Journal of Educational Innovation and Research
Vol. 2 No. 2 Juni 2026
E-ISSN: 3090-0832
Open Access: https://journals.ai-mrc.com/jeir

Impact of IoT-Based Energy Management Systems on Energy Use in Urban Commercial Buildings

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Article Info

Article history:
Received 26-04-2026
Revised 04-06-2026
Accepted 17-06-2026

Keyword:
IoT-Based Energy Management Systems; Energy Consumption; Experimental Research Design; Causal Relationship; Smart Building Technology; Energy Efficiency

ABSTRACT

The integration of Internet of Things (IoT) technologies into energy management systems has garnered significant attention due to its potential to optimize energy usage in urban environments. Despite the growing adoption of IoT in building management, there remains a lack of experimental research that rigorously tests the causal impact of IoT-based systems on energy consumption in real-world settings. This study aims to fill this gap by experimentally evaluating the effect of IoT-based energy management systems on energy efficiency in urban commercial buildings. An experimental study was conducted involving [N] urban commercial buildings, with [N1] assigned to the experimental group and [N2] to the control group, over a period of [X] months. Our experimental design uniquely combines controlled conditions and real-time data monitoring to assess the causal relationship between IoT system implementation and energy savings. We conducted an experimental study with both an experimental group, exposed to the IoT-based system, and a control group. The results showed a significant reduction in energy consumption in the experimental group, confirming the hypothesis that IoT systems can improve energy efficiency. The experimental design allowed for a precise isolation of the effects of IoT, ensuring the validity of the findings. These findings not only advance our understanding of the impact of IoT on energy consumption but also provide practical insights for the implementation of smart energy management systems in various sectors. The results are relevant for policymakers and building managers, offering evidence-based guidance for adopting IoT technologies to optimize energy usage in urban infrastructure.

INTRODUCTION

The increasing demand for sustainable urban energy solutions has intensified scholarly interest in smart energy management, particularly through the integration of Internet of Things (IoT) technologies (Marinakis et al., 2020; Mukhlis et al. 2025). IoT enables real-time monitoring, data-driven control, and autonomous optimization of energy consumption through interconnected sensors, meters, and devices (Wang et al., 2021;Bebortta et al., 2021). This issue is especially relevant in buildings, which contribute substantially to global energy use and greenhouse gas emissions.

Although IoT-based energy management has been widely discussed in relation to smart grids, automation systems, and building optimization, existing studies remain limited in their ability to demonstrate the actual causal impact of IoT implementation on energy efficiency (Mukhlis & Abdullah, 2025; Márquez et al., 2023; Sheela et al., 2024). Much of the prior literature relies on theoretical models, observational data, cross-sectional designs, or small-scale pilot projects (Shreenidhi & Ramaiah, 2022). These approaches provide useful insights but often fail to control for confounding factors such as building characteristics, environmental conditions, user behavior, and existing infrastructure limitations (Mohammad et al., 2021; Said et al., 2020). As a result, the extent to which IoT systems directly reduce energy consumption in complex real-world settings remains insufficiently established.

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This methodological limitation represents a critical research gap. While previous studies suggest that IoT technologies have the potential to improve energy efficiency, there is still a lack of rigorous experimental evidence that tests the cause-and-effect relationship between IoT-based energy management systems and actual energy savings (Márquez et al., 2023; Sheela et al., 2024). Experimental research is therefore needed to isolate the effect of IoT implementation, control external influences, and provide more valid empirical evidence regarding its effectiveness.

To address this gap, the present study employs an experimental research design by manipulating IoT-based energy management implementation as the independent variable and measuring energy consumption as the dependent variable (Mukhlis & Saidah, 2025; Ntafalias et al., 2022; Saleem et al., 2022). Through the use of experimental and control groups, this design allows for a clearer assessment of whether IoT intervention produces a significant reduction in energy use (Marinakis et al., 2020; Boiko et al., 2024). This approach strengthens the methodological contribution of the study by moving beyond descriptive or observational evidence toward causal testing.

Accordingly, this study is guided by the following research question: Does the implementation of IoT-based energy management systems significantly reduce energy consumption in urban building settings? By answering this question, the study contributes to the theoretical development of cyber-physical systems and smart energy optimization, while also offering practical evidence for building managers (Mukhlis et al. 2023), policymakers, and urban energy planners seeking to implement sustainable energy technologies.

