



Journal of Sustainable Engineering & Renewable Energy (JSERE)

VOLUME 1 ISSUE 1 (2025)



PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

Examination of the Energy Use Configuration of Hotel Buildings in Minna, Nigeria

Bawa Agmada John^{1*}, Zhiri Gabriel Hassan², Bassa Ayuba John¹

Article Information

Received: June 17, 2025

Accepted: July 19, 2025

Published: December 23, 2025

Keywords

Energy Consumption, Hotel Buildings, Occupancy Rates, VACH Systems

ABSTRACT

Hospitality buildings are among the highest energy consumers due to their extensive demand for lighting, domestic hot water need, and ventilation, air conditioning and heating (VACH) systems. This study examines the energy-use patterns of hotels in Minna, Nigeria, focusing on consumption trends, management practices, and electricity supply challenges. A mixed-methods approach, combining energy audits, direct observations, and structured interviews was employed. Six hotels were purposively selected in Minna and assessed in this study. Findings indicate that occupancy rates significantly influence energy consumption, with air conditioning and lighting as primary contributors. The study reveals a substantial gap between estimated energy demand and actual supply, leading to heavy reliance on diesel generators. Guests' behavior was identified as a critical factor in energy wastage, underscoring the need for awareness programs and conservation incentives. The study emphasizes the importance of energy-efficient solutions, including smart VACH systems, sub-metering, and the integration of renewable energy. Addressing these inefficiencies through policy interventions, architectural strategies, and improved energy management practices can enhance sustainability in the Nigerian hospitality sector.

INTRODUCTION

Hospitality buildings characteristically consume energy primarily for ventilation, air conditioning and Heating (VACH) as rearranged by Bawa *et al.* (2024) and Bawa and Ukpabia (2025), lighting, and domestic hot water systems. Dibene-Arriola *et al.* (2021) and Zhang *et al.* (2024) agreed that hotels, as significant energy consumers, often rank among the highest energy-consuming building types, with studies indicating that they can account for over 50% of total energy consumption in certain regions. Consequently, Wang *et al.* (2022) and Acharya and Shakya (2021) note the energy management strategies of hotels are complicated by their operational complexities such as varying occupancy rates and diverse guest behaviors, further. In tropical climates, where high temperatures necessitate extensive cooling, the energy demand is exacerbated, leading to increased operational costs and environmental impacts (Hong *et al.*, 2013; Kihal & Saffidine, 2024). This scenario highlights the need for energy efficiency measures tailored to the unique climatic and operational conditions of hotels in these regions.

According to Hong *et al.* (2013) growing concerns over energy efficiency in tropical climates stem from the increasing energy demands associated with high cooling loads, which significantly contribute to greenhouse gas emissions and operational costs. The reliance on conventional energy sources, coupled with inadequate building regulations that do not account for tropical conditions, exacerbates the inefficiencies in energy use (Babalola *et al.*, 2024; Wu *et al.*, 2022). However, Babalola *et al.* (2024) and Wu *et al.* (2022) suggest the potential for renewable energy sources, such as solar power, remains largely untapped in these regions, limiting the

sustainability of hotel operations. As the hospitality industry faces pressure to reduce its carbon footprint and enhance sustainability, understanding the specific energy use patterns in tropical climates becomes critical for developing effective energy management strategies.

LITERATURE REVIEW

Key determinants of energy consumption in hotels include the availability and efficiency of electrical appliances, staff and guest behavior, and local climatic conditions. The classification of hotels plays a vital role in shaping energy consumption, as higher-rated hotels tend to have more extensive amenities and greater energy demands. Studies indicate that the total energy consumption in hotels can be modeled using regression analysis to identify key determinants, such as occupancy rates, building design, and operational efficiency (Wang *et al.*, 2022; Nižić *et al.*, 2017; Moia-Pol, *et al.*, 2017a). Hence, Lai (2016) advocates that operational stage of hotels is particularly critical, as it accounts for over 80% of energy consumption, highlighting the importance of effective management practices. Achieving a zero-carbon footprint in tourism requires fundamental changes across all aspects of the industry, including transportation, accommodation, and visitor behavior (Kanwal *et al.*, 2024; Tezel, 2025).

