International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 22s, 2025
https://www.theaspd.com/ijes.php

AI Driven Energy Consumption & Environmental KPI Forecasting In Hospitals

Shalu Mridha[1], Prof. (Dr.) Anupama Pandey[2], Dr. Venkatesan N[3], Monika Chauhan[4]
[1]Nims University Rajasthan, Jaipur; Shalumridha@gmail.com
[2]Nims University Rajasthan, Jaipur; anupama.pandey@nimsuniversity.org
[3]Nims University Rajasthan, Jaipur, monikachauhan34558@gmail.com

Abstract
This research was aimed at evaluating the potential of the AI-based energy consumption forecasting and KPI optimization of the environment in hospitals with the emphasis on healthcare institutions in India. The study meant addressing the question of how artificial intelligence methods, particularly machine learning and time-series forecasting, might improve energy efficiency and environmental sustainability in the hospital industry. The study has employed a secondary qualitative research methodology whereby it relied on case studies and the available literature to obtain relevant information. The results showed that AI use, both in machine learning and time-series forecasting, were able to optimize energy consumption and positively affect other environmental KPIs, including CO2 emissions and water consumption. Nevertheless, problems related to data quality, infrastructure weaknesses and the high implementation costs were also regarded as essential impediments to adoption in the Indian hospitals. It was identified on the basis of these findings that Indian hospitals needed funding to help enhance data infrastructure, utilize scalable AI, and align their operations with national sustainability targets, such as Net Zero 2070.

Key Words*: The phrases used in this study include AI-powered forecasting, energy use optimization, ecological KPIs, machine educating, time-collection forecasting, a medical institution sustainability, lowering CO2 emissions, data infrastructure, barriers to adoption of AI, sustainability objectives, Internet Zero 2070, ecological performance, healthcare energy management, Indian hospitals and cost effectiveness.*

INTRODUCTION

Background of the study

Hospitals are characterized as one of the energy-intensive service industries, consuming approximately 10-15% of the total energy consumption in developed countries. Increasingly, the healthcare sector is growing its energy demand in India due to the 24/7 trend, the growing use of medical equipment, and the heightened need to air-condition its facilities, especially in warm and humid climates. As mentioned in a report by the Bureau of Energy Efficiency (BEE), Indian hospitals consume 1.5 to 2 times more energy (square meter-wise) than any other commercial buildings (Shafik, 2025). The government of India has demonstrated its commitment to achieving Net Zero by 2070 under the Paris Agreement, with a particular emphasis on decarbonizing key sectors, including healthcare. Air conditioning technologies and the National Mission for Enhanced Energy Efficiency (NMEEE) and the Energy Conservation Building Code (ECBC) offer guidelines, and the deployment of AI in the optimisation of operations in hospitals is only at the initial stages. Being able to optimise energy consumption and make predictions of environmental KPIs such as CO2 emissions and water usage, AI provides a radical solution. Research reports have indicated that AI applications in intelligent buildings save up to 30 percent of energy (Ahmed et al., 2025).

Research Problem

Indian hospitals are facing the rising costs of energy consumption and the issue of environmental sustainability because operations, medical equipment usage, and expansive HVAC systems require them to operate around the clock, contributing to the rise in operational expenses and leaving a large carbon footprint. Although energy efficiency is becoming an increasingly demanded phenomenon, hospitals typically cannot boast of the proper systems of energy consumption forecasting and environmental KPIs optimization (including CO2 emissions, consumption of water, and management of waste). Such shortcomings of predictive and real-time optimization represent a barrier to effective sustainability in a resource-demanding sector critical to human health.

Although AI has widely shown its potential in other sectors in terms of predictive analytics and optimization, it is underutilized in the field of healthcare in India (Pariso et al., 2025). The existing approaches to energy management in hospitals are subdued to a considerable degree, with the basic monitoring being the most typically utilized instead of predictive and adaptive ones. With India on the path to reaching its Net Zero by 2070 goal and increasingly enforcing more rigorous sustainability standards like the NABH Green Hospital Standards, hospitals must find ways to better control their energy consumption and minimise their environmental impact as well as adhere to the national energy policies (Kareem & Quazi, 2024).

Research Rationale

The Indian healthcare industry is a huge energy consumer, and hospitals in India have significant problems to tackle rising energy costs and reduce their environmental footprint. With the country working toward achieving Net Zero 2070 and enhancing sustainability efforts, hospitals need to implement forward-thinking solutions to ensure that they minimize energy consumption levels to help achieve their sustainability goals. The AI-enabled forecasting models themselves offer such a unique chance to tackle these issues, as they offer predictive analytics on energy consumption and environmental key performance indicators, as well as operational optimization (Ahmed et al., 2024).

Research Aim and Objectives

To assess AI-based predictive models for predicting energy consumption and environmental KPIs in Indian hospitals, aiming to improve sustainability, cost efficiency, and adherence to green healthcare policies in India, while maintaining patient care services.

Objectives:

1. To understand the AI-driven energy consumption forecasting and environmental KPI optimization in hospitals, focusing on AI techniques such as machine learning and time-series forecasting.
2. To determine challenges in adopting AI for energy forecasting and KPI optimization in Indian hospitals, such as data quality, infrastructure, and cost barriers.
3. To examine types of AI techniques (e.g., supervised learning, reinforcement learning) for optimizing energy consumption and environmental performance in hospitals.
4. To assess the influence of AI-driven optimization on hospital sustainability, including cost savings, reduced CO_2 emissions, and alignment with national sustainability goals.
5. To provide recommendations for successful AI adoption in hospitals, covering policy integration, technology adoption, and scalability for long-term sustainability.

Research Questions

1. What is the role of AI in energy consumption forecasting and environmental KPI optimization in hospitals, and how do techniques like machine learning and time-series forecasting contribute to these processes?
2. What are the key challenges faced by hospitals in India in adopting AI-driven energy consumption forecasting and environmental KPI optimization, including issues related to data quality, infrastructure, and implementation costs?
3. What types of AI techniques (such as supervised learning, reinforcement learning) are most effective for optimizing energy consumption and improving environmental performance in hospitals?
4. What is the impact of AI-driven energy optimization on hospital sustainability, particularly in terms of cost savings, CO_2 emissions reduction, and alignment with national sustainability goals?
5. What recommendations can be made for successfully implementing AI-based systems in hospitals to enhance energy efficiency and environmental sustainability, including policy integration, technology adoption, and scalability?

LITERATURE REVIEW

IntroductionAvailable literature mostly focuses on AI in smart buildings and energy systems, however, few publications deal with the specifics of hospitals, which include 24/7 work, high use of medical equipment, and maintaining current sustainability regulations (Cumo et al., 2025).