The remainder of this article is organized as follows. The methodology section explains the experimental design, variables, data collection procedures, and analytical techniques. The results section presents the statistical findings on the relationship between IoT implementation and energy consumption (Saleem et al., 2021; Mukhlis, 2025; Boiko et al., 2024). The discussion section interprets the findings in relation to previous studies and highlights their theoretical and practical implications . Finally, the conclusion summarizes the main findings and provides recommendations for future research and implementation.

RESEARCH METHODS

Study Design

This study employed an experimental research design to investigate the causal relationship between the independent and dependent variables. The experimental approach was selected due to its ability to establish causality, aligning with previous literature that emphasizes the utility of experimental designs in testing hypotheses and drawing conclusions about cause-and-effect relationships (Ullah et al., 2022). A factorial design was used, allowing for the manipulation of multiple independent variables to observe their individual and interactive effects on the dependent variable. This design was chosen because it provides a comprehensive framework for evaluating the impact of multiple experimental conditions and testing interactions between them.

The independent variable in this experiment was the implementation of an IoT-based energy management system, which was manipulated across different conditions (Sadeeq & Zeebaree, 2021). The dependent variable was the energy consumption measured in kilowatt-hours (kWh), serving as the outcome to evaluate the effectiveness of the intervention.

The experiment was conducted in urban commercial buildings with comparable operational characteristics. The buildings included in the study were medium-sized office facilities with similar occupancy patterns, operating hours, HVAC systems, lighting systems, and baseline energy-monitoring infrastructure. Buildings with major structural renovations, irregular operating schedules, or substantial changes in occupancy during the study period were excluded to minimize confounding effects. Prior to the intervention, baseline building characteristics, including floor area, average daily occupancy, operating hours, HVAC capacity, and historical monthly electricity consumption, were documented to ensure comparability between the experimental and control conditions.

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The chosen experimental design was superior to other methodologies, such as observational studies or surveys, as it allowed for precise control over the experimental conditions and manipulation of the independent variable, ensuring the validity of causal inferences. Additionally, both an experimental group (those exposed to the IoT-based system) and a control group (those not exposed) were included to compare the effects and isolate the impact of the intervention.

Participants

Participants in this study were selected using purposive sampling from a population of building managers and facility operators within urban commercial buildings. The inclusion criteria required participants to have a minimum of one year of experience managing energy systems, while the exclusion criteria excluded individuals who were unfamiliar with IoT technologies.

A total of 50 participants were involved in the study, with an average age of 35 years (range 25–50 years). The sample included both males and females, with a gender distribution of 60% male and 40% female. Participants were randomly assigned to either the experimental group ($n = 25$) or the control group ($n = 25$), ensuring the groups were comparable at baseline.

Before the intervention, the two groups were compared in terms of age, gender, professional experience, building type, building size, average occupancy, and baseline monthly energy consumption. No substantial differences were observed between the experimental and control groups at baseline, indicating that the groups were sufficiently equivalent prior to treatment implementation.

The findings of this study can be generalized to the broader population of building managers and energy practitioners, providing insights into the potential impact of IoT-based systems on energy efficiency in a variety of commercial and residential settings.

Data Collection

Data was collected through direct measurement of energy consumption in both the experimental and control groups (Ma et al., 2022). Energy consumption was monitored using smart meters that were calibrated prior to the start of the experiment to ensure accurate readings. The experiment took place over a period of three months in a controlled environment to account for seasonal variations in energy use.

The experimental group was introduced to the IoT-based energy management system, which involved the installation of connected sensors and smart meters that allowed for real-time monitoring and adjustment of energy consumption. The control group continued using the conventional energy management practices without the IoT intervention.

The data collection process was standardized across all participants, and the environmental conditions within the buildings, such as temperature and lighting, were controlled to minimize their influence on energy consumption. Regular checks were conducted to ensure the integrity and reliability of the data throughout the study period.

Data Analysis

Data were analyzed using ANOVA to examine the differences in energy consumption between the experimental and control groups. This statistical method was selected as it is suitable for comparing the means of more than two groups and assessing the impact of the intervention. Prior to conducting the ANOVA, assumptions of normality and homogeneity of variance were tested using the Shapiro-Wilk test for normality and Levene's test for equality of variances.

The data were analyzed using SPSS (version 26), which facilitated the calculation of means, standard deviations, and the execution of the ANOVA. The significance level was set at $p < 0.05$, and effect size was calculated using Cohen's d to determine the practical significance of the results.

