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Intelligent Energy Planning and Optimization in Smart Buildings With Green Power Integration

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Abstract: The rapid expansion of urbanization, increasing energy demand, and global efforts toward carbon neutrality have accelerated the transition from conventional building energy management approaches to intelligent and sustainable energy planning frameworks. Smart buildings integrated with renewable energy systems represent a significant pathway for improving energy efficiency, reducing environmental impacts, and enhancing operational resilience. However, the effective implementation of intelligent energy optimization requires the integration of advanced computational techniques, renewable energy coordination, demand-side management strategies, and effective project planning mechanisms. This research paper investigates an intelligent energy planning and optimization framework for smart buildings incorporating green power integration. The study develops a conceptual research model based on artificial intelligence-driven optimization, renewable energy utilization, energy efficiency improvement, and sustainable infrastructure management principles.

The research synthesizes existing studies related to net-zero energy strategies, smart green city planning, renewable electricity adoption, energy efficiency improvement, and intelligent building management. The methodology adopts a systematic analytical approach by examining technological, operational, and managerial dimensions influencing smart building energy performance. The proposed framework considers renewable generation forecasting, intelligent load management, energy consumption prediction, and adaptive optimization mechanisms as key components for achieving sustainable building operations. Previous research highlights that integration of renewable energy systems with intelligent decision-making approaches can support long-term emission reduction objectives and improve energy system flexibility (Jiyoung Kong & Cho, 2021).

The findings indicate that intelligent energy planning enables better coordination between energy generation, consumption patterns, and environmental objectives. Artificial intelligence-based optimization approaches can enhance energy utilization efficiency by continuously analyzing operational data and adjusting energy strategies according to changing conditions. The integration of renewable power sources further strengthens sustainability performance by reducing dependency on conventional energy systems. The study also identifies challenges related to technological complexity, investment requirements, interoperability issues, and policy coordination. As demonstrated in recent research, AI-based energy optimization in smart buildings provides opportunities for improving energy performance through predictive analytics, automated control, and renewable integration strategies (Philip, 2026).

This research contributes to the academic understanding of sustainable building energy management by presenting an integrated perspective combining technological intelligence and green energy planning. The proposed framework provides insights for researchers, policymakers, construction managers, and energy professionals seeking effective strategies for developing future-ready smart buildings. The study concludes that intelligent energy optimization supported by renewable integration is essential for achieving sustainable urban development and carbon-neutral infrastructure objectives.

Keywords: Smart Buildings; Intelligent Energy Management; Renewable Energy Integration; Artificial Intelligence; Energy Optimization; Green Power Systems; Sustainable Infrastructure; Energy Planning.

INTRODUCTION

The global energy sector is undergoing a significant transformation due to increasing environmental concerns, rising energy consumption, and the urgent requirement to achieve sustainable development objectives. Buildings represent one of the largest contributors to global energy demand, making their transformation into intelligent and energy-efficient systems a critical component of future energy strategies. Traditional building energy management systems generally operate through fixed operational schedules and limited monitoring capabilities, resulting in inefficient energy utilization and increased dependence on conventional power sources. The emergence of smart building technologies provides an opportunity to overcome these limitations by integrating digital intelligence, renewable energy resources, and adaptive energy management approaches.

The concept of smart buildings extends beyond automated control systems by incorporating interconnected technologies capable of collecting operational data, analyzing energy patterns, and optimizing resource utilization. Intelligent energy planning enables buildings to dynamically respond to energy availability, user requirements, environmental conditions, and renewable generation variations. Such approaches support the transition toward low-carbon infrastructure by improving energy efficiency while maintaining occupant comfort and operational reliability. Research on smart green cities has emphasized that integrated planning techniques are essential for achieving sustainable urban development because energy systems, infrastructure design, and environmental objectives must be considered collectively rather than independently (Lee & Oh, 2015).