The size of a hotel directly influences its energy demand, as larger establishments with multiple floors and facilities require more power for lighting, heating, cooling, and operational services. According to Wang *et al.* (2022) the energy consumption of lighting systems in large establishments is often exceeded by that of VACH systems. Additionally, occupancy rates directly correlate

¹ Department of Architecture, Faculty of Environmental Sciences, Baze University, Abuja, Nigeria

² Department of Architecture, School of Environmental Technology, Federal University of Technology, Minna, Nigeria

* Corresponding author's e-mail: john.bawa@bazeuniversity.edu.ng

with energy use; higher occupancy leads to increased demand for heating, cooling, and lighting, thereby escalating overall energy consumption (Wang *et al.*, 2022; López-Bernabé *et al.*, 2021). The type and efficiency of appliances also play a crucial role; energy-efficient appliances can mitigate some of the demand associated with larger hotel operations (Wang *et al.*, 2022; Eras *et al.*, 2016).

Based on Eras *et al.* (2016) and Papallou *et al.* (2024), the adoption of energy-efficient solutions, such as LED lighting, motion sensors, and daylight harvesting techniques, can significantly reduce energy use. Moreover, Wang *et al.* (2022) and Hutabarat *et al.* (2023) agree that optimizing VACH systems through regular maintenance, energy-efficient air conditioners, and smart thermostats can help reduce wastage and enhance energy efficiency. Also, studies support the use of tools such as energy management systems, sub-meters in different zones to track usage patterns, and Building Management Systems (BMS) for real-time energy tracking to provide real-time data on energy consumption, enabling hotel managers to make informed decisions (Eras *et al.*, 2016; Udawatta *et al.*, 2010). This proactive approach not only reduces energy costs but also contributes to sustainability goals. Researches indicate that guest behavior is a critical factor in energy-saving practices can lead to significant reductions in energy use (Talib *et al.*, 2023; Baker *et al.*, 2013). Many guests tend to use energy more liberally in hotels than they would at home, leaving lights, air conditioning, and televisions on even when not in use. Lack of awareness or incentives for energy conservation further exacerbates this issue. According to Talib *et al.* (2023) and Han *et al.* (2018), when hotels actively promote energy conservation practices, such as reusing towels and turning off lights, guests are more likely to participate, thereby reducing overall energy demand. However, the effectiveness of these initiatives often hinges on the hotel's ability to communicate its sustainability efforts effectively (Baker *et al.*, 2013).

Architectural features, thermal insulation, and building orientation are vital in minimizing energy use in hotels. Borowski *et al.* (2020) noted that proper building orientation, such as positioning windows and walls to minimize heat gain, and incorporation of energy-efficient materials and techniques can significantly reduce cooling demands. Thermal insulation in walls, roofs, and windows helps maintain indoor temperatures, thereby lowering VACH energy consumption, while strategic building orientation can maximize natural light and reduce reliance on artificial lighting (Borowski *et al.*, 2020). Also, natural ventilation, shaded outdoor areas, and energy-efficient building materials can further enhance energy savings. Additionally, Moia-Pol *et al.* (2017b) suggested that the incorporation of passive cooling techniques can reduce dependency on mechanical cooling systems, ultimately leading to lower energy costs, while the integration of renewable energy sources, such as solar panels, can further enhance a hotel's energy efficiency and sustainability profile.