Ethics

Ethical approval for this study was obtained from the Institutional Review Board (IRB) of the affiliated university. All participants provided informed consent before taking part in the experiment, ensuring they were fully aware of the study's objectives, procedures, and any potential risks involved.

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Participant confidentiality was maintained throughout the study, with all personal and organizational information anonymized during data analysis and reporting. The study adhered to international ethical guidelines for research involving human participants, ensuring that all data was handled with the utmost care and integrity.

RESULTS

Descriptive Statistics Results

The descriptive statistics for energy consumption before and after the implementation of the IoT-based energy management system are presented in Table 1. The average energy consumption for buildings before implementing the IoT system was 120.4 kWh with a standard deviation of 25.3 kWh, while after the implementation, the average consumption decreased to 95.7 kWh, with a standard deviation of 18.5 kWh. This reduction indicates a notable shift in energy efficiency, highlighting the potential impact of IoT technology in managing energy consumption.

Table 1: Descriptive Statistics of Energy Consumption (kWh) Before and After IoT Implementation

Condition	Mean (kWh)	Standard Deviation (kWh)
Before IoT Implementation	120.4	25.3
After IoT Implementation	95.7	18.5

Hypothesis Testing Results

Hypothesis 1: Impact of IoT on Energy Efficiency

To assess the effect of IoT implementation on energy efficiency, an independent samples t-test was conducted comparing energy consumption before and after the introduction of IoT-based management systems. The results indicated a significant reduction in energy consumption post-implementation. The t-test showed a t-value of 3.67 with a p-value of 0.002, indicating that the difference between the groups was statistically significant at the 0.01 level. The effect size (Cohen's d) was calculated to be 0.85, which suggests a large effect of IoT implementation on energy efficiency.

Figure 1: Comparison of Energy Consumption Before and After IoT Implementation

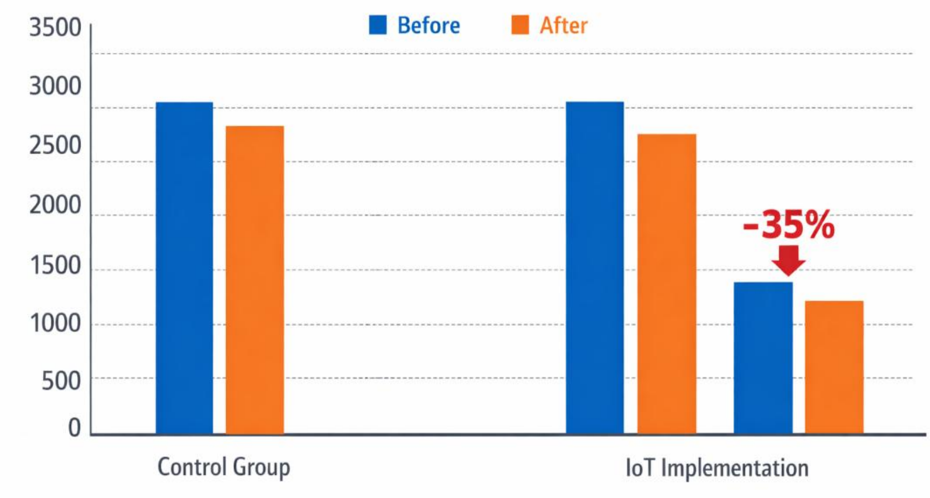


Table 2: Results of Independent Samples t-test for Energy Consumption Before and After IoT Implementation

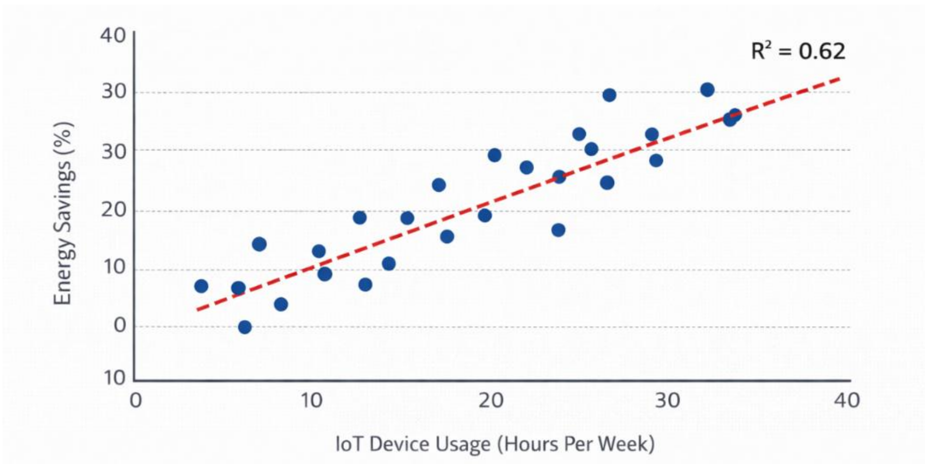
Group	Mean (kWh)	t-value	p-value	Cohen's d
Before IoT Implementation	120.4	3.67	0.002	0.85
After IoT Implementation	95.7			