Renewable energy integration has become a fundamental element of sustainable building development. Solar photovoltaic systems, wind-based generation, and other clean energy technologies provide alternatives to fossil-fuel-based electricity supply. However, renewable energy sources are characterized by variability and uncertainty, creating challenges for maintaining stable energy management. Intelligent optimization techniques address these challenges by forecasting energy production, predicting consumption patterns, and adjusting operational strategies accordingly. The combination of artificial intelligence and renewable energy management allows smart buildings to operate as adaptive energy ecosystems rather than passive energy consumers.

Recent research has highlighted the importance of energy system integration for achieving net-zero emission goals. Energy planning strategies increasingly focus on combining renewable generation, energy efficiency measures, and policy frameworks to create sustainable energy networks. Jiyoung Kong and Cho (2021) emphasized that achieving net-zero emissions requires coordinated energy system integration and effective policy direction for renewable energy expansion. Similarly, carbon-neutral city planning studies demonstrate that urban energy strategies must incorporate technological innovation and long-term planning approaches to reduce environmental impacts (Kim & Choi, 2011).

Despite technological advancements, several challenges remain in implementing intelligent energy optimization systems within buildings. High initial investment costs, complex infrastructure requirements, data management challenges, and compatibility issues between different energy technologies can limit adoption. Furthermore, successful implementation requires coordination among construction professionals, energy engineers, policymakers, and building operators. The integration of intelligent energy systems should therefore be considered not only as a technological challenge but also as a project management and organizational planning issue.

The application of artificial intelligence in smart building energy optimization has introduced new possibilities for improving operational efficiency. Machine learning algorithms can analyze historical energy data, identify consumption patterns, and generate predictive models for future energy requirements. These capabilities allow buildings to automatically optimize heating, cooling, lighting, and electrical systems while incorporating renewable energy availability. Philip (2026) demonstrated that AI-based energy optimization combined with renewable energy integration can provide a comprehensive approach for improving building energy performance from a construction project management perspective.

The increasing importance of green electricity markets and renewable energy adoption further strengthens the need for intelligent energy planning frameworks. Studies examining renewable electricity trading and consumer preferences indicate that economic incentives, environmental awareness, and policy mechanisms influence renewable energy adoption. Wang et al. (2024) highlighted the importance of renewable portfolio standards, environmental perceptions, and market mechanisms in promoting green electricity trading. These factors demonstrate that energy optimization requires consideration of both technical and socio-economic dimensions.

This research aims to develop a comprehensive framework for intelligent energy planning and optimization in smart buildings with green power integration. The primary objectives of this study are:

- To analyze the role of intelligent technologies in improving building energy efficiency.
- To examine renewable energy integration strategies for smart building environments.
- To develop a conceptual framework combining AI-based optimization and sustainable energy planning.
- To evaluate implementation challenges and practical implications of intelligent energy systems.

The significance of this research lies in providing an integrated understanding of how digital intelligence and renewable energy technologies can support sustainable building development. Unlike conventional energy management approaches focused primarily on consumption reduction, the proposed perspective emphasizes adaptive optimization, renewable coordination, and strategic planning. The research contributes to the growing field of sustainable infrastructure by connecting energy technology development with smart building management practices.

The scope of this study focuses on intelligent energy planning approaches applicable to smart buildings incorporating renewable power systems. The research considers technological, operational, and managerial aspects while analyzing existing literature related to energy efficiency, renewable integration, and sustainable urban development. Through this approach, the study provides insights into future pathways for developing energy-efficient, environmentally responsible, and intelligent building systems.

2. LITERATURE REVIEW

The development of intelligent energy planning frameworks for smart buildings has emerged from the intersection of sustainable infrastructure development, renewable energy integration, digital intelligence, and energy efficiency management. Existing studies demonstrate that future energy systems require a transition from conventional centralized energy models toward flexible, adaptive, and integrated systems capable of responding to changing energy demands and environmental objectives. The literature provided for this study collectively addresses energy system integration, carbon neutrality strategies, smart city planning, renewable energy adoption, and efficiency improvement mechanisms, creating a theoretical foundation for intelligent energy optimization in smart buildings.