Despite the recognized significance of energy consumption in hotels, there is a notable gap in research focusing on the specific energy use patterns of hotel buildings in Minna, Nigeria. Existing studies predominantly address energy efficiency in temperate climates or specific regions, leaving a lack of localized data that can inform energy management practices in tropical settings like Minna (Amanda & Sanjei, 2019; Llano *et al.*, 2021). This gap in research according to Babalola *et al.* (2024) is particularly concerning given the unique climatic challenges and energy demands faced by hotels in Minna, which consistent with Acharya and Shakya (2021) may differ significantly from those in other parts of the world. Therefore, a focused investigation into the energy use patterns of hotels in Minna is essential to address these challenges and contribute to the broader discourse on energy efficiency in tropical climates. The significance of this study lies in its potential to provide valuable insights into the energy consumption trends and management practices of hotel buildings in Minna, Nigeria. This will help inform strategies for enhancing energy efficiency in the hospitality sector. The research aims to examine the energy use patterns of hotel buildings in Minna, Nigeria, by analyzing energy consumption trends, management practices, and the impact of electricity supply on the energy use of hotel buildings. This study will provide a comprehensive overview of energy consumption in hotels in Minna, focusing on the identification of key factors influencing energy use, the effectiveness of current management practices, and the implications of electricity supply variability on energy efficiency. By employing a mixed-methods approach that combines quantitative energy consumption data with qualitative insights from hotel management.

MATERIALS AND METHODS

The study was conducted in Minna, a city located in the tropical savannah climate zone of Nigeria. The research focused on hotels in the Tunga area, a prominent hospitality hub within Minna. A mixed-method approach combining quantitative and qualitative methodologies was employed. The study utilized energy audits, direct observations, structured interviews, and secondary data collection to examine the energy use pattern in selected hotel buildings. This was done similar to Arenhart *et al.* (2024) and Torres *et al.* (2022) which used structured interviews and energy audits.

A purposive sampling technique was used to select ten (10) hotels within the Tunga area of Minna for the energy audit. However, only six (6) hotels (Aloe Vera "A", Nasfah "B", Brighter Suites "C", Yai "D", Nothing Pass God (NPG) "E", and Carol Deep Sleep "F") provided valid data required for analysis, representing 60% of the total sampled hotels. The selection criteria were the availability of electricity bills for at least one year, and the ready presence of occupancy data. This was to improve credibility and transferability of findings, and with proper consideration of ethical implications and the limited

effect it had on the outcome in line with Denieffe (2020) and Memon *et al.* (2023).

The study collected primary data through energy audit, energy demand estimation, interviews with hotel managers, and direct physical observations. Electricity bills from the Abuja Electricity Distribution Company (AEDC) were analyzed to determine monthly energy consumption trends. A theoretical estimation of energy consumption was performed based on the number of rooms, installed electrical appliances, and assumed full-capacity operations. Structured interviews with hotel managers were conducted to gather insights into energy management practices, challenges, and the impact of electricity supply on hotel operations. On-site inspections were carried out to validate data from electricity bills and interviews, assess energy efficiency measures, and identify energy conservation strategies.

The Energy Demand Estimation Model of this study exclusively considered lighting and cooling loads to estimate daily energy demand per room. For lighting, it was estimated that each room would use four (4) LED CFL lamps, with each consuming 15W, totaling 60W. The cooling load accounted for one (1) air conditioner per room, which consumes 1200W. Consequently, the total estimated demand for each room was 1260W (1.26kW), resulting in a daily energy demand of 30.24 kWh, assuming continuous 24-hour usage. The Estimated daily energy demand for the hotel (kWh) was computed using Eq. (1). Total number of rooms (N_r), Energy demand per room per day in kWh (E_r), and Occupancy rate in % (O_r) were considered in Eq. (1).

$$E_d = (N_r \times E_r) \times O_r \quad \dots(1)$$

These estimates were compared with the actual recorded energy consumption from electricity bills to determine the extent of energy supply shortages and reliance on alternative power sources. The study employed descriptive statistics, including mean, standard deviation, and percentage analysis, to examine energy consumption

trends across the sampled hotels. Additionally, a comparative analysis was conducted to assess energy supply sufficiency by comparing estimated energy demand with actual consumption, while qualitative content analysis of hotel managers' responses provided insights into energy use behaviors, conservation practices, and management challenges.

The study adhered to ethical research practices by ensuring voluntary participation, maintaining confidentiality of hotel data, and obtaining consent from hotel managers before conducting audits and interviews. The study assumes a continuous 24-hour electricity supply, which may not accurately reflect the impact of power outages and alternative energy sources on hotel operations. Additionally, reliance on self-reported data from hotel managers may introduce bias, and the focus on a specific urban area limits the generalizability of the findings to other tropical savannah regions. The integration of energy audits, empirical estimations, and qualitative insights from hotel managers enhances the validity and applicability of the findings, making them relevant for sustainable energy management in the hospitality industry.