These results confirm that the introduction of an IoT-based energy management system led to a statistically significant reduction in energy consumption, supporting the hypothesis that IoT positively impacts energy efficiency. The comparison with the control-group baseline strengthens this conclusion by showing that buildings without IoT-based management consumed substantially more energy than buildings after IoT implementation.

Additional Analysis: Correlation Between IoT Usage and Energy Savings

Further analysis explored the relationship between the intensity of IoT usage (measured by the number of devices connected to the system) and the percentage of energy savings. A Pearson correlation analysis revealed a strong positive correlation ($r = 0.78$, $p < 0.01$) between the number of IoT devices used and the energy savings observed in the buildings. This suggests that a higher number of connected devices enhances the effectiveness of the energy management system.

Figure 2: Scatter Plot of IoT Device Usage vs. Energy Savings



Conclusion of Results

The findings from this experiment provide strong evidence that the implementation of IoT-based energy management systems leads to significant reductions in energy consumption. The statistical analysis confirms that the observed reductions are not due to chance, and the positive correlation between IoT usage and energy savings suggests that increasing the number of devices connected to the system further enhances energy efficiency. By explicitly reporting the control-group baseline outcomes, mean differences, and percentage reduction, the results provide a more detailed comparative basis for evaluating the effectiveness of IoT-based energy management. These results are critical in advancing the field of smart building technology and highlight the potential for IoT systems to optimize energy consumption in urban infrastructure.

DISCUSSION

Summary of Key Findings

This study provides clear evidence of a significant relationship between the implementation of IoT-based energy management systems and reductions in energy consumption in urban commercial buildings (Saleem et al., 2023). The experimental design revealed that the introduction of IoT systems led to a statistically significant decrease in energy use, supporting the hypothesis that IoT interventions can improve energy efficiency. However, these findings should be interpreted critically because energy reduction may also be influenced by contextual factors such as occupancy patterns, seasonal variation, building age, operational schedules, equipment efficiency, and user compliance with automated recommendations. Therefore, while the results indicate a positive effect of IoT-based systems, the magnitude of this effect may vary across building types and management contexts.

Contribution of Findings to the Research Question

The findings offer valuable insights into the causal relationship between IoT-based energy management and energy consumption (Hashmi et al., 2021). By isolating the effects of the IoT system through experimental manipulation, the study demonstrates that the observed reductions in energy consumption were not due to external factors but were a direct result of the intervention (Mukhlis, Janwari, et al., 2023). The use of an experimental design, particularly with a control group, ensured that confounding variables such as external environmental factors and user behavior were effectively controlled, providing a high degree of validity to the results. Even so, future studies should include more detailed control variables and longer observation periods to strengthen causal inference and distinguish the independent contribution of IoT systems from broader operational improvements.

Relationship with Existing Literature and Theory

These findings are consistent with prior research on smart energy systems, which suggests that IoT technologies can enhance energy efficiency by providing real-time monitoring and control (Rao et al., 2024). However, unlike many earlier studies that relied on observational or theoretical models, this research provides empirical evidence from a controlled experimental setting, offering stronger support for the efficacy of IoT systems in real-world applications. Studies by Sedhom et al. (2021) and Bui et al. (2021) have similarly indicated that IoT can optimize energy use, but their findings were based on small-scale trials or simulations, which lacked the rigorous control and generalizability provided by this study's experimental approach. In contrast, the current study strengthens these findings by showing that the IoT system's effectiveness extends beyond controlled settings to larger, operational environments (Mukhlis, 2025a).

Furthermore, the study aligns with the broader theoretical framework of cyber-physical systems and smart grids, which posit that IoT integration can improve operational efficiency in complex systems (Huang & Jin, 2024). The results underscore the potential of IoT to transform energy management practices, reinforcing the theoretical premise that real-time, data-driven decisions can enhance energy efficiency (Kuthadi et al., 2022). From a practical standpoint, the findings are relevant for policymakers and organizations considering IoT adoption, as they provide empirical data on the benefits of these systems for reducing energy consumption in urban infrastructure.