Energy system integration has become a critical research direction for achieving long-term sustainability objectives. Jiyoung Kong and Cho (2021) examined the relationship between net-zero emission goals and renewable energy system integration, emphasizing that technological development alone is insufficient without coordinated policy frameworks and systematic energy planning. Their research indicates that renewable energy adoption requires integration between generation technologies, energy management strategies, and institutional mechanisms. This perspective is directly relevant to smart buildings because building-level energy optimization depends on effective coordination between renewable generation, energy storage, and consumption management.

The concept of carbon-neutral development has significantly influenced modern urban and building energy strategies. Kim and Choi (2011) investigated urban planning strategies for carbon-neutral cities and highlighted the importance of integrating environmental objectives into urban development processes. Their findings suggest that sustainable energy planning should not be limited to individual technologies but should consider broader relationships between infrastructure, resource management, and urban systems. For smart buildings, this implies that intelligent energy optimization must operate within a larger sustainable development framework.

Smart green city planning research provides additional theoretical support for intelligent building energy management. Lee and Oh (2015) analyzed strategies for smart green cities by examining planning priorities and application techniques. Their study demonstrated that successful implementation of smart sustainable environments requires systematic planning approaches capable of balancing technological innovation, environmental performance, and practical applicability. Similarly, Oh, Park, and Lee (2015) investigated energy planning techniques for smart green cities and emphasized the importance of applying appropriate planning methods according to specific environmental and operational conditions. These studies establish that energy optimization is a multidimensional process involving technical evaluation, planning methodology, and implementation strategies.

Research on smart green complexes further demonstrates the importance of integrating energy considerations into building design and management. Park (2013) examined planning elements for smart green multi-complex developments and identified energy-related planning components as important factors affecting sustainable performance. This indicates that energy efficiency should be considered during early project planning stages rather than implemented only after construction completion. The integration of intelligent energy optimization into construction project management therefore provides opportunities for improving long-term building performance.

Energy efficiency improvement has also been widely examined through industrial and urban energy management perspectives. Ouyang et al. (2019) analyzed industrial energy efficiency improvement mechanisms and identified technological advancement, structural transformation, and management practices as important drivers of efficiency enhancement. Although their research focuses on industrial environments, the underlying principle is applicable to smart buildings: energy performance improvement depends on continuous monitoring, data analysis, and optimization of operational processes.

The emergence of renewable electricity markets has introduced additional considerations for energy optimization. Ni and Xiong (2024) discussed the increasing market potential of green electricity trading and highlighted the accelerated development of renewable energy participation mechanisms. These market developments influence how smart buildings interact with energy systems because future buildings may function not only as consumers but also as active participants in energy networks. Intelligent optimization systems can support this transition by determining optimal periods for energy consumption, storage, and renewable energy utilization.

Consumer acceptance and economic factors also influence renewable energy implementation. Loaiza-Ramírez et al. (2022) examined renewable energy preferences and identified the relationship between perceived benefits, consumer values, and willingness to adopt green energy solutions. Their findings indicate that technical efficiency alone does not guarantee successful renewable energy adoption. Smart building energy frameworks must therefore consider user behavior, economic incentives, and occupant acceptance when designing optimization strategies.

Renewable electricity trading and policy mechanisms represent another important research dimension. Wang et al. (2024) investigated methods for promoting green electricity trading through environmental perceptions, renewable portfolio standards, and subsidy mechanisms. Their study demonstrates that policy support and market structures significantly influence renewable energy deployment. For smart buildings, these findings suggest that intelligent energy management should be connected with broader energy market mechanisms to maximize economic and environmental benefits.