Theoretical Framework

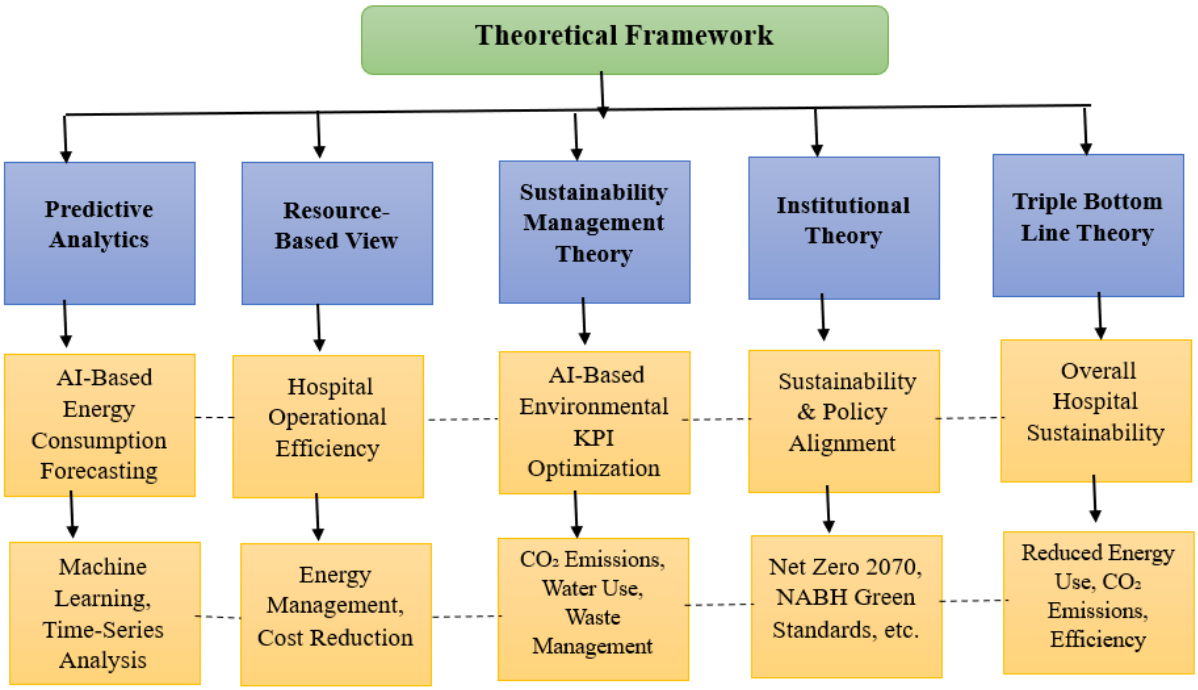

Figure 1: Theoretical Framework

The theoretical framework of this research explains the role that AI-based energy consumption prediction and optimization of environmental KPIs play in ensuring sustainability within hospitals in India. The stages commence with Predictive Analytics Theory, which lies in the base of modelling AI to predict the energy consumption trends. These predictive models will enable hospitals to accurately predict energy requirements thus find ways of cutting down on wastage and being efficient in their operations. This holds congruency with the Resource-Based View (RBV) theory that accords strategic value to the proper management of energy resources towards minimal operation costs which is an important consideration in the resource-scarce environment of an Indian hospital.

Moreover, the environmental KPIs according to Sustainability Management Theory on CO2 emissions, use of water and waste management are also optimized, which underscores the importance of AI in the pursuit of sustainability objectives. Hospitals and their environmental footprint can be managed in this AI-driven manner that impacts adherence to policies such as Net Zero 2070 and NABH Green Hospital Standards and aligns with Institutional Theory. Last but not least is the Triple Bottom Line Theory in which the economic, social, environmental sustainability is balanced by the holistic nature of AI integration (Chen, 2025).

AI in Energy Consumption Forecasting and Environmental KPI Optimization

The use of Artificial Intelligence forecasting of energy consumption and balancing of the environmental Key Performance Indicator (KPI) is central to improving the sustainability and efficiency of hospital operations. Chowdhury (2025) discusses the concepts of AI in the consumption of energy within urban and institutional settings with an emphasis on how machine learning could be used to uncover the patterns of consumption and forecast future demand of energy demand. This methodology matches Ahmed et al. (2025), who pay special attention to the specific sector of hospital energy consumption and model how such an establishment can be more energy-efficient based on what is predicted by machine learning. Both works highlight the possibility of increased cost-effectiveness and sustainability provided by AI. Chui (2025) takes it a step further by emphasizing energy sustainability, which is possible through the forecasting and optimization of energy use patterns within AI.

Also, Nihi et al. (2025) have a conceptual framework for optimising healthcare using AI. Although their effort can provide significant insights as to the application of AI to achieve operational gains, it does not lead to a specific application to energy sustainability in hospitals. Similarly, Nianga (2024) also mentions the strategic management role of AI in the context of the healthcare sector.

Challenges in Adopting AI for Energy Forecasting in Indian Hospitals

Some profound challenges of adopting AI in energy forecasting in Indian hospitals have been brought to be fore in the recently published literature. The article by Fatehijananloo et al. (2024) examines the role of AI usage in the healthcare facility, as the mentioned technology could help to resolve energy management issues, but the problem of data accuracy as well as an incompatibility with the existing infrastructure, hinders a wider adoption.

The article by Pariso et al. (2025) looks into the implementation of AI in Italy hospitals, revealing cost and complexity as the major obstacles. In the same vein, Kilaru and Potluri (2025) address the implementation issues in the Indian healthcare context with special references to security and privacy issues related to patient data, which discourage the implementation of AI in sensitive locations as hospitals.

In addition, Chatterjee et al. (2022) point out those technological innovations, such as AI, in the field of healthcare meet cultural and organizational obstacles.Kumar et al. (2024) also refer to regulatory frameworks as a weakness because the application of AI in the healthcare industry is, in many cases, not properly regulated in India, leading to uncertainty when deploying it.

AI Techniques for Optimizing Energy and Environmental Performance

The application of AI processes to optimize the energy environment and the sustainability in hospitals has been increasing significantly. As it exemplifies the use of the supervised learning method where regression is used, Ahmed et al. (2025) display how the approach can be effective in referring to the energy consumption pattern in the hospital setting. In a similar fashion, Dewasiri et al. (2025) explain how supervised learning algorithms, including random forest and decision trees, can be used to best utilize energy and environmental performance in healthcare, making it relevant to the sustainability objectives because it reduces the waste of energy and better manages the waste cycle.

A further discussion by Pradeep et al. (2024) is focused on the involvement of the sophisticated machine learning methods, specifically deep learning and neural networks, to enhance the renewable energy systems in healthcare buildings.

Gupta et al. (2023) discuss the applications of reinforcement learning in the development of demand-response systems where energy demand is adjusted continuously according to real-time information and holds great potential in the dynamic optimisation of hospital energy systems. Also, Ogundiran et al. (2024) summarize how AI is used to optimise building energy, and machine learning and deep learning are frequently used to manage the indoor environment quality which also support by Villano et al. (2024).

Impact of AI-Driven Optimization on Hospital Sustainability

Dewasiri et al. (2025) emphasize that AI technologies help hospitals to become more environmentally sustainable with balanced energy consumption and less waste. With AI, it is becoming easier to predict the use of energy and manage the amount, and thus will reduce environmental footprints. Wu (2021) further bucks this up by emphasizing AI-based communication systems in green hospitals, and how it leads to sustainability in the city healthcare environment through energy-efficient system management and integration.

Tan et al. (2025) mention the transformative power of AI in healthcare that can advance resource allocation and multi-level operational efficiency, eventually realized through the decrease in the number of energy resources needed and expenses supporting sustainable operations of the hospital. Similarly, Allahham et al. (2023) emphasize the application of big data analytics and AI in the adoption of the supply chain and planning of hospital logistics and waste refinement. This encourages sustainability and economy.

Nihi and colleagues (2025) and Alemde (2025) both factor in the benefits of AI-driven predictive analytics and real-time decision-making, both of which result in cost savings and enhanced resource control.