RESULTS AND DISCUSSION

The energy audit findings revealed that the six analyzed hotels had an average of 43.33 rooms with an occupancy rate of 40.50%, and half of them had more than 50 rooms (Table 1). The estimated daily energy demand per room, considering lighting and space cooling, was 30.24 kWh, derived from the combined consumption of four 15W LED CFL lamps and a 1200W air conditioner. When compared to actual electricity consumption recorded from Abuja Electricity Distribution Company (AEDC) bills, discrepancies were observed, indicating a significant gap between estimated energy requirements and supply. These findings highlight the insufficiency of electricity supply for the hotels, reinforcing the need for alternative energy sources and improved energy management strategies.

Table 1: Energy use and demand by design for lighting and space cooling for rooms

Hotels	Energy consumption (monthly mean)	Estimated daily Energy consumption	Room	Energy design demand per day in full capacity	Occupancy Rate (%)	Rooms occupied	Energy design demand per day at occupancy rate
A	2211.42	72.65	79	2388.96	30	23.70	716.69
B	1983.13	65.15	63	1905.12	50	31.50	952.56
C	5330.50	175.13	60	1814.4	20	12.00	362.88
D	3859.57	126.80	26	786.24	50	13.00	393.12
E	1589.00	52.21	21	635.04	33	6.93	209.56
F	909.50	29.88	11	332.64	60	6.60	199.58
Mean	2647.19	86.97	43.33	1310.40	40.50	15.62	482.22

The energy audit revealed a significant gap between actual electricity consumption and the estimated daily energy demand, confirming the hotel managers' concerns about inadequate power supply. The analysis indicated that electricity supply was approximately 82% insufficient,

forcing hotels to rely heavily on costly alternative energy sources such as diesel and petrol generators to cover an average daily shortfall of 395.25 kWh (Figure 1). Furthermore, the relationship between estimated energy demand, occupancy rates, and hotel capacity suggested

a declining energy requirement per room as the total number of rooms increased. These findings underscore the critical need for improved electricity supply and

energy management strategies to enhance efficiency and reduce operational costs in the hospitality sector.

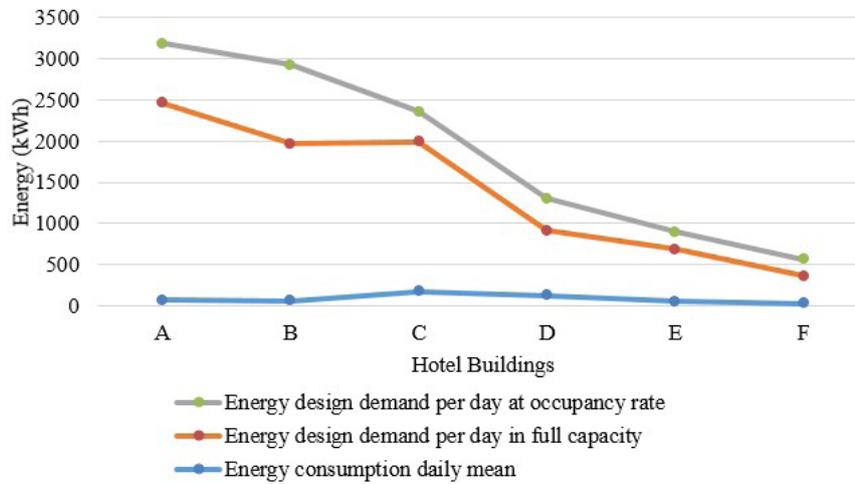


Figure 1: Energy consumption and demand

Hotel managers in the Tunga area primarily monitored energy consumption through monthly electricity bills, with few regularly checking their meters (Table 2). They identified air conditioners, refrigerators, and heaters as major energy consumers and expressed concerns over unreliable electricity supply, which increased dependence on costly diesel or petrol generators. Many felt electricity billing was unfair and did not reflect actual consumption. Some hotels implemented strict energy management by monitoring unoccupied rooms