The integration of multiple renewable energy sources has been explored through hybrid energy system research. Zhou et al. (2020) proposed and analyzed an integrated gas-wind-photovoltaic-hydrogen energy system considering multiple participant interests. Their work demonstrates that complex energy systems require optimization approaches capable of balancing technical performance, economic objectives, and stakeholder requirements. Similar principles apply to smart buildings where renewable generation, energy storage, grid interaction, and consumption patterns must be simultaneously optimized.

The adoption of renewable electricity also depends on consumer willingness to participate in green energy programs. Knapp et al. (2020) examined consumer preferences regarding green electricity programs and found differences between stated preferences and actual adoption behavior. This highlights a critical limitation in sustainable energy planning: technological availability does not automatically translate into practical implementation. Intelligent building systems must therefore incorporate behavioral considerations alongside technical optimization.

Recent research has expanded the role of artificial intelligence in smart building energy management. Philip (2026) emphasized that AI-based energy optimization combined with renewable energy integration can improve energy prediction, operational efficiency, and sustainable project management outcomes. The study highlights the importance of combining intelligent algorithms with construction management strategies to achieve effective implementation of smart energy systems.

Although existing studies provide valuable insights, several research gaps remain. First, many studies examine renewable energy integration, smart city planning, or energy efficiency independently rather than developing integrated intelligent optimization frameworks. Second, limited attention has been given to the relationship between artificial intelligence-based energy management and construction project management practices. Third, practical challenges associated with implementing adaptive energy optimization systems in real-world buildings require further investigation.

This research addresses these gaps by proposing an integrated perspective that combines intelligent optimization technologies, renewable energy integration, and sustainable building management. The theoretical positioning of this study is based on the assumption that smart buildings should function as dynamic energy systems capable of continuous learning, adaptation, and optimization.

3. METHODOLOGY

3.1 Research Design

This study adopts a conceptual analytical research methodology to develop an intelligent energy planning framework for smart buildings integrated with green power systems. The methodology is based exclusively on the analysis and synthesis of the provided literature related to renewable energy integration, smart building development, energy efficiency improvement, and intelligent optimization approaches.

The research approach combines theoretical evaluation and framework development. Rather than testing a single technology experimentally, the study analyzes relationships among energy generation, consumption patterns, optimization algorithms, and project management strategies. This approach is suitable for examining complex sustainability challenges where multiple technical and organizational factors influence system performance.

3.2 Framework Development Approach

The proposed intelligent energy planning framework consists of four interconnected layers:

1. Energy Data Acquisition Layer

The first layer focuses on collecting operational information from smart building environments. Data sources include electricity consumption patterns, renewable energy generation levels, environmental conditions, and operational requirements. Continuous data collection enables intelligent systems to understand current performance conditions and identify opportunities for optimization.

The importance of data-driven management is supported by research on energy efficiency improvement, where continuous monitoring and analysis were identified as essential mechanisms for improving energy performance (Ouyang et al., 2019). In smart buildings, accurate data acquisition provides the foundation for predictive decision-making.

2. Intelligent Prediction and Optimization Layer

The second layer applies artificial intelligence techniques to analyze collected data and generate optimization decisions. Machine learning-based approaches can identify consumption trends, forecast future energy requirements, and recommend efficient operational strategies.

AI-based optimization provides significant advantages compared with traditional energy management approaches because it enables adaptive responses rather than fixed operational schedules. Philip (2026) highlighted that AI-driven energy optimization can support improved energy performance by combining predictive analysis with renewable energy integration strategies.

The optimization process includes:

- Energy demand prediction
- Renewable generation forecasting
- Load balancing
- Operational scheduling
- Efficiency improvement analysis

3. Renewable Energy Integration Layer

The third layer focuses on coordinating renewable energy resources with building energy requirements. Renewable sources such as solar photovoltaic systems provide clean electricity but introduce variability due to weather conditions and seasonal changes.

The framework considers intelligent coordination between renewable generation availability and building consumption requirements. Hybrid energy system research demonstrates that effective integration requires balancing multiple energy sources and stakeholder objectives (Zhou et al., 2020).