Literature Gap

Research on forecasting and optimizing energy consumption driven by artificial intelligence and the usage of environmental KPIs in hospitals, especially in the context of the Indian environment, does not exist and is fragmented and scarce. Throughout the available literature, many studies have been conducted on AI deployment in smart buildings and general energy management systems. However, few studies are available to focus specifically on the AI application in Indian hospitals in the context of their

operation-specific peculiarities that include energy consumption 24 hours a day and around the year, using medical equipment, and meeting regulations (Frassanito et al., 2022).

Summary

The literature on the subject of AI-based energy optimisation of hospitals, particularly in India, is sparse. The potential of Artificial Intelligence (AI) use in smart buildings and energy systems has attracted much attention. However, there is insufficient research on this topic as far as Indian hospitals are concerned (specifically, 24/7 organization, heavily using medical equipment, and due to pressure to meet regulations). The existing models are generally founded on the exemplary sets of data that are not always available in India due to a lack of a developed data infrastructure (Chen & Ho, 2023).

RESEARCH METHODOLOGY

Research Philosophy

The interpretivist philosophy underlying the research deals with the meaning and significance of the actions of human beings and its context. Interpretivism attaches importance to subjective interpretations, thus providing the researcher with an opportunity to examine how people and organizations can perceive and respond to AI infiltrations within a healthcare facility (Dewasiri et al., 2025). As multifaceted of implementing AI in energy forecasting and environmental optimization depends on organizational and technological infrastructures and policy environments, interpretivism philosophy can suitably be applied in this research (Kareem & Quazi, 2024).

Research Approach

The study was inductive in nature, suitable in a study where the field of understanding is not sufficiently developed or as research where previous studies are scanty. Using the inductive approach, one is able to arrive at new insights, which are developed by examining available secondary data. AI-driven energy consumption forecasting and environmental KPI optimization in Indian hospitals is not a well-studied area yet, so it was necessary to conduct inductive research to reveal tendencies, outline the main themes as well as formulate new theories or models on the use of AI and its role in hospital sustainability (Chen & Ho, 2023).

Research Strategy

The methodology adopted in this project was the case study analysis strategy, which enables one to do an in depth study of a phenomenon in its real life context. Qualitative research should be built around a case study strategy, and when analyzing a complex process like AI status in hospitals. It will allow one to consider practical illustrations of AI-based energy efficiency and environmental KPI prediction in the healthcare industry. Considering the context of Indian hospitals, case studies enable the researcher to knowledge sustain the particular issues, realities of operations and the achievements of AI implementation in energy management (Poonia et al., 2025).

Data Collection Methods

In the study, secondary techniques of data collection employed qualitative methods of collecting data. A secondary data can be defined as data that was previously gathered by someone and used in an alternative study. The researcher gathered case studies, reports, and scholarly papers that apply to the topic of AI in energy use and environmental sustainability in hospitals. This method gave access to very rich information that was based on various sources including the hospital reports, government publications and academic researches (Abdullah et al., 2022).

Inclusion and Exclusion Criteria

Inclusion and exclusion criteria were used to make sure that data gathered was relevant and dependable. Concentration with regard to the inclusion criteria was given to case studies and reports that had explicitly considered the application of AI in energy consumption estimations and environmental KPI optimization of Indian hospital settings. This was important due to the fact that AI functioning may have substantial differences among countries and healthcare systems, and the targeted population of the Indian hospitals enabled the researchers to capture specific needs and environments of the Indian health care system (Sethi & Caemmerer, 2024).

The exclusion criteria eliminated the studies that studied other industries than healthcare in which AI might be applied or the studies that lacked the direct interest in energy management and environmental

KPIs. Articles that were older than 10 years were not considered, except those that established initial knowledge on how AI could be used in energy management.

Data Analysis

The research study utilized thematic analysis in data analysis because it is flexible and useful in the analyzing qualitative information. Pattern identification or theme identification in large amounts of text can be done through thematic analysis, which makes it suitable to be used in research on secondary data such as case studies, reports and in academic texts. This approach assisted in identifying important insights concerning the use of AI in energy use prediction and betterment of the environments KPIs in hospitals. The first step in the analysis was the familiarization of the data, then coding was done to identify main segments that were pertinent to the research questions. The codes were categorized into more general themes, including implementation issues of AI, energy optimization methods, and policy compliance (Kaur, 2023).

Ethical consideration

Though the current study investigates the secondary data and direct contact with the participants was not involved, some major ethical issues were considered to achieve integrity in the research process. To start with, a secondary data was cited correctly, and it guarantees transparency and academic honesty (Adeshina, 2025). Where proprietary and confidential information formed part of the data, the relevant precautions were taken to anonymize sensitive data to ensure privacy and confidentiality of the institutions or individuals (Pandya et al., 2025). The study followed the principles of objectivity and bias elimination and as such, the information was not used subjectively.

Limitations of the methodology

Although the secondary methodology of qualitative research proved to be quite insightful, it has its own weaknesses. Another serious weakness was the usage of available information, which may not provide the most up-to-date and real-time innovations or current updates in AI technologies or hospital energy management. The fact that other researchers gathered the information on different purposes means that the data might lack full compatibility with the research objectives that this study may have (Pandya et al., 2025).

DATA ANALYSIS AD FINDINGS

Introduction

This chapter includes the processing of the secondary data obtained by using case studies, reports and academic literature on AI-based energy consumption forecasting and environmental KPI optimization in Indian hospitals. The purpose of the chapter is to present the information on how AI can help to increase energy efficiency, decrease carbon footprints, and align hospitals with sustainability in the Indian healthcare.

Data Sources

The primary sources of data used in the study to gain a deep insight into the use of AI in the consumption forecasting of energy and optimization of environmental KPIs within hospitals, specifically the Indian context, had been chosen carefully. The fundamental data sources were case studies, publications of the governments and other institutional publications as well as academic research articles.

The case studies were harvested out of hospitals around the world and in India particularly which have adopted the use of AI systems to ensure better utilization of energy and environmental KPIs. The case studies provided specific details on how AI is practiced in reality, the tactics employed, challenges involved, and the results of such applications.

Policy frameworks and regulatory guidelines were very useful in terms of shaping AI in the Indian healthcare sector, and the Government reports and announcements of the Bureau of Energy Efficiency (BEE), National Mission for Enhanced Energy Efficiency (NMEEE) and NABH Green Hospital Standards were significant in providing information on the same. They also discussed in these reports how to establish sustainability goals and the vision of the government pursuing Net Zero by the year 2070.

Thematic Analysis

Theme 1: AI-driven energy consumption forecasting and environmental KPI optimization in hospitals.