and exterior fixtures, while others allowed unrestricted energy use. Guest behavior was a concern, as some were indifferent to conservation efforts. Energy demand was largely driven by thermal comfort, lighting, and water supply needs. Managers expressed the need for more knowledge on electricity billing (60%), guest energy awareness (40%), building insulation (30%), VACH installation (30%), and efficient heating, lighting, and water systems (20%), with only 10% prioritizing guest comfort alongside energy management.

Table 2: Energy use pattern from the opinion of the Hotel Managers

/n	Category	Findings
1.	Number of Hotels Interviewed	10 (Tunga area)
2.	Average Rooms per Hotel	49.89 rooms
3.	Average Occupancy Rate	42.29% per night
4.	Energy Monitoring Practices	Majority track energy consumption via electricity bills; Less than 20% check meters weekly
5.	Major Energy-Consuming Devices	Air conditioners, refrigerators, heaters, televisions, lighting bulbs, water pumping machines.
6.	Impact of Power Supply	Frequent power outages lead to generator use, increasing operational costs.
7.	Energy Management Practices	Some hotels assign staff to check unoccupied rooms and unused fixtures; others believe energy charges do not align with actual consumption.
8.	Customer Behavior in Energy Use	Some managers find customer energy usage unimpressive; some hotels implement supervisory measures through housekeeping, while others allow free usage.
9.	Challenges Faced	Belief that electricity bills are unfair due to erratic supply; high dependence on generators.
10.	Areas Where More Information is Needed	<ul style="list-style-type: none"> - Electricity bills (60%) - User sensitization (40%) - Building thermal insulation (30%) - Domestic hot water system (20%) - Lighting system (20%) - VACH installation (30%) - Customer relaxation and energy management procedures (10%)

The energy consumption estimates from Table 1 and the personal interviews with hotel managers in Table 2 align in several aspects but also reveal some discrepancies. Both sources indicate that energy use in hotels is significantly influenced by occupancy rates, as seen in the estimated energy demand per day at full capacity versus actual occupancy rates. The finding that occupancy rates significantly impact energy use in Minna hotels aligns with Wang *et al.* (2022) and López-Bernabé *et al.* (2021), which suggests that higher occupancy leads to increased demand for VACH systems, lighting, and other facilities. The energy audit and interview also highlight that major energy-consuming devices include air conditioners, refrigerators, heaters, lighting, and water pumping machines, which managers acknowledge as significant contributors to energy consumption. This agrees with Wang *et al.* (2022), which identifies VACH systems as the dominant energy consumers in hotel buildings.

Additionally, the interview findings support the estimated high energy demand, as managers' report concerns about high electricity costs, unreliable power supply, and the need for generators, which aligns with the substantial energy consumption figures in Table 1. While managers believe energy charges do not align with actual consumption, the detailed consumption estimates in Table 1 suggest that the energy use patterns largely follow expected trends based on occupancy. Hotel managers in Minna perceiving electricity charges as unfair due to erratic supply highlights an economic challenge not directly discussed in Moia-Pol *et al.*, (2017a), which focus more on reducing energy costs through efficiency measures rather than supply reliability issues.

Furthermore, the interviews emphasize energy monitoring challenges, with most managers relying on electricity bills rather than real-time tracking, with less than 20% checking meters weekly, which may contribute to their perception of unfair billing. The lack of real-time energy tracking in Minna hotels, with most managers relying on electricity bills, contradicts best practices globally, where Building Management Systems (BMS) and sub-meters are recommended for real-time energy monitoring (Eras *et al.*, 2016; Udawatta *et al.*, 2010). This suggests a gap between actual energy use and perceived consumption, possibly leading to concerns about unfair billing and energy management inefficiencies. It further suggests that while the estimated consumption figures provide a factual basis for energy demand, hotel managers' perspectives on energy costs and management practices reflect operational and financial concerns beyond just technical consumption measurements.