4. Sustainable Management and Decision Layer

The final layer connects technical optimization with project management and sustainability objectives. Smart building implementation requires coordination among engineers, construction managers, policymakers, and facility operators.

Energy planning strategies should therefore include lifecycle considerations, investment evaluation, maintenance planning, and policy alignment. Research on smart green cities demonstrates that successful sustainable infrastructure requires integration between planning techniques and practical implementation mechanisms (Lee & Oh, 2015).

3.3 Intelligent Energy Optimization Model

The proposed research framework considers smart buildings as dynamic energy ecosystems where generation, consumption, and management processes interact continuously. Unlike traditional energy management approaches based on predefined operational schedules, intelligent optimization enables adaptive decision-making by using real-time information and predictive analysis.

The optimization model consists of three major functional processes: energy forecasting, performance optimization, and adaptive control. Energy forecasting focuses on predicting future electricity demand and renewable energy availability. Accurate forecasting allows building systems to anticipate energy requirements and reduce unnecessary consumption. Performance optimization evaluates different operational scenarios to identify strategies that achieve maximum energy efficiency while maintaining user requirements.

The adaptive control mechanism enables automatic adjustment of building systems according to changing conditions. For example, when renewable generation exceeds immediate demand, the system may prioritize energy storage or flexible loads. During periods of low renewable availability, the system can modify consumption patterns or utilize alternative energy sources. Such adaptive approaches support efficient energy utilization and improve system reliability.

The relationship between artificial intelligence and energy optimization has become increasingly important in sustainable building development. AI-based approaches provide analytical capabilities that allow buildings to learn from historical operational patterns and continuously improve decision-making processes. According to Philip (2026), artificial intelligence integration within renewable energy-based smart buildings provides opportunities for improving energy efficiency, operational control, and sustainable project management outcomes.

3.4 Renewable Energy Coordination Strategy

Renewable energy integration represents a central component of the proposed framework. Smart buildings equipped with renewable generation technologies can reduce dependency on conventional electricity sources while contributing to emission reduction objectives. However, renewable energy variability requires intelligent coordination mechanisms.

The proposed methodology considers renewable energy sources as active components of the building energy ecosystem rather than supplementary power sources. Solar generation, wind energy, and other renewable technologies are evaluated according to availability, demand patterns, and operational requirements.

Energy coordination involves four major functions:

1. Renewable generation monitoring
2. Demand forecasting
3. Energy storage management
4. Grid interaction optimization

The integration of renewable energy requires consideration of technical and economic factors. Research on integrated energy systems indicates that multiple energy sources must be coordinated through optimization strategies to achieve balanced performance among different objectives (Zhou et al., 2020).

Furthermore, renewable energy adoption is influenced by market conditions and policy frameworks. Studies on green electricity trading demonstrate that renewable energy markets, incentives, and regulatory mechanisms significantly affect adoption rates (Wang et al., 2024). Therefore, intelligent building energy systems should consider both internal operational efficiency and external energy market conditions.

3.5 Construction Project Management Integration

The implementation of intelligent energy optimization systems requires integration with construction project management practices. Building energy performance is influenced by decisions made during planning, design, construction, and operational phases. Therefore, energy optimization should be considered throughout the entire building lifecycle.

During the planning phase, project managers must evaluate renewable energy feasibility, infrastructure requirements, and technology compatibility. During construction, proper installation and integration of intelligent systems become essential for achieving expected performance levels. During operation, continuous monitoring and optimization ensure long-term efficiency.

The construction management perspective is particularly important because technological solutions may fail if implementation planning is inadequate. Philip (2026) emphasized that AI-based energy optimization should be considered alongside project management strategies to achieve successful deployment of smart building systems.

3.6 Performance Evaluation Indicators

The methodology evaluates intelligent energy planning effectiveness through multiple performance indicators:

Energy Efficiency Improvement:

This indicator measures the reduction in unnecessary energy consumption through intelligent optimization strategies. Improved efficiency reflects better utilization of available energy resources.

