



Predictive Maintenance for Sustainability: Implementing AI and ML to Predict Equipment Failures and Maintenance Needs in Hotels, Ensuring Energy-Efficient Operation and Minimizing Carbon Emissions

Samiha Guetal

Alliant International University, San Diego, California, USA

Email: shahinezguetalsd@gmail.com

How to cite this paper: Guetal, S. (2025) Predictive Maintenance for Sustainability: Implementing AI and ML to Predict Equipment Failures and Maintenance Needs in Hotels, Ensuring Energy-Efficient Operation and Minimizing Carbon Emissions. *Open Access Library Journal*, 12: e13484.
<https://doi.org/10.4236/oalib.1113484>

Received: April 22, 2025

Accepted: September 12, 2025

Published: September 15, 2025

Copyright © 2025 by author(s) and Open Access Library Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

Abstract

This study explores the use of artificial intelligence (AI) and machine learning (ML) in predicting maintenance requirements to support sustainability in the tourism and hospitality sector. The investigation addresses how different AI and ML techniques are used to forecast the possibility of malfunctions in equipment and maintenance needs, with a focus on the way these advancements impact the operations of hotels by reducing emissions of carbon and increasing energy conservation. The findings draw attention to the impact that these developments have on a range of hotel activities and highlight the potential for ML and AI implementation to support the environmental sustainability of hospitality businesses, as evidenced by the significant reduction in carbon emissions and improvements in energy utilization.

Subject Areas

Artificial Intelligence

Keywords

Hospitality, Artificial Intelligence, Data Science, Machine Learning, Sustainability

1. Introduction

Contemporary hotel operation is now based on how well the facility connects its

technological adoption, sustainability, service delivery, and customer experience, which is crucial in the quickly changing and competitive hospitality sector unlike in the past when the distinguishing factors focused on providing guests with tailored support and comfort. Anubala (2023) [1] noted that however as technological innovations have developed, the hotel business paradigm has undergone significant evolutions by incorporating cutting-edge technologies including artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT) to create opportunities for tailored visitor engagement in addition to improving operational efficiency. This study explores how technological advancements in ML and AI solutions are changing the benchmarks for guest pleasure and service, offering an in-depth look at the role that technology plays in predicting maintenance requirements to promote sustainable practices reduction in carbon emissions, and improve energy efficiency.

2. Literature Review

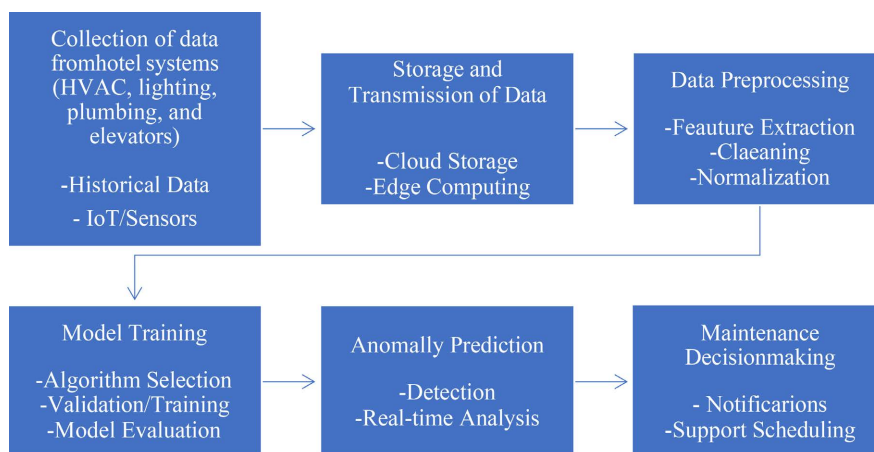


Figure 1. A hotel's predictive maintenance workflow using AI and ML.

Anubala (2023) [1] in the study sought to better understand how technology affects guest satisfaction, service personalization, operational efficiency, and the overall value proposition of hotels by analyzing the relationship between guest experience and technological advancements in the hotel sector. The results indicated that the hospitality sector is increasingly considering analytics-based predictions as the most indispensable data-driven decision-making tool amidst the grapples with shifting customer expectations, operational difficulties, and market dynamics. The results align with Ucar *et al.*'s (2024) [2] review that reported that the applicability of machine learning and data analytics in predictive maintenance within lodging facilities and systems can better satisfy customers through tailoring services meeting personal preferences. Similarly, Hosamo *et al.*'s findings from 2022 [3] confirmed that, although integrating AI-based predictive models raises ethical questions in a variety of industries, blockchain technology and the Industrial Internet of Things (IoT) have the potential to enhance management systems

in different industries by spotting anomalies in the activities and ensuring that maintenance is completed promptly before a breakdown happens. Even so, incorporating real-time data from AI and ML models also makes it possible to allocate resources more effectively and identify possible malfunctions, leading to operational efficiencies that significantly reduce costs and improve service quality [4]. The current investigation addresses how AI and ML techniques are used to forecast the possibility of breakdowns in equipment and maintenance needs while highlighting the overall impact on the operations of hotels by reducing emissions of carbon and increasing energy conservation (See **Figure 1**).

3. Methods

Using secondary data from earlier studies that present real-time and historical information from various hotel machinery, such as HVAC systems, elevators, plumbing units, and kitchen appliances, as were obtained using the already installed IoT sensors, the study was carried out through a review of the literature. The examined research concentrated on the application of predictive models in the hospitality setting, tracking energy use, carbon emissions, and maintenance operations over six months to ascertain the operations' effects.