Moreover, the energy audit data, which shows varying daily mean consumption values (ranging from 29.88 kWh to 175.13 kWh across different hotels), aligns with the interview findings that energy demand is influenced by occupancy rates and operational factors. Both sources also highlight challenges with power supply, with managers reporting frequent outages that necessitate generator use, increasing operational costs. Additionally, while the audit focuses purely on quantitative energy use, the interviews

highlight customer behavior as a contributing factor, with some managers attributing high energy costs to guest habits, which is not directly reflected in the audit figures. Thus, while both sources agree on high energy demand and key consumption drivers, they differ in how energy use is tracked and perceived by hotel managers. The findings of this study agree with Talib *et al.* (2023) and Han *et al.* (2018) that guest awareness and incentives are critical for reducing consumption

CONCLUSION

This study examined the energy use patterns of hotel buildings in Minna, Nigeria, revealing key determinants of consumption, operational challenges, and management inefficiencies. The findings indicate that occupancy rates play a significant role in energy demand, which means that higher guest occupancy directly increases VACH, lighting, and appliance usage. Additionally, energy consumption estimates and hotel managers' perceptions highlight high operational costs in hotels in Minna due to unreliable power supply, frequent generator use, and concerns over electricity billing accuracy. However, a major discrepancy between energy audit data and managerial insights exists in energy monitoring practices, as most hotels in Minna rely on electricity bills rather than real-time tracking, contrasting with global best practices that emphasize Building Management Systems (BMS) and sub-metering for precise energy management. Guest behavior also emerged as a significant factor, as many managers attribute high consumption to uncontrolled energy use by guests, emphasizing the need for guest awareness and incentive-based conservation strategies.

Despite these insights, the study reveals several gaps that future research should address. First, there is limited focus on architectural and passive design strategies for reducing energy demand in Minna hotels. Future research should explore the integration of energy-efficient design elements tailored to Nigeria's climate. Second, the study identifies a knowledge gap among hotel managers regarding energy-efficient technologies such as smart VACH controls, motion sensors, and automated lighting systems. Future investigations should assess the feasibility of these technologies in the Nigerian hospitality sector. Lastly, the study highlights the need for policy-driven interventions to improve energy efficiency in hotels, such as mandatory energy audits, incentives for energy-efficient appliances, and training programs for hotel staff. Nigerian policymakers should also explore incentives for renewable energy integration in hotels, such as solar power solutions to mitigate reliance on diesel generators. Hotel industry stakeholders should prioritize awareness campaigns and guest engagement programs that promote responsible energy use, while building designers should incorporate passive cooling techniques and energy-efficient infrastructure to reduce long-term consumption. Addressing these gaps will significantly enhance energy efficiency, cost-effectiveness, and sustainability in the Nigerian hospitality sector.