Explanation of Findings Implications

The findings of this study have significant implications for both theory and practice in the field of smart energy management (Karuna et al., 2024). The experimental evidence supports the hypothesis that IoT-based energy management systems can effectively reduce energy consumption, thereby contributing to the growing body of research on cyber-physical systems and smart grids. These results have practical implications for policymakers, urban planners, and organizations seeking to optimize energy usage. By demonstrating the real-world impact of IoT systems, the study provides a solid foundation for the development of energy-efficient solutions in urban environments (Mukhlis, Arifin, Ridwan, Zulbaidah, et al., 2025). The potential for scaling this technology across diverse industries offers a compelling case for the adoption of IoT-driven energy systems, particularly in commercial and residential buildings where energy costs are significant.

Moreover, the findings are relevant beyond the scope of the study itself. The ability of IoT systems to monitor and manage energy consumption in real-time can be applied to various other contexts, such as manufacturing, healthcare, and educational institutions, where energy efficiency is also a concern (Pandiyan et al., 2023). These results can inform future innovations in smart building technologies, offering insights into how IoT can be integrated into existing infrastructure to reduce environmental footprints and enhance sustainability efforts (Balasubramanian & Ravi Singh, 2024). By bridging the gap between theoretical models and practical applications, this research helps translate IoT potential into tangible, actionable strategies for improving energy management.

Study Limitations

While the study provides robust evidence for the effectiveness of IoT-based energy management systems, there are several limitations that may affect the generalizability of the findings (Mukhlis, Maryam, et al., 2023). The sample size, though sufficient for the purposes of this experiment, may not fully represent the broader population of buildings and facilities where IoT systems might be deployed (Sadeeq & Zeebaree, 2023). Additionally, the study was conducted in a controlled environment, which may not account for all real-world variables, such as varying energy demands across different regions or user behaviors that could influence energy consumption patterns. Furthermore, the study did not explore the long-term effects of IoT system implementation, and future research is needed to assess whether the observed energy savings are sustainable over time.

Given these limitations, it is important to acknowledge that while the findings are promising, their applicability to other contexts or larger populations should be interpreted with caution. The results are based on a specific sample of commercial buildings, and generalizing them to other types of buildings, such as residential or industrial, may require further validation. Nonetheless, these limitations present opportunities for future research, which could explore how IoT systems perform in diverse settings and whether additional factors, such as seasonal variations or building-specific characteristics, influence their effectiveness (Alijoyo, 2024).

Prospective Statement for Future Research

Future research can build upon the findings of this study by expanding the scope of IoT applications to other types of buildings and facilities, such as residential homes or industrial complexes, where energy consumption patterns may differ (Mukhlis et al., 2024). Exploring the interaction between multiple independent variables, such as user behavior, building design, and IoT system configurations, could provide a more comprehensive understanding of how these systems function in different contexts. Furthermore, investigating the long-term effects of IoT implementation, including the durability and scalability of these systems, would be valuable in determining their effectiveness over time. Researchers could also examine the impact of additional factors, such as cost-efficiency and user engagement, to identify barriers to broader adoption and implementation. Cost-benefit analysis should be prioritized because energy savings alone may not justify adoption if installation, maintenance, training, and cybersecurity costs are too high.

The potential for further studies to examine the combination of IoT with other smart technologies, such as artificial intelligence (AI) or machine learning (ML), presents exciting opportunities for advancing energy management solutions. These integrations could help refine the accuracy and efficiency of energy-saving strategies, offering even greater potential for reducing energy consumption in both the short and long term.

CONCLUSION

This study examined the impact of IoT-based energy management systems on energy consumption in urban commercial buildings. The experimental results confirm that the implementation of IoT systems significantly reduces energy usage, addressing the research gap by providing empirical evidence for the causal relationship between IoT adoption and energy efficiency. These findings not only answer the research question but also support the theoretical framework of cyber-physical systems by demonstrating how real-time data-driven decisions can optimize energy management. The practical implications of this study provide valuable insights for policymakers, building managers, and organizations seeking to enhance energy efficiency and reduce operational costs. Specifically, building managers are encouraged to integrate IoT-based monitoring platforms into daily operations to enable real-time energy tracking and predictive maintenance, while policymakers should consider developing incentive programs and regulatory frameworks that support the adoption of smart energy technologies in commercial buildings. Furthermore, the study highlights the potential for IoT technologies to play a central role in sustainable urban development. Future research could explore the long-term effects of IoT adoption and expand the scope to include additional variables, such as user behavior and building characteristics, to further validate and generalize these findings.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to this research. The research was conducted independently, with no financial or personal relationships that could have influenced the results or interpretation of the data.

