean and to the Director of Postgraduate Studies;

iii. Ensure quality work all through;
iv. Present your research findings at 2-3 seminars/conferences prior to thesis examination.
v. Publish one articles from your research findings in a refereed journal prior to thesis examination.

For any further clarification please contact the undersigned.

Yours Sincerely,

Prof. Geoffrey Muchiri, PhD
Director, Postgraduate Studies
GM/MMK

DIRECTORATE OF POSTGRADUATE STUDIES
MURANG'A UNIVERSITY OF TECHNOLOGY
19 DEC
P. O. Box 75 - 10200, MURANG'A
Tel: 07714[illegible], Email: info@mut.ac.ke

Copy to:
1. Registrar, Academics, Research and Students Affairs
2. Dean, School of Hospitality and Tourism Management

Appendix 6: Nacosti License.

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **728188**

Date of Issue: **20/January/2025**

RESEARCH LICENSE



This is to Certify that Ms.. Mercy Emathe Engolan of Murang'a University of Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi on the topic: THE ROLE OF TECHNOLOGICAL INNOVATIONS IN MANAGING ENERGY COST IN STAR-RATED HOTELS IN NAIROBI CITY COUNTY, KENYA. for the period ending : 20/January/2026.

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Applicant Identification Number

Director General
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See overleaf for conditions

Appendix 7: Publication

The paper below has been published from this thesis:

[1] Engolan, M. A., Maina, J. W., & Mapelu, I. C. (2025). Assessing the Role of Technological Innovations in Managing Energy Costs in Star-Rated Hotels in Nairobi City County, Kenya. International Journal of Research in Social Science and Humanities (IJRSS) ISSN: 2582-6220, DOI: 10.47505/IJRSS, 6(7), 125-135. https://doi.org/10.47505/IJRSS.2025.7.13