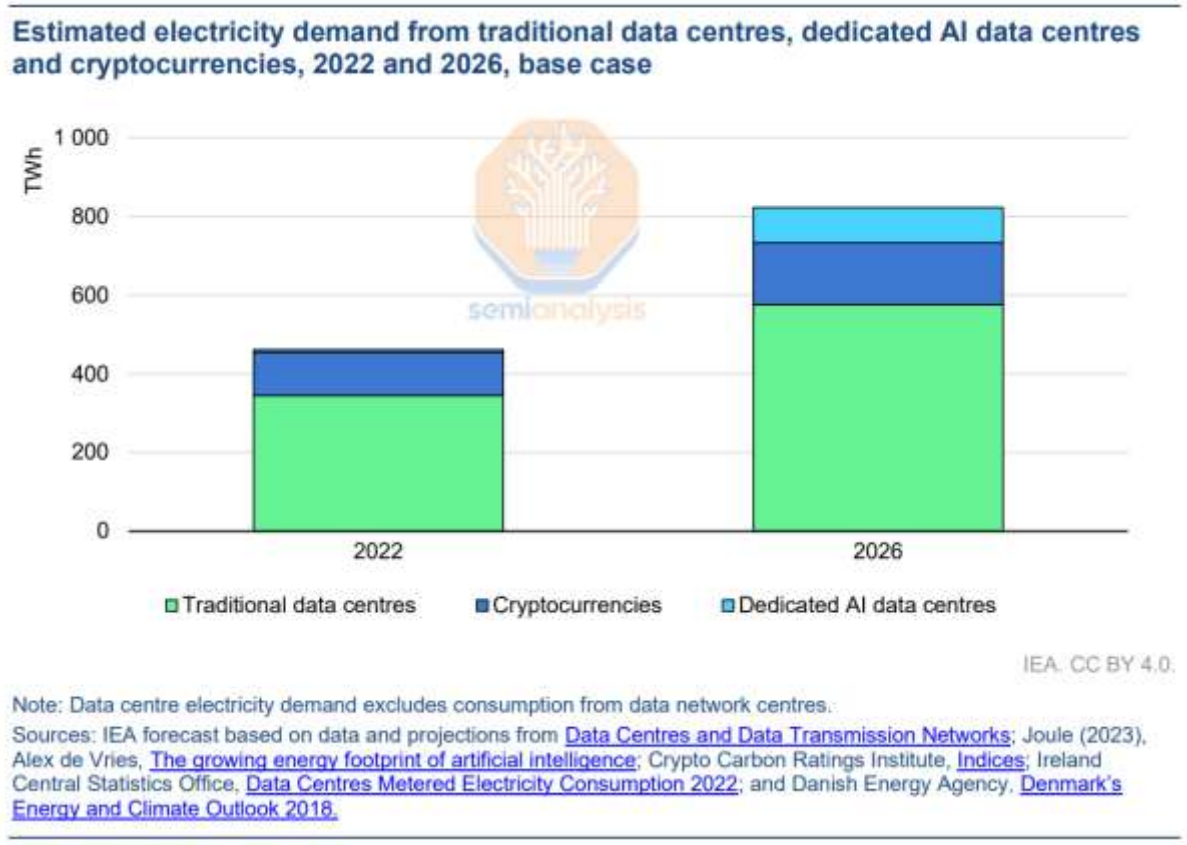

Figure 1: Case study

Source: (Patel, 2024)

Environmental KPI optimization in hospitals and the forecasting of energy consumption with the assistance of AI have received a great deal of attention, as sustainability and cost efficiency are becoming more and more of a concern.

As an example, a hospital case study conducted in the United States of America used machine learning algorithms to predict energy demand based on parameters such as occupancy of the hospital, seasonal impacts and operating times (Nong et al., 2025). Hospital saved 20-25 percent of its energy usage throughout a year, which resulted in a large savings in its budget and decrease of the carbon footprint (Gangahar et al., 2024).

These technologies are increasingly used in the hospitals in India. Application of AI to the real-time energy optimization was studied in a case study at AIIMS Delhi. The assisted machine learning provided ways of predicting peak energy demands which have resulted in a 15 percent decrease in costs of electricity and increased allocation of resources (Ammar Kamoona et al., 2023). Hospitals also used AI to maximize environmental KPIs such as CO 2 emissions, water usage, and waste management to support India sustainability-related initiatives such as the Net Zero by 2070.

Theme 2: Challenges in adopting AI for energy forecasting and KPI optimization in Indian hospitals, such as data quality, infrastructure, and cost barriers.

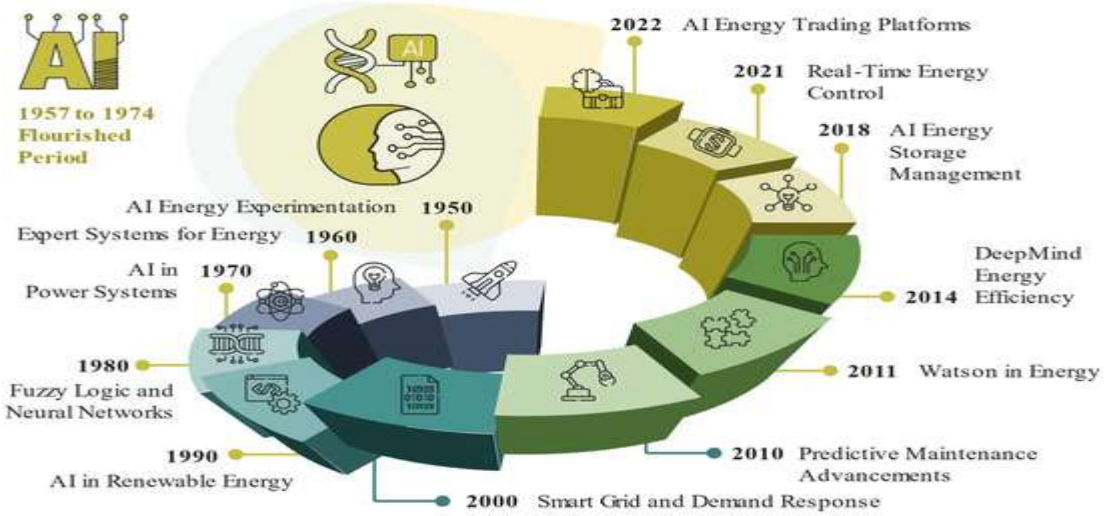

Figure 2: AI Adoption
Source: (Danish, 2023)

A report published by Bureau of Energy Efficiency (BEE) claims that nearly half of India hospitals do not have precise, real-time energy consumption data, and most of them use manual recording strategies, which results in inaccurate and incomplete information. In a study conducted at AIIMS Delhi, it was revealed that hospitals had a hard time in generating consistent energy consuming data without automated energy metering systems, which is necessary in order to optimize effectively using AI (ANI, 2023).

In a study done by the World Bank, it was revealed that in one such survey where 500 of the total public hospitals were surveyed by the Indian Ministry of Health, about 70 percent of the hospitals surveyed were reported to have insufficient IT infrastructure to implement an AI system (Bank, 2022). The weaknesses are the obsolete systems of energy administration, insufficiency of computing assets, and limited availability of high-speed web in hinterland healthcare facilities.

Lastly, there is the cost barrier which is a major hindrance. One report released by the National Health Systems Resource Centre (NHSRC) revealed that initial costs of setting up AI (up to 5-10 crore on hardware and software) are too much to afford by most hospitals (NATIONAL HEALTH ACCOUNTS ESTIMATES for INDIA, 2024).

Theme 3: Types of AI techniques (e.g., supervised learning, reinforcement learning) for optimizing energy consumption and environmental performance in hospitals.