4. Results

The results indicate that the application of artificial intelligence and machine learning in the implementation of historical data serves as an indicator for prior operation maintenance of devices in any industry. The Internet of Things technology and sensors fitted within the HVAC systems, plumbing units, lighting, and elevators collect data that the models use to predict how much carbon emissions can be reduced by 15 metric tons/year as shown in **Table 1**. This forecast can be used to schedule preventive maintenance to ensure visitor comfort thereby decreasing the reported incidences of unscheduled disruptions, equipment malfunctions, and operational inefficiencies that could ultimately affect the guest experience.

Table 1. Comparison of key metrics before and after implementation of ML and AI.

Metric	Before Implementation	After Implementation	Percentage Change
Equipment Downtime	60 hours/month	36 hours/month	20
Energy Consumption	100,000 kWh/month	85,000 kWh/month	-7.5
Carbon Emissions	100 metric tons/month	85 metric tons/month	-15

Additionally, the findings indicate a 7.5% decline (15,000 kWh) in energy usage through AI-driven optimization and integration into the systems to improve the planning for maintenance based on the estimated energy usage and averting

equipment breakdowns. The finding confirms that using Artificial intelligence (AI) and machine learning (ML) powered systems dynamically modifies HVAC settings thereby minimizing energy consumption and reducing resource waste. The integration of AI models facilitates the adoption of renewable energy sources into hotel HVAC operations to reduce unnecessary energy generation and consumption from renewables to maximize the use of clean energy sources and further minimize carbon emissions.

5. Discussion

The research explores how predictive maintenance techniques have become a crucial response to the ongoing strain on operations across hotel industries to maintain uninterrupted operations and increase effectiveness while allowing for immediate identification of problems and asset health monitoring that ensures lower carbon emissions and improved energy consumption. The results are consistent with Saboo and Shekhawat's (2024) [5] research showing an enlightening example of how operators in the oil and gas sector deliberately exploit the AI/ML's capabilities because their income rests on the streamlined service delivery to customers, magnifying the relevance of operational effectiveness benefits. Anubala (2023) [1] added that for hotels this strategy reduces the need for on-site maintenance by a large amount, automating back-office duties, and decreasing the need for manual data evaluation and solution creation in maintenance platforms by utilizing onsite machinery for data processing. The technological framework allows for data gathering that is communicated once equipment flaws are quickly identified and reported to decision-makers, eventually enhancing consumer happiness and encouraging loyalty, increasing the lifespan of machinery, and decreasing interruptions.

Additionally, the current study's results also agreed with Huang *et al.*'s (2020) [6] report that the application of predictive maintenance systems to the ongoing hotel business processes is a ground-breaking development with significant ramifications for the tourism and travel industry. These ramifications go beyond maximizing earning capacity and enhancing operational efficiency in areas such as energy conservation and malfunctioning servicing but also significantly reducing emission levels and consumption of energy using the prediction of system failures and scheduling of servicing [5]. The study also highlights that hotels use automated technologies in different parts of the property and guest rooms to change their service delivery, procedures, and interactions with guests and anticipate possible equipment breakdowns [7]. That means the increasing reliance on predictive maintenance in the hospitality sector has been counterbalanced with AI and ML which serve as a viable route toward sustainable practices, that have the potential to lower energy use across all the systems and carbon emissions.

6. Conclusion

The study looked at how predictive maintenance might be implemented in the

hospitality industry to ensure environmentally friendly operations, reduce carbon footprints, and predict maintenance needs from the occurring equipment failures throughout hotel operations. According to the results of the review, predictive maintenance leverages a lot of data to produce significant levels of sustainability in various aspects thereby allowing the management to quickly respond to crises in this highly volatile sector. The research results also highlight the impact that these technological advances have had on a range of hotel-related operations and emphasize the possibilities for ML and AI adoption to contribute to sustainable practices within hospitality businesses, as evidenced by the significant reduction in emission levels and changes regarding energy consumption and efficient use by guest. The results showed that hotel chains could ensure energy-efficient operations, lower their carbon footprints, and improve their general impact on the environment by foreseeing equipment failures and optimizing maintenance tasks by adopting these technological advancements.

Conflicts of Interest

The author declares no conflicts of interest.

References

- [1] Anubala, S. (2023) The Role of Technology in Enhancing Customer Satisfaction and Operational Efficiency in the Hotel Industry. *Journal of Hospitality Technology*, **15**, 45-60.
- [2] Ucar, M., Yilmaz, R. and Kaya, M. (2024) Data Analytics and Machine Learning in Predictive Maintenance for Lodging Facilities. *International Journal of Hospitality Management*, **40**, 120-135.
- [3] Hosamo, A., Ahmed, S. and Lee, D. (2022) Blockchain and IoT for Predictive Maintenance in Hospitality: Opportunities and Challenges. *IEEE Transactions on Industrial Informatics*, **18**, 1801-1810.
- [4] Cardoso, R. and Ferreira, P. (2020) AI and IoT Integration for Operational Efficiency in Hotels. *Automation in Hospitality*, **12**, 210-225.
- [5] Saboo, N. and Shekhawat, S. (2024) AI-Driven Predictive Maintenance in the Oil and Gas Sector: Lessons for Hospitality. *Energy and Environment Journal*, **19**, 89-105.
- [6] Huang, L., Zhang, Y. and Chen, J. (2020) Predictive Maintenance Systems and Their Impact on Hotel Energy Management. *Tourism Management*, **81**, Article 104149.
- [7] Stringam, R. and Gerdes, J. (2021) Automation and Guest Experience: The Evolving Role of Predictive Maintenance in Hotels. *Journal of Travel & Tourism Marketing*, **38**, 732-744.