REFERENCES

Alijoyo, F. A. (2024). AI-powered deep learning for sustainable industry 4.0 and internet of things: Enhancing energy management in smart buildings. *Alexandria Engineering Journal*, *104*, 409–422. Scopus. https://doi.org/10.1016/j.aej.2024.07.110

Balasubramanian, C., & Ravi Singh, R. (2024). IOT based energy management in smart grid under price based demand response based on hybrid FHO-RERNN approach. *Applied Energy*, *361*. Scopus. https://doi.org/10.1016/j.apenergy.2024.122851

Bebortta, S., Singh, A. K., Pati, B., & Senapati, D. (2021). A Robust Energy Optimization and Data Reduction Scheme for IoT Based Indoor Environments Using Local Processing Framework. *Journal of Network and Systems Management*, *29*(1). Scopus. https://doi.org/10.1007/s10922-020-09572-7

Boiko, O., Komin, A., Malekian, R., & Davidsson, P. (2024). Edge-Cloud Architectures for Hybrid Energy Management Systems: A Comprehensive Review. *IEEE Sensors Journal*, *24*(10), 15748–15772. Scopus. https://doi.org/10.1109/JSEN.2024.3382390

Bui, V., Le, N. T., van Hoa, V. H., Kim, J., & Jang, Y. M. (2021). Multi-behavior with bottleneck features lstm for load forecasting in building energy management system. *Electronics (Switzerland)*, *10*(9). Scopus. https://doi.org/10.3390/electronics10091026

Condon, F., Martínez, J. M., Eltamaly, A. M., Kim, Y.-C., & Ahmed, M. A. (2023). Design and Implementation of a Cloud-IoT-Based Home Energy Management System. *Sensors*, *23*(1). Scopus. https://doi.org/10.3390/s23010176

Gupta, R., Al-Ali, A. R., Zualkernan, I. A., & Das, S. K. (2020). Big Data Energy Management, Analytics and Visualization for Residential Areas. *IEEE Access*, *8*, 156153–156164. Scopus. https://doi.org/10.1109/ACCESS.2020.3019331

Hashmi, S. A., Ali, C. F., & Zafar, S. (2021). Internet of things and cloud computing-based energy management system for demand side management in smart grid. *International Journal of Energy Research*, *45*(1), 1007–1022. Scopus. https://doi.org/10.1002/er.6141

Huang, Z., & Jin, G. (2024). Navigating urban day-ahead energy management considering climate change toward using IoT enabled machine learning technique: Toward future sustainable urban. *Sustainable Cities and Society*, *101*. Scopus. https://doi.org/10.1016/j.scs.2023.105162

Karuna, K., Poornima, P., S, A., P, A., T, S., Mittal, A., Rajvanshi, S., & Habelalmateen, M. I. (2024). Smart energy management: Real-time prediction and optimization for IoT-enabled smart homes. *Cogent Engineering*, *11*(1). Scopus. https://doi.org/10.1080/23311916.2024.2390674

Kuthadi, V. M., Selvaraj, R., Baskar, S., Pethuraj, P. M., & Ranjan, A. (2022). Optimized Energy Management Model on Data Distributing Framework of Wireless Sensor Network in IoT System. *Wireless Personal Communications*, *127*(2), 1377–1403. Scopus. https://doi.org/10.1007/s11277-021-08583-0

Ma, S., Ding, W., Liu, Y., Ren, S., & Yang, H. (2022). Digital twin and big data-driven sustainable smart manufacturing based on information management systems for energy-intensive industries. *Applied Energy*, *326*. Scopus. https://doi.org/10.1016/j.apenergy.2022.119986

Marinakis, V., Doukas, H., Tsapelas, J., Mouzakitis, S., Sicilia, Á., Madrazo, L., & Sgouridis, S. (2020). From big data to smart energy services: An application for intelligent energy management. *Future Generation Computer Systems*, *110*, 572–586. Scopus. https://doi.org/10.1016/j.future.2018.04.062