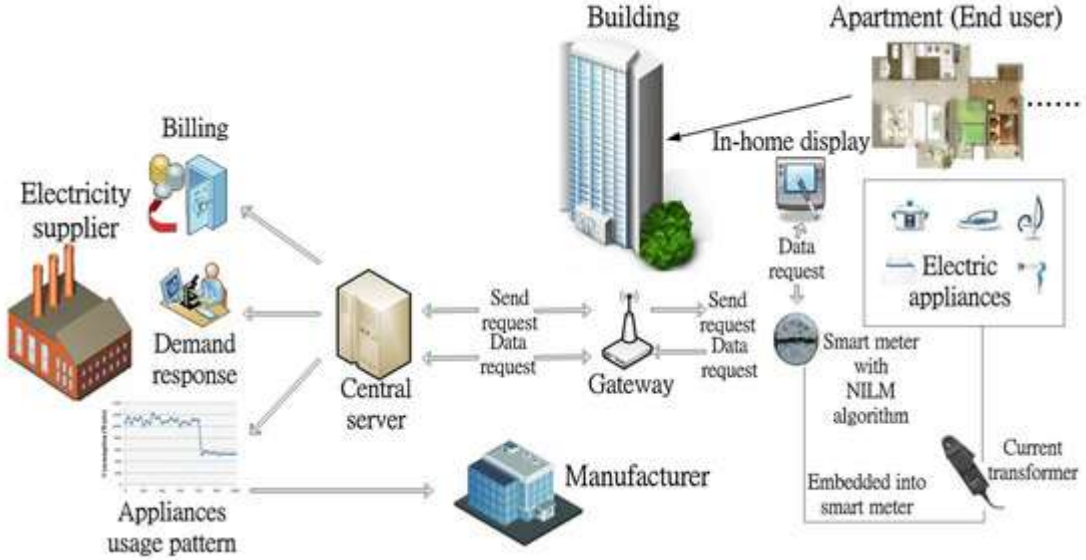

Figure 3: Types of AI techniques
Source: (Chui et al., 2018)

In hospital settings, especially in India applications of AI including supervised learning and reinforcement learning have shown a high potential within optimising energy consumption, and environmental performance. The most popular type of energy consumption forecasting is supervised learning that trains AI models on the basis of labeled dataset to make the predictions. Prescription of energy at AIIMS Delhi A Case study used machine learning supervised models to predict energy use as a function of inputs such as weather, hospital occupancy, and time of the day (Ushering Green & Digital Hospitals: Enabling Energy Saving through ICT, 2021). The results stated that the energy bill reduced by 20 percent in the first year of implementing the strategy of controlling the peak demand time by predicting the peak demand time and regulating the energy consumption.

Comparatively, reinforcement learning (RL), consisting of allowing systems participating in trials to learn the optimum strategies through experimentation, has been used to optimize HVAC systems in hospitals in real-time. As an example, a personal hospital in Bangalore introduced an RL-based system that was able to modify the HVAC parameters depending on the real-time environmental parameters temperature and humidity. The utilization of this system resulted in 15-18 percent decrease in energy use, and in a comfortable patient environment (Amir Mosavi & Abdullah Bahmani, 2019).

Also, in hospitals, unsupervised learning methods are applied to identify the peculiarities in using energy. One of these methods was used in a hospital in Chennai to implement it could realize up to 10 percent energy savings, by reducing inefficiencies previously unobserved by the hospital (José Chen-Xu et al., 2024).

Theme 4: Influence of AI-driven optimization on hospital sustainability, including cost savings, reduced CO_2 emissions, and alignment with national sustainability goals.

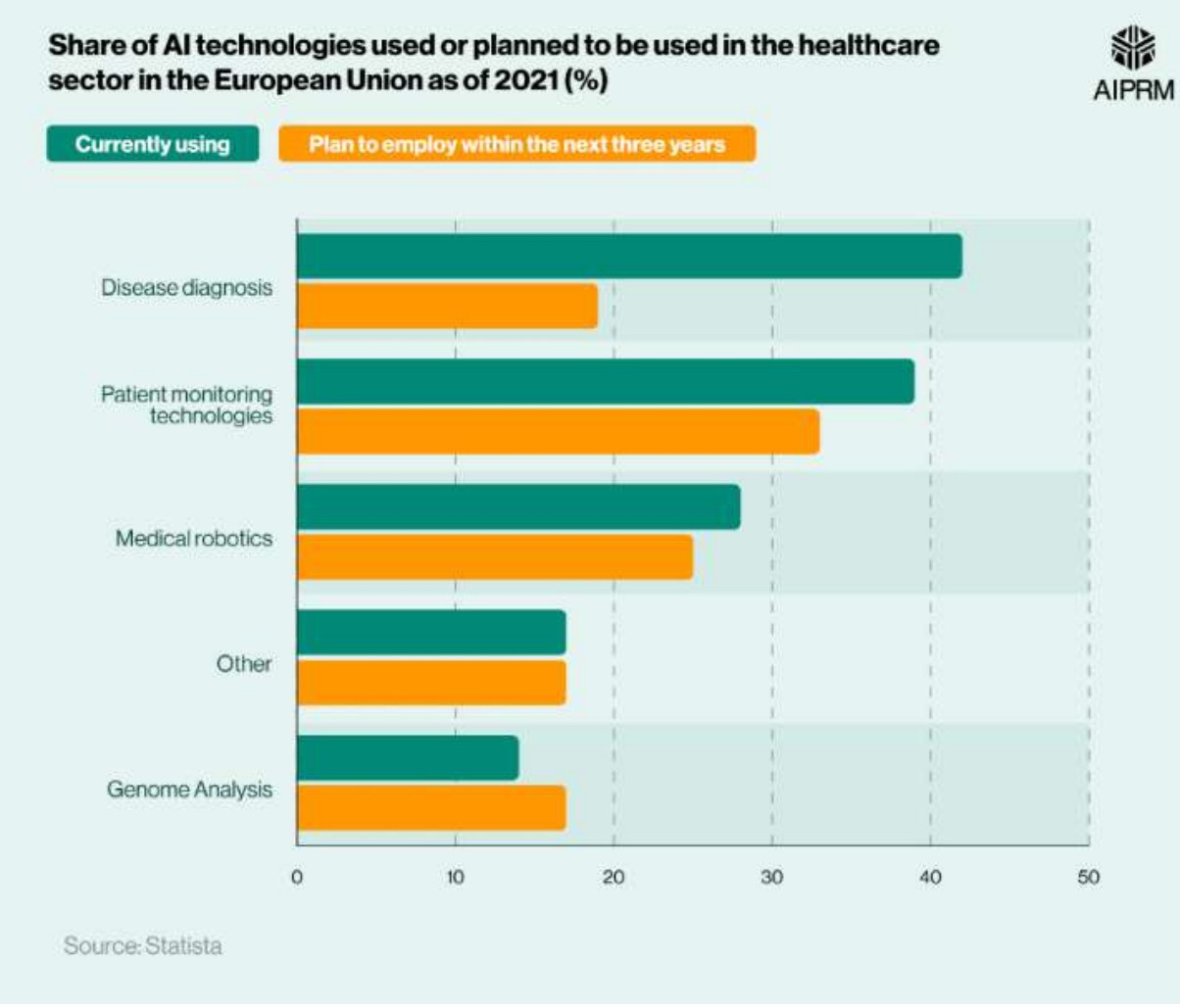

Figure 4: AI in Hospitality sector
Source: (AIPRM, 2024)

AI-enhanced optimization has significantly impacted hospital sustainability and can result in significant cost savings, CO2 emissions reduction, and adherence to national sustainability targets, like Net Zero by 2070. The case study conducted in AIIMS Del used the opportunities of AI to optimize energy demanding possibilities. In deploying AI-powered predictive analytics to predict energy use, the hospital saved 25 percent of its energy bills during the initial year (manuelap-msft, 2025; tedisel, 2023).

At a single-facility, AI-based optimization of HVAC systems in a private hospital in Bangalore led to 16 percent in energy consumption (Badrudeen Teslim, 2024). The hospital achieved more efficient energy use and optimal comfort of patients and staff by applying reinforcement learning to carry out real-time adaptations of the air-conditioning system as per Chatterjee et al. (2022).