REFERENCES

- Acharya, S., & Shakya, S. R. (2021). Energy demand analysis of a five star hotel in Nepal- A case study of Bhairahawa, Nepal. *Journal of Innovations in Engineering Education*, 4(1), 74–82. <https://doi.org/10.3126/jiee.v4i1.34670>
- Amanda, H. a. H., & Sanjei, C. (2019). Energy Performance and energy efficiency retrofitting in existing hotel buildings – a review. *Engineer Journal of the Institution of Engineers Sri Lanka*, 52(4), 51. <https://doi.org/10.4038/engineer.v52i4.7393>
- Arenhart, R. S., Martins, T., Ueda, R. M., Souza, A. M., & Zanini, R. R. (2024). Energy use and its contributors in hotel buildings: A systematic review and meta-analysis. *PLoS ONE*, 19(10), e0309745. <https://doi.org/10.1371/journal.pone.0309745>
- Babalola, O., Ugah, U. U. K., & Ekeh, E. (2024). *Tropical building sustainability and the energy regulations*. Preprints. <https://doi.org/10.20944/preprints202408.1595.v1>
- Baker, M. A., Davis, E. A., & Weaver, P. A. (2013). Eco-friendly attitudes, barriers to participation, and differences in behavior at green hotels. *Cornell Hospitality Quarterly*, 55(1), 89–99. <https://doi.org/10.1177/1938965513504483>
- Bawa, J. A., Abdullahi, M. L., & Abdulrahman, N. J. (2024). Sustainable Architecture and the Impact of Smart Ventilation, Air Conditioning, and Heating (VACH) Systems. *Open Journal of Engineering Science (ISSN 2734-2115)*, 5(2), 19–31. <https://doi.org/10.52417/ojes.v5i2.776>
- Bawa, N. J. A., & Ukpabia, N. C. U. (2025). Optimizing building envelope design for cooling loads reduction in Abuja. *International Journal of Latest Technology in Engineering Management & Applied Science*, 13(12), 57–65. <https://doi.org/10.51583/ijltemas.2024.131206>
- Borowski, M., Mazur, P., Kleszcz, S., & Zwolińska, K. (2020). Energy monitoring in a heating and cooling system in a building based on the example of the Turówka Hotel. *Energies*, 13(8), 1968. <https://doi.org/10.3390/en13081968>
- Denieffe, S. (2020). Commentary: Purposive sampling: complex or simple? Research case examples. *Journal of Research in Nursing*, 25(8), 662–663. <https://doi.org/10.1177/1744987120928156>
- Dibene-Arriola, L. M., Carrillo-González, F. M., Quijas, S., & Rodríguez-Urbe, M. C. (2021). Energy Efficiency Indicators for hotel buildings. *Sustainability*, 13(4), 1754. <https://doi.org/10.3390/su13041754>
- Eras, J. J. C., Santos, V. S., Gutiérrez, A. S., Plasencia, M. A. G., Haeseldonckx, D., & Vandecasteele, C. (2016). Tools to improve forecasting and control of the electricity consumption in hotels. *Journal of Cleaner Production*, 137, 803–812. <https://doi.org/10.1016/j.jclepro.2016.07.192>
- Han, H., Lee, J., Trang, H. L. T., & Kim, W. (2018). Water conservation and waste reduction management for increasing guest loyalty and green hotel practices. *International Journal of Hospitality Management*, 75, 58–66. <https://doi.org/10.1016/j.ijhm.2018.03.012>
- Hong, T., Kim, J., Lee, J., Koo, C., & Park, H. (2013). Assessment of seasonal energy efficiency strategies of a double skin façade in a monsoon climate region. *Energies*, 6(9), 4352–4376. <https://doi.org/10.3390/en6094352>
- Hutabarat, D. P., Saleh, R., Sebastian, L., Jonathan, J., & Aroska, S. M. N. (2023). Smart system for controlling and monitoring electronic facilities in budget hotel rooms. *Indonesian Journal of Electrical Engineering and Computer Science*, 30(2), 770-777. <https://doi.org/10.11591/ijeecs.v30.i2.pp770-777>
- Kanwal, N., Meng, C. S., Watabe, M., Zainal, N., & Siew, J. K. K. (2024). Carbon footprint of tourism activities including transportation, accommodation, and infrastructure: A Critical analysis. In *Emerald Publishing Limited eBooks* (pp. 95–120). <https://doi.org/10.1108/978-1-83608-668-020241015>
- Kihal, N. G., & Saffidine, N. D. R. (2024). Glazing Systems with Silica Aerogel for Optimizing Energy Consumption in Hotel Building. *International Journal of Innovative Technologies in Social Science*, 1(41). https://doi.org/10.31435/rsglobal_ijitss/30032024/8104
- Lai, J. H. (2016). Energy use and maintenance costs of upmarket hotels. *International Journal of Hospitality Management*, 56, 33–43. <https://doi.org/10.1016/j.ijhm.2016.04.011>
- Llano, M., Mesa-Cruz, R., Hamilton, A., Acosta, J., & Perez, J. A. M. (2021). A fuzzy-based approach for energy management of DHW systems in hotels. *Atlantis Studies in Uncertainty Modelling*. <https://doi.org/10.2991/asum.k.210827.034>
- López-Bernabé, E., Foudi, S., Linares, P., & Galarraga, I. (2021). Factors affecting energy-efficiency investment in the hotel industry: survey results from Spain. *Energy Efficiency*, 14(4). <https://doi.org/10.1007/s12053-021-09936-1>
- Memon, M. A., Thuramy, R., Cheah, J., Ting, H., Chuah, F., & Cham, T. H. (2023). Addressing Common Method Bias, Operationalization, Sampling, and Data Collection Issues in Quantitative Research: Review and Recommendations. *Journal of Applied Structural Equation Modeling*, 7(2), 1–14. [https://doi.org/10.47263/jasem.7\(2\)01](https://doi.org/10.47263/jasem.7(2)01)
- Moiá-Pol, N. A., Karagiorgas, N. M., Coll-Mayor, N. D., Martínez-Moll, N. V., & Riba-Romeva, N. C. (2017a). Evaluation of the energy consumption in Mediterranean Islands hotels: Case study: The Balearic Islands Hotels. *Renewable Energy and Power Quality Journal*, 3(1). <https://doi.org/10.24084/repqj03.233>
- Moiá-Pol, N. A., Karagiorgas, N. M., Martínez-Moll, N. V., Pujol, N. R., & Riba-Romeva, N. C. (2017b). Evaluation of the renewable energy application in Mediterranean hotels: Case study the Balearic Islands' hotels. *Renewable Energy and Power Quality Journal*, 4(1). <https://doi.org/10.24084/repqj04.250>
- Nižić, M. K., Trinajstić, M., & Blažević, B. (2017). New