Renewable Energy Utilization Rate:

This evaluates the percentage of building energy demand supplied through renewable sources. Higher renewable utilization indicates stronger sustainability performance.

Operational Cost Reduction:

Intelligent optimization can reduce energy expenses by identifying efficient consumption patterns and minimizing unnecessary usage.

Carbon Emission Reduction:

The framework evaluates environmental benefits by analyzing reductions in conventional energy dependence.

System Adaptability:

This measures the ability of the energy system to respond effectively to changing demand conditions and renewable generation variations.

3.7 Analytical Framework

The analytical framework developed in this study establishes relationships between technological intelligence, renewable integration, and sustainable energy management.

The framework assumes that:

- Advanced data analysis improves energy prediction accuracy.
- Improved prediction enables better optimization decisions.
- Better optimization increases renewable energy utilization.
- Higher renewable utilization contributes to sustainability objectives.

This relationship creates a continuous improvement cycle where smart building systems learn from operational performance and improve future decision-making.

4. RESULTS

The analysis indicates that intelligent energy planning combined with renewable power integration provides significant potential for improving smart building performance. The findings demonstrate that energy optimization is most effective when technological intelligence, renewable energy systems, and management strategies operate as an integrated framework.

The first major finding is that artificial intelligence-based optimization enhances energy management efficiency by enabling predictive and adaptive decision-making. Traditional energy systems often respond to demand changes after they occur, whereas intelligent systems can forecast future requirements and adjust operations proactively. This improves resource utilization and reduces unnecessary energy consumption.

The second finding relates to renewable energy integration. Renewable sources provide substantial sustainability benefits; however, their variable nature requires intelligent coordination mechanisms. The proposed framework demonstrates that combining renewable generation forecasting with adaptive energy control can improve renewable utilization and reduce dependence on conventional energy sources.

The third finding highlights the importance of integrating energy optimization with construction and infrastructure management. Smart building energy performance depends not only on installed technologies but also on planning decisions, system integration quality, and operational management. This supports the argument that intelligent energy systems should be incorporated throughout the building lifecycle rather than added as separate technological components.

The literature analysis also reveals that policy and market conditions influence the success of renewable energy implementation. Green electricity markets, renewable energy incentives, and regulatory frameworks affect adoption decisions and economic feasibility. Therefore, intelligent energy optimization should consider external factors beyond technical performance.

The study further identifies that user behavior remains an important factor affecting energy efficiency outcomes. Although intelligent systems can optimize technical operations, occupant acceptance and participation influence actual performance. Renewable energy adoption studies indicate that consumer perceptions, environmental awareness, and economic considerations affect willingness to participate in sustainable energy programs (Loaiza-Ramírez et al., 2022).

Overall, the findings indicate that smart buildings with integrated renewable energy systems can achieve improved efficiency, sustainability, and operational flexibility through intelligent optimization approaches. However, successful implementation requires coordinated planning, technological compatibility, and supportive policy environments.

5. DISCUSSION

The findings of this research demonstrate that intelligent energy planning represents a significant advancement over conventional building energy management approaches. The integration of artificial intelligence, renewable energy systems, and sustainable project management creates opportunities for developing adaptive infrastructure capable of responding to future energy challenges.

The theoretical contribution of this study lies in connecting technological intelligence with sustainable infrastructure planning. Previous research has examined renewable energy integration, smart cities, and energy efficiency separately; however, this study presents an integrated perspective where these elements function together within a smart building environment.

The results align with previous research emphasizing the importance of energy system integration for achieving sustainability objectives. Jiyoung Kong and Cho (2021) highlighted that renewable energy transitions require coordinated approaches combining technology development and policy support. The current study extends this concept by emphasizing the role of intelligent optimization as a connecting mechanism between renewable generation and building operations.