Additionally, AI has also brought hospital in line with national sustainability ambitions, as AI-based energy management enables hospitals to achieve national sustainability targets such as net Zero 2070 and Energy Conservation Building code (ECBC). One hospital in Chennai that has adopted AI to optimize energy use showed savings of 20 lakh rupees yearly, as well as a 10 percent decrease in CO2 emissions, making its activities comply with India Group R green building norms (27% Energy Savings at National Hospital by Resync's Energy Optimisation. – Resync | AI-Smart Energy Management, 2024).

Key Findings

The thematic analysis furnished a few critical notes concerning the implementation of AI in estimating energy consumption, and environmental KPIs optimization in hospitals, notably in India. To start with, AI methods like machine learning and time-series forecasting were shown to be successful solutions to optimize energy consumption and operate environmental KPIs. The methods enable hospitals to forecast how much energy is going to be needed depending on issues such emperance, weather and when hospital activities are supposed to occur resulting in giant reductions in the amount of power that is used.

Many hospitals in India continue to use manual data registration and their low-resource poor datasets become inaccurate or incomplete, thus diminishing the performance of AI systems. Moreover, most hospitals (rural hospitals in particular) do not have the IT infrastructure needed to adopt AI solutions. Another impediment, particularly to the public hospitals, is high startup costs at an average of between 5-10 crore of implementing AI. Nevertheless, the results highlighted that the use of AI-based optimization can result in large cost savings and CO2 emission cuts, which would support long-term sustainability goals, such as Net Zero in 2070 as adopted in India.

DISCUSSION

The results obtained in the course of the thematic analysis are consistent with the literature reviewed concerning AI-based energy optimization and environmental KPI forecasting in hospitals all over the world and in India, in particular. As seen in the findings, AI technology, such as machine learning and time-series forecasting, has played a critical role in improving energy efficiency, as prescribed by Nong et al. (2025) and Gangahar et al. (2024) who showed the ability of AI to forecast energy demand in terms of occupancy and seasonal variations. Such outcomes do not contradict the study of Chowdhury (2025) and Ahmed et al. (2025), who underlined the importance of AI in intelligent buildings that would help induce energy savings on a scale of up to 30 percent due to the optimized consumption patterns.

Even the challenges identified in the analysis or those relating to data quality, infrastructure, and cost barriers all echoed the findings of the body of literature. Fatehijananloo et al. (2024) and Kilaru and Potluri (2025) observed that contradictory data and absence of stable information technology infrastructure are significant hitches of implementing AI-based solutions in health institutions, particularly in the developing nations. This can be supported by new findings presented in Bureau of Energy Efficiency (2024) which indicate that a significant number of Indian hospitals do not have the necessary data and energy metering systems so that they could use AI.

Nevertheless, the results justify the sustainability of AI integration in hospitals in the long-term, which justifies the national Net Zero 2070 vision outline by BEE and NABH Green Hospital Standards in India. The amount of energy saved and the decrease in CO 2 emissions that such hospitals as AIIMS Delhi and those in Bangalore have achieved support the possibilities of the AI in promoting national sustainability, as it is outlined in Tan et al. (2025) and Resync (2024).

CONCLUSION

This paper has examined the prospects of the AI-based energy consumption prediction and environmental KPI optimization in hospitals, specifically of the Indian healthcare environment. The results highlight the disruptive nature of AI to enhance energy efficiency and sustainability, such as predicting energy demand, HVAC optimization, and CO 2 emissions minimalization. Institutions of the medical complex, including AIIMS Delhi, have well illustrated the practical and positive effects of AI and cost savings in thousands of dollars and concurrence with national sustainability targets, including a Net Zero by 2070. With application of AI methods such as machine learning and time-series forecasting, energy use can be predicted to a degree of higher accuracy, which subsequently enables more effective use of resources in hospitals. Nonetheless, the study revealed that there are still some obstacles to adopting AI especially in the aspects of data quality, infrastructure, and costs. Not all hospitals, particularly located in rural areas, have the IT systems and appropriate data to make use of AI solutions. In addition, the upfront cost of AI technologies is a great challenge, especially to public hospitals operating on low budgets. To address these issues, the study suggests better data infrastructure, measured and targeted policy incorporation, and economic rewards in a bid to substantiate the introduction of AI.

RECOMMENDATIONS

According to the results of the research, a number of practical recommendations are given regarding the effective implementation and integration of AI-driven energy consumption forecasting and environmental KPI optimization in hospitals, especially in the context of the Indian healthcare industry:

- Improve Data Infrastructure: Hospitals need to keep investing in quality energy metering systems that have automated data collection systems. This will enhance the quality of real-time data thus enhancing the effectiveness of the AI-driven forecasting models. Creating smart grids and data storage repositories will facilitate maintenance of similar and quality data access to predictive analytics.
- Government and Policy Support: Government should support AI implementation by providing financial incentives, subsidy and grants including in case of public hospitals. Such policies as the Energy Conservation Building Code (ECBC) and NABH Green Hospital Standards should also be mapped to AI-driven solutions which would provide definite guidelines to hospitals to achieve the sustainability goals (Mominkhan et al., 2023).
- Long-Term Sustainability: Hospitals must take a holistic approach in their sustainability by combining AI-assisted energy management with other green steps like renewable energy, waste management, and water utilization in an effort to consume their fair share of the energy net calculus of India by 2070.

LIMITATIONS OF THE STUDY

Although this paper gives a good understanding of the area of AI-passive energy optimization in hospitals, there are some limitations that must be mentioned. To begin with, the study mainly used secondary data, meaning that it might fail to capture issues and innovations in the field of AI application in Indian hospitals in real-time. Moreover, only case studies were in the spotlight, so it was not possible to make generalizations across the hospital context (Medidhi et al., 2024). The examination did not also tap on primary data, including firsthand experiences or interviews with the hospital management, that would have given better insights on the obstacles and advantages of using AI.

FURTHER SUGGESTIONS

It is important to rely on interviews, surveys, or field observations as the means of collecting primary data on the barriers and opportunities of AI adoption in Indian hospitals in the real time. Another issue is that the studies must cover a broader hospital diversity, such as urban and rural public and private hospitals to get a broader analysis. The applicability and usefulness of the AI models ought to be evaluated according to the sustainability and cost reduction on a broader scale of hospitals (Taliento, 2024).