- energy measures for sustainable local development – A challenge for the hotel industry. *Tourism in Southern and Eastern Europe*, 4, 279–290. <https://doi.org/10.20867/tosee.04.4>
- Papallou, E., Katafygiotou, M., & Dimopoulos, T. (2024). Emerging sustainability trends in Tourist Facilities: A Comparative assessment of multiple hotels and resorts. *Sustainability*, 16(9), 3536. <https://doi.org/10.3390/su16093536>
- Talib, A. a. A., Ariff, N. R. M., Hasim, M. S., Hanafiah, M. H., & Sivam, A. (2023). Sustainable Facilities Management (SFM) initiatives in Malaysia hotel industry. *International Journal of Sustainable Construction Engineering Technology*, 14(5). <https://doi.org/10.30880/ijscet.2023.14.05.007>
- Tezel, S. E. (2025). Zeroing carbon footprint in tourism: Sustainable approaches and innovative solutions. *American Journal of Tourism and Hospitality*, 3(1), 86–96. <https://doi.org/10.54536/ajth.v3i1.4265>
- Torres, S. G. M., Tzuc, O. M., Aguilar-Castro, K. M., Téllez, M. C., Sierra, J. O., Del Rosario Cruz-Y Cruz, A., & Barrera-Lao, F. J. (2022). Analysis of energy and environmental indicators for sustainable operation of Mexican hotels in tropical climate aided by artificial Intelligence. *Buildings*, 12(8), 1155. <https://doi.org/10.3390/buildings12081155>
- Udawatta, N. L., Perera, N. A., & Witharana, N. S. (2010). Analysis of sensory information for efficient operation of energy management systems in commercial hotels. *Electronic Journal of Structural Engineering*, 01, 113–120. <https://doi.org/10.56748/ejse.13701>
- Wang, Y., Dong, L., & Li, H. (2022). Economic evaluation of Energy-Saving retrofit of existing hotels. *Energies*, 15(3), 757. <https://doi.org/10.3390/en15030757>
- Wu, Y., Xin, B., Zhu, H., & Ye, Z. (2022). Energy-Saving Operation Strategy for hotels considering the impact of COVID-19 in the context of carbon neutrality. *Sustainability*, 14(22), 14919. <https://doi.org/10.3390/su142214919>
- Zhang, J., Yuan, C., Yang, J., & Zhao, L. (2024). Research on energy consumption prediction models for High-Rise hotels in Guangzhou, based on different machine learning algorithms. *Buildings*, 14(2), 356. <https://doi.org/10.3390/buildings14020356>