A major practical implication is that building developers and construction managers should consider intelligent energy systems during early project planning stages. Implementing optimization technologies after construction may create compatibility challenges and increase costs. Therefore, sustainable energy planning should become an essential component of modern construction management strategies.

However, several limitations must be considered. First, the implementation of AI-based energy optimization requires significant investment in sensors, computational infrastructure, and system integration. Second, data quality and cybersecurity concerns may affect system reliability. Third, renewable energy availability varies depending on geographical and environmental conditions, influencing optimization performance.

The study also identifies a balance between automation and human involvement. Although intelligent systems can improve decision-making, human oversight remains necessary for strategic planning, maintenance, and policy alignment. Future smart buildings should therefore adopt hybrid approaches combining artificial intelligence capabilities with expert management.

The findings support the perspective that smart buildings should evolve from passive energy consumers into active participants within sustainable energy networks. Through intelligent optimization and renewable integration, buildings can contribute to broader carbon reduction objectives while improving operational efficiency.

6. CONCLUSION

The transition toward sustainable and intelligent building infrastructure requires a comprehensive approach that combines renewable energy integration, advanced computational technologies, and effective energy management strategies. This research examined the concept of intelligent energy planning and optimization in smart buildings with green power integration by analyzing existing literature related to renewable energy systems, smart city development, energy efficiency improvement, and artificial intelligence-based optimization.

The study demonstrates that intelligent energy planning provides a promising pathway for improving building energy performance by enabling predictive analysis, adaptive control, and efficient coordination between energy generation and consumption. Unlike traditional energy management systems that rely on fixed operational patterns, intelligent systems can dynamically respond to changing conditions, including variations in energy demand, renewable energy availability, and operational requirements.

The integration of renewable energy sources represents a fundamental component of sustainable smart building development. However, renewable energy systems require intelligent coordination mechanisms due to their intermittent nature. The proposed framework highlights that artificial intelligence-based forecasting, optimization algorithms, and automated control systems can improve renewable energy utilization while reducing dependency on conventional power sources.

The research also emphasizes the importance of considering construction project management perspectives in smart building implementation. Energy optimization cannot be treated as an isolated technological intervention because building performance depends on decisions made throughout planning, design, construction, and operational phases. Effective collaboration among construction managers, energy engineers, technology developers, and policymakers is essential for successful implementation.

The analysis of previous studies indicates that sustainable energy development requires integration between technical innovation and supportive institutional frameworks. Research on net-zero energy strategies, smart green cities, and renewable electricity markets demonstrates that technological solutions must operate within broader economic and policy environments. Therefore, future intelligent energy systems should incorporate both technical optimization capabilities and external factors such as regulatory mechanisms, market conditions, and user participation.

Despite significant potential, several challenges remain. High implementation costs, technological complexity, interoperability issues, and data security concerns may restrict widespread adoption of intelligent energy optimization systems. Additionally, renewable energy performance depends on environmental conditions, creating uncertainty in long-term operational planning. Addressing these limitations requires continued research, improved infrastructure development, and stronger policy support.

This research contributes to the field of sustainable infrastructure by presenting an integrated conceptual framework that connects artificial intelligence, renewable energy integration, and smart building management. The findings support the development of future buildings that are more energy-efficient, environmentally responsible, and capable of adaptive operation.

Future research should focus on empirical validation of intelligent energy optimization frameworks through real-world smart building implementations. Additional studies may investigate advanced machine learning models, energy storage integration, digital twin technologies, and real-time energy trading mechanisms. Furthermore, interdisciplinary research combining engineering, construction management, behavioral science, and policy analysis will be necessary to achieve comprehensive sustainable building solutions.

In conclusion, intelligent energy planning combined with renewable power integration represents a critical approach for advancing sustainable building development. By enabling efficient energy utilization, reducing environmental impacts, and supporting adaptive management, intelligent smart building systems can play a significant role in achieving future energy sustainability objectives.

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