REFERENCES

1. Chowdhury BR. AI-Powered Forecasting and Optimization of Energy Consumption in the USA: Machine Learning Approaches for Sustainable Urban and Institutional Development. Euro Vantage journals of Artificial intelligence. 2025 Jun 3;2(2):21-38.
2. Ahmed A, Jakir T, Mir MN, Zeeshan MA, Hossain A, hoque Jui A, Hasan MS. Predicting energy consumption in hospitals using machine learning: a data-driven approach to energy efficiency in the USA. Journal of Computer Science and Technology Studies. 2025 Feb 14;7(1):199-219.
3. Chui KT. Artificial Intelligence in Energy Sustainability: Predicting, Analyzing, and Optimizing Consumption Trends. International Journal of Sustainable Science and Technology. 2025 Apr 8;1(1).
4. Nihi TV, Forkuo AY, Ojo OO, Collins Nwannebuike Nwokedi OS. A Conceptual Framework for AI-Driven Healthcare Optimization and Predictive Analytics. Multidisciplinary Journal of Engineering, Technology and Sciences. 2025 Jul 6;2(1).
5. Nianga ZW. Leveraging AI for Strategic Management in Healthcare: Enhancing Operational and Financial Performance. Journal of Intelligence and Knowledge Engineering (ISSN: 2959-0620). 2024;2(3):1.
6. Fatehijananloo M, Stopps H, McArthur JJ. Exploring artificial intelligence methods for energy prediction in healthcare Facilities: An In-Depth extended systematic review. Energy and Buildings. 2024 Oct 1;320:114598.
7. Pariso P, Picariello M, Marino A. AI integration in energy management: enhancing efficiency in Italian hospitals. Health Economics Review. 2025 May 19;15(1):40.
8. Kilaru M, Potluri RM. Artificial Intelligence (AI) Adoption and Implementation Challenges in Indian Healthcare Sector. InArtificial Intelligence in Healthcare Information Systems—Security and Privacy Challenges 2025 Mar 30 (pp. 171-183). Cham: Springer Nature Switzerland.
9. Chatterjee S, Chaudhuri R, Thrassou A, Vrontis D. Technology disruption in healthcare: artificial intelligence application, challenges, and policy recommendations in India. International Journal of Internet Marketing and Advertising. 2022;17(3-4):394-414.
10. Kumar G, Singh RK, Arya V, Mishra SK. Analyzing barriers in adoption of artificial intelligence for resilient health care services to society. Global Journal of Flexible Systems Management. 2024 Mar;25(1):179-97.
11. Olagunju E. Integrating AI-driven demand forecasting with cost-efficiency models in biopharmaceutical distribution systems. Int J Eng Technol Res Manag. 2022 Jun 6.
12. Ahmed A, Jakir T, Mir MN, Zeeshan MA, Hossain A, hoque Jui A, Hasan MS. Predicting energy consumption in hospitals using machine learning: a data-driven approach to energy efficiency in the USA. Journal of Computer Science and Technology Studies. 2025 Feb 14;7(1):199-219.
13. Dewasiri NJ, Rathnasiri MS, Karunarathna KS. Artificial intelligence-driven technologies for environmental sustainability in the healthcare industry. InTransforming Healthcare Sector Through Artificial Intelligence and Environmental Sustainability 2025 Jan 23 (pp. 67-87). Singapore: Springer Nature Singapore.
14. Pradeep S, Kalpana P, Sreeram G, Adgaonkar A, Roy DR, Namdev A. Advanced Machine Learning Techniques for Optimizing Renewable Energy Systems in Healthcare Facilities. In2024 4th International Conference on Technological Advancements in Computational Sciences (ICTACS) 2024 Nov 13 (pp. 1801-1807). IEEE.
15. Ogundiran J, Asadi E, Gameiro da Silva M. A systematic review on the use of AI for energy efficiency and indoor environmental quality in buildings. Sustainability. 2024 Apr 26;16(9):3627.
16. Villano F, Mauro GM, Pedace A. A review on machine/deep learning techniques applied to building energy simulation, optimization and management. Thermo. 2024 Mar 6;4(1):100-39.
17. Gupta SK, Patel S, Mannepalli PK, Gangrade S. Designing Dense-Healthcare IOT Networks for Industry 4.0 Using AI-Based Energy Efficient Reinforcement Learning Protocol. InIndustry 4.0 and Healthcare: Impact of Artificial Intelligence 2023 Dec 2 (pp. 37-58). Singapore: Springer Nature Singapore.
18. Dewasiri NJ, Rathnasiri MS, Karunarathna KS. Artificial intelligence-driven technologies for environmental sustainability in the healthcare industry. InTransforming Healthcare Sector Through Artificial Intelligence and Environmental Sustainability 2025 Jan 23 (pp. 67-87). Singapore: Springer Nature Singapore.
19. Wu Q. Optimization of AI-driven communication systems for green hospitals in sustainable cities. Sustainable Cities and Society. 2021 Sep 1;72:103050.
20. Tan L, Singi A, Cross A. AI-Driven Innovation For A Sustainable Future: Transforming Healthcare. Metallurgical and Materials Engineering. 2025 May 7:1432-9.
21. Allahham MA, Sharabati AA, Hatamlah HE, Ahmad AY, Sabra S, Daoud MK. Big data analytics and AI for green supply chain integration and sustainability in hospitals. WSEAS Transactions on Environment and Development. 2023;19:1218-30.
22. Nihi TV, Forkuo AY, Ojo OO, Collins Nwannebuike Nwokedi OS. A Conceptual Framework for AI-Driven Healthcare Optimization and Predictive Analytics. Multidisciplinary Journal of Engineering, Technology and Sciences. 2025 Jul 6;2(1).
23. Alemde VO. Deploying strategic operational research models for AI-augmented healthcare logistics, accessibility, and cost reduction initiatives. Int Res J Mod Eng Technol Sci. 2025 Feb;7(2):2353.
24. Gangahar M, Goenka A, Kachhawa S, Mathew S, Kumar S, Kurup R, et al. Hospital Energy Consumption Survey: The Lived Experience. PROCEEDINGS OF ENERGISE 2023 Lifestyle, Energy Efficiency, and Climate Action [Internet]. 2024 Apr [cited 2025 Aug 18];171–7. Available from: https://www.energiseindia.in/wp-content/uploads/2024/05/Hospital-Energy-Consumption-Survey.pdf
25. Ammar Kamoona, Song H, Kian Keshavarzian, Levy K, Jalili M, Wilkinson R, et al. Machine learning based energy demand prediction. Energy reports. 2023 Nov 1;9:171–6.