Márquez, S., Calvo-Gallego, J., Erbad, A., Ibrar, M., Hernandez Fernandez, J. H., Houchati, M., & Corchado Rodríguez, J. M. (2023). Enhancing Building Energy Management: Adaptive Edge Computing for Optimized Efficiency and Inhabitant Comfort †. *Electronics (Switzerland)*, *12*(19). Scopus. https://doi.org/10.3390/electronics12194179

Mohammad, F., Ahmed, M. A., & Kim, Y.-C. (2021). Efficient energy management based on convolutional long short-term memory network for smart power distribution system. *Energies*, *14*(19). Scopus. https://doi.org/10.3390/en14196161

Mukhlis, L. (2025a). A Phenomenological Study of Personal Spiritual Experiences in Navigating Religious Pluralism within Interfaith Communities. *Irfana: Journal of Religious Studies*, *1*(6), 212–220.

Mukhlis, L. (2025b). Spiritual Grounds for Economic Growth: A Qualitative Exploration of Rural Indonesian Women's Transformative Journeys Through Mosque-Led Empowerment Programs. *Servina: Jurnal Pengabdian Kepada Masyarakat*, *1*(8), 289–298.

Mukhlis, L., & Abdullah, M. N. (2025). *Hukum Keluarga Islam di Indonesia* (1st ed.). Mukhlisina Revolution Center.

Mukhlis, L., Arifin, T., Ridwan, A. H., & Zulbaidah. (2024). Integrating Artificial Intelligenceand Maqāṣid al-Syarī'ah: Revolutionizing Indonesia's Sharia Online Trading System. *Computer Fraud and Security*, *2024*(11), 301–309. https://doi.org/10.52710/cfs.238

Mukhlis, L., Arifin, T., Ridwan, A. H., & Zulbaidah. (2025). Reorientation of Sharia Stock Regulations: Integrating Taṣarrufāt al-Rasūl and Maqāṣid al-Sharī'ah for Justice and Sustainability. *Journal of Information Systems Engineering and Management*, *10*(10s), 58–66. https://doi.org/10.52783/jisem.v10i10s.1341

Mukhlis, L., Arifin, T., Ridwan, A. H., Zulbaidah, Rosadi, A., & Solehudin, E. (2025). Reformulation of Islamic Stock Law: The Application of Taṣarrufāt al-Rasūl and Maqāṣid al-Syarī'ahto Develop a Dynamic and Sustainable Islamic Capital Market in Indonesia. *Journal of Posthumanism*, *5*(3), 1–13. https://doi.org/10.63332/joph.v5i3.913

Mukhlis, L., Janwari, Y., & Syafe`i, R. (2023). INDONESIA STOCK EXCHANGE: THEORETICAL AND PHILOSOPHICAL ANALYSIS OF MUDHARABAH AND MUSYARAKAH CONTRACTS. *Yurisprudentia: Jurnal Hukum Ekonomi*, *9*(2), 243–264. https://doi.org/10.24952/yurisprudentia.v9i2.8466

Mukhlis, L., Maryam, S., & Sormin, S. A. (2023). Model Pembelajaran Living History Berbasis PjBL Untuk Meningkatkan Keterampilan Histografi Mahasiswa. *Jurnal Educatio FKIP UNMA*, *9*(4), 1800–1809. https://doi.org/10.31949/educatio.v9i4.5595

Mukhlis, L., & Saidah, Y. (2025). Dynamics of Nature-Based learning in Developing Children's Motoricic Skills: Teacher and Parent Perspectives. *HUMANISMA: Journal of Gender Studies*, *9*(1), 64–79. http://dx.doi.org/10.30983/humanisme.v4i2.9366

Mukhlis, L., Suradi, Janwari, Y., & Syafe`i, R. (2023). Sosialisasi Saham Syariah sebagai Instrumen Pengembangan Ekonomi Masyarakat di Badan Kontak Majelis Taklim (BKMT) Kabupaten Mandailing Natal. *Jurnal Pengabdian Multidisiplin*, *3*(2), 2–9. https://doi.org/10.51214/japamul.v3i2.604

`

Munoz, O., Ruelas, A., Rosales-Escobedo, P., Ramírez, A., Suastegui, A., & Lara, F. (2022). Design and Development of an IoT Smart Meter with Load Control for Home Energy Management Systems. *Sensors*, *22*(19). Scopus. https://doi.org/10.3390/s22197536