26. Nong P, Adler-Milstein J, Apathy NC, Holmgren AJ, Everson J. Current Use And Evaluation Of Artificial Intelligence And Predictive Models In US Hospitals. Health Affairs. 2025 Jan 1;44(1):90–8.
27. ANI. Delhi hospitals witness spike in patients as air pollution rises: AIIMS [Internet]. @bsindia. Business Standard; 2023 [cited 2025 Aug 18]. Available from: https://www.business-standard.com/india-news/delhi-hospitals-witness-spike-in-patients-as-air-pollution-rises-aiims-123110201069_1.html
28. Bank W. The World Bank Annual Report 2022 : Helping Countries Adapt to a Changing World [Internet]. World Bank. 2022. Available from: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099030009272214630/bosib0db37c9aa05a0961a08a83a0ea76ea
29. NATIONAL HEALTH ACCOUNTS ESTIMATES FOR INDIA [Internet]. 2024 [cited 2025 Aug 18]. Available from: https://www.mohfw.gov.in/sites/default/files/NHA%202020-21_up.pdf
30. Ushering Green & Digital Hospitals: Enabling Energy Saving through ICT [Internet]. Social Innovation. 2021 [cited 2025 Aug 18]. Available from: https://social-innovation.hitachi/en-in/case_studies/aiimshospital/
31. Amir Mosavi, Abdullah Bahmani. Energy Consumption Prediction Using Machine Learning; A Review [Internet]. 2019. Available from: https://www.researchgate.net/publication/331638667_Energy_Consumption_Prediction_Using_Machine_Learning_A_Review
32. José Chen-Xu, Kislaya I, Fernandes RM, Carvalho J, Blanco-Rojas BJ, Omnia El-Omrani, et al. Interventions for increasing energy efficiency in hospitals. The Cochrane library. 2024 Mar 5;2024(3).
33. manuelap-msft. Perform predictive data analysis using Dataverse, Fabric, and Azure AI services - Power Platform [Internet]. Microsoft.com. 2025. Available from: https://learn.microsoft.com/en-us/power-platform/architecture/reference-architectures/ai-predictive-data-analysis
34. tedisel. Green innovation in hospitals: technology and sustainability [Internet]. Tedisel Medical. 2023. Available from: https://tediselmedical.com/en/green-innovation-in-hospitals-technology-and-sustainability-for-a-healthier-future/
35. Badrudeen Teslim. Optimizing HVAC Systems Using Artificial Intelligence [Internet]. ResearchGate. unknown; 2024. Available from: https://www.researchgate.net/publication/384844095_Optimizing_HVAC_Systems_Using_Artificial_Intelligence
36. 27% Energy Savings at National Hospital by Resync's Energy Optimisation. – Resync | AI-Smart Energy Management [Internet]. Resynctech.com. 2024 [cited 2025 Aug 18]. Available from: https://www.resynctech.com/27-energy-savings-at-national-hospital-by-resyncs-energy-optimisation/
37. Patel D. AI Datacenter Energy Dilemma – Race for AI Datacenter Space [Internet]. SemiAnalysis. 2024. Available from: https://semianalysis.com/2024/03/13/ai-datacenter-energy-dilemma-race/
38. Danish MSS. AI in Energy: Overcoming Unforeseen Obstacles. AI [Internet]. 2023 Jun 1;4(2):406–25. Available from: https://www.mdpi.com/2673-2688/4/2/22
39. Chui KT, Lytras MD, Visvizi A. Energy Sustainability in Smart Cities: Artificial Intelligence, Smart Monitoring, and Optimization of Energy Consumption. Energies. 2018 Oct 23;11(11):2869.
40. AIPRM. 50+ AI in Healthcare Statistics 2024 [Internet]. Aiprm.com. 2024. Available from: https://www.aiprm.com/ai-in-healthcare-statistics/
41. Ahmed A, Jakir T, Mir MN, Zeeshan MA, Hossain A, hoque Jui A, Hasan MS. Predicting energy consumption in hospitals using machine learning: a data-driven approach to energy efficiency in the USA. Journal of Computer Science and Technology Studies. 2025 Feb 14;7(1):199-219.
42. Pariso P, Picariello M, Marino A. AI integration in energy management: enhancing efficiency in Italian hospitals. Health Economics Review. 2025 May 19;15(1):40.
43. Kareem SA, Quazi F. Optimizing Energy Usage in Hospitals and Medical Centers with AI/ML: Ensuring Continuous Critical Operations while Reducing Costs and Carbon Footprint. International Journal of Global Innovations and Solutions (IJGIS). 2024 Aug 31.
44. Ahmed N, Bennati S, Anglani N. Energy Performance Benchmarking and Indicators: A Comprehensive Framework for Scientifically Sound Data-Driven and Energy Management Improvements in Hospitals. In2024 IEEE 8th Energy Conference (ENERGYCON) 2024 Mar 4 (pp. 1-6). IEEE.
45. Cumo F, Giovenale AM, Pennacchia E, Tiburcio VA. Towards a Healthier Hospital Environment: The Role of Digital Twins in Achieving Optimal Environmental Comfort. Digital Twins and Applications. 2025 Jan;2(1):e70002.
46. Chen A. Optimising HVAC Operations in Hospitals with AI and IoT: An Economic Analysis. InInternational Workshop on Navigating the Digital Business Frontier for Sustainable Financial Innovation (ICDEBA 2024) 2025 Feb 24 (pp. 377-383). Atlantis Press.
47. Frassanito R, Buso T, Aumann S, Toniolo J, Albrici P, Canevari P, Iemmi M, Mapelli F. How IoT and Artificial Intelligence can improve energy efficiency in hospitals-a North Italian case study. InE3S Web of Conferences 2022 (Vol. 343, p. 02001). EDP Sciences.
48. Chen JK, Ho HH. Asset resource optimization solution for smart hospital facilities and energy management through an interpretive structural model. Buildings. 2023 Dec 8;13(12):3064.
49. Dewasiri NJ, Rathnasiri MS, Karunarathna KS. Artificial intelligence-driven technologies for environmental sustainability in the healthcare industry. InTransforming Healthcare Sector Through Artificial Intelligence and Environmental Sustainability 2025 Jan 23 (pp. 67-87). Singapore: Springer Nature Singapore.
50. Kareem SA, Quazi F. Optimizing Energy Usage in Hospitals and Medical Centers with AI/ML: Ensuring Continuous Critical Operations while Reducing Costs and Carbon Footprint. International Journal of Global Innovations and Solutions (IJGIS). 2024 Aug 31.

51. Chen JK, Ho HH. Asset resource optimization solution for smart hospital facilities and energy management through an interpretive structural model. Buildings. 2023 Dec 8;13(12):3064.
52. Poonia P, Tewolde B, Surendar D, Naghapushanam M. AI-Enhanced Robotics for Efficient Hospital Facility Maintenance in Cloud Environments. In2025 11th International Conference on Communication and Signal Processing (ICCSP) 2025 Jun 5 (pp. 441-446). IEEE.
53. Abdullah A, Ahmad S, Athar MA, Rajpoot N, Talib F. Healthcare performance management using integrated FUCOM-MARCOS approach: The case of India. The International Journal of Health Planning and Management. 2022 Sep;37(5):2635-68.
54. Sethi S, Caemmerer B. The Implementation of Integrated Energy Management Systems in Healthcare Facilities-Balancing Efficiency and Effectiveness. IJLRP-International Journal of Leading Research Publication.;5(8).
55. Kaur J. IoT empowered smart cities for green healthcare: a sustainable pathway to transforming healthcare systems. In2023 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS) 2023 Nov 3 (pp. 64-70). IEEE.
56. Adeshina YT. Strategic implementation of predictive analytics and business intelligence for value-based healthcare performance optimization in US health sector.
57. Pandya J, Sarkar D, Kaul DS. Application of Fuzzy Factor Comparison Method for Evaluation of Key Performance Indicators Affecting Air Quality in India: A Decision Matrix Approach for Mitigating Anthropogenic Pollution Sources. Journal of The Institution of Engineers (India): Series A. 2025 Mar;106(1):175-93.
58. Pandya J, Sarkar D, Kaul DS. Application of Fuzzy Factor Comparison Method for Evaluation of Key Performance Indicators Affecting Air Quality in India: A Decision Matrix Approach for Mitigating Anthropogenic Pollution Sources. Journal of The Institution of Engineers (India): Series A. 2025 Mar;106(1):175-93.
59. Mominkhan D, Alamri FA, Balharith M, Alharbi M, Alshebli A, Alshareef SY, Khairaldain A, Almutairi N, Abusit A, Almuzaini Y, Alahmari AA. The current state and potential evolution of carbon emissions in the healthcare sector: a narrative review article. Frontiers in Sustainable Energy Policy. 2023 Dec 15;2:1230253.
60. Medidhi W, Srikanth K, Selvam PP, Anbalagan A, Parthiban KG, Das A. Renewable Energy and Smart Healthcare Infrastructure for Sustainable Urban Development. InInternational Conference on Innovative Discoveries and Emerging Advancements in Applied Sciences 2024 Apr 18 (pp. 251-263). Cham: Springer Nature Switzerland.
61. Taliento M. Empowering the management and performance accounting system in healthcare organisations with Artificial Intelligence: Literature and industry cases. Economia Aziendale Online-. 2024 Dec 30;15(4):711-31.
62. Shafik W. The Role of Artificial Intelligence of Medical Things (AIoMT) in Green Healthcare: Navigating Sustainable Healthcare System. InUtilizing AI of Medical Things for Healthcare Security and Sustainability 2025 (pp. 119-156). IGI Global Scientific Publishing.