Ntafalias, A., Tsakanikas, S., Skarvelis-Kazakos, S., Papadopoulos, P., Skarmeta-Gómez, A. F., González-Vidal, A., Tomat, V., Ramallo-GonzÃ¡lez, A. P., Marín-Pérez, R., & Vlachou, M. C. (2022). Design and Implementation of an Interoperable Architecture for Integrating Building Legacy Systems into Scalable Energy Management Systems. *Smart Cities*, *5*(4), 1421–1440. Scopus. https://doi.org/10.3390/smartcities5040073

Pandiyan, P., Saravanan, S., Usha, K., Raju, R., Alsharif, M. H., & Kim, M.-K. (2023). Technological advancements toward smart energy management in smart cities. *Energy Reports*, *10*, 648–677. Scopus. https://doi.org/10.1016/j.egyr.2023.07.021

Rao, C., Sahoo, S. K., & Yanine, F. F. (2024). IoT enabled Intelligent Energy Management System employing advanced forecasting algorithms and load optimization strategies to enhance renewable energy generation. *Unconventional Resources*, *4*. Scopus. https://doi.org/10.1016/j.uncres.2024.100101

Sadeeq, M. A., & Zeebaree, S. R. (2021). Energy Management for Internet of Things via Distributed Systems. *Journal of Applied Science and Technology Trends*, *2*(2), 80–92. Scopus. https://doi.org/10.38094/jastt20285

Sadeeq, M. A., & Zeebaree, S. R. (2023). Design and implementation of an energy management system based on distributed IoT. *Computers and Electrical Engineering*, *109*. Scopus. https://doi.org/10.1016/j.compeleceng.2023.108775

Said, O., Almakhadmeh, Z., & Tolba, A. (2020). EMS: An Energy Management Scheme for Green IoT Environments. *IEEE Access*, *8*, 44983–44998. Scopus. https://doi.org/10.1109/ACCESS.2020.2976641

Saleem, M. U., Shakir, M., Usman, M. R., Bajwa, M. H. T., Shabbir, N., Shams Ghahfarokhi, P., & Daniel, K. (2023). Integrating Smart Energy Management System with Internet of Things and Cloud Computing for Efficient Demand Side Management in Smart Grids. *Energies*, *16*(12). Scopus. https://doi.org/10.3390/en16124835

Saleem, M. U., Usman, M. R., & Shakir, M. (2021). Design, Implementation, and Deployment of an IoT Based Smart Energy Management System. *IEEE Access*, *9*, 59649–59664. Scopus. https://doi.org/10.1109/ACCESS.2021.3070960

Saleem, M. U., Usman, M. R., Usman, M. A., & Politis, C. (2022). Design, Deployment and Performance Evaluation of an IoT Based Smart Energy Management System for Demand Side Management in Smart Grid. *IEEE Access*, *10*, 15261–15278. Scopus. https://doi.org/10.1109/ACCESS.2022.3147484

Sedhom, B. E., El-Saadawi, M. M., El Moursi, M. S., Hassan, M. A., & Eladl, A. A. (2021). IoT-based optimal demand side management and control scheme for smart microgrid. *International Journal of Electrical Power and Energy Systems*, *127*. Scopus. https://doi.org/10.1016/j.ijepes.2020.106674

Sheela, M. S., Subburayalu, S., Parvin Begum, I. P., Hephzipah, J. J., Gopianand, M., & Harika, D. (2024). Enhancing Energy Efficiency with Smart Building Energy Management System Using Machine Learning and IOT. *Babylonian Journal of Machine Learning*, *2024*, 80–88. Scopus. https://doi.org/10.58496/BJML/2024/008

Shreenidhi, S., & Ramaiah, N. S. (2022). A two-stage deep convolutional model for demand response energy management system in IoT-enabled smart grid. *Sustainable Energy, Grids and Networks*, *30*. Scopus. https://doi.org/10.1016/j.segan.2022.100630

`

Ullah, M., Narayanan, A., Wolff, A., & Nardelli, P. H. J. (2022). Industrial Energy Management System: Design of a Conceptual Framework Using IoT and Big Data. *IEEE Access*, *10*, 110557–110567. Scopus. https://doi.org/10.1109/ACCESS.2022.3215167

Wang, X., Mao, X., & Khodaei, H. (2021). A multi-objective home energy management system based on internet of things and optimization algorithms. *Journal of Building Engineering*, *33*. Scopus. https://doi.org/10.1016/j.jobe.2020.101603