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Review Article

A review of green building research: Key findings, challenges, energy efficiency and proposed solutions

Shrikant HARLE[1], Rajan L. WANKHADE[2,*]

[1]*Department of Civil Engineering, Prof. Ram Meghe College of Engineering and Management, Maharashtra, 444701, India*
[2]*Department of Applied Mechanics, Government Polytechnic Bramhapuri, Maharashtra, 441206, India*

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ABSTRACT

This review article scrutinizes several studies focusing on various aspects and impacts of green building practices. The potential and limitations of the green building sector in different areas, measuring and evaluating the effectiveness of green building, evaluating electricity use, social interest and health, technology potential and challenges, return on investment are thus discussed. The ideas are debated regarding green buildings certification, zero-energy building construction, knowledge and commitment, sustainable urban development and energy-utilizing building design and technology development. This review highlighted key findings from all the studies, such as the need for a framework that takes environmental, social and economic considerations to facilitate the transition to development in the Arab world. Potential improvements to existing green building assessments, including interactive decision-making tools, management software, and improved user experience are also explored. The review addresses issues related to energy efficiency, HVAC [heating, ventilation and air conditioning equipment] controls, and health and wellness practices in office buildings. In addition, the cost-benefit analysis demonstrates the integration of active and passive strategies in a warming climate. The analysis also highlights the impact of luxury goods on the performance of green projects and the potential for local energy services in China. Green buildings especially LEED-certified buildings afford the resources to diminish the climate impacts of inhabitants of the buildings. The summary provides a brief overview of the various issues addressed in the research, highlighting their impact on promoting the sustainable development and global diversity of green buildings.

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INTRODUCTION

Background on the Importance of Green Building Technologies

Green building technologies have emerged as a critical solution to address the environmental challenges posed by conventional construction practices. The built environment is a significant contributor to global energy consumption, greenhouse gas emissions, and resource depletion. As a result, there is a growing recognition of the need for sustainable and environmentally conscious approaches to building design, construction, and operation.

One of the key drivers behind the importance of green building technologies is the urgent need to mitigate climate

***Corresponding author.**
*E-mail address: rajanw04@gmail.com

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change. The building sector is responsible for a substantial portion of global carbon dioxide emissions, primarily due to the energy consumption associated with heating, cooling, and powering buildings. Green building technologies offer energy-efficient solutions that reduce the reliance on fossil fuels and minimize greenhouse gas emissions. By optimizing energy performance, incorporating renewable energy sources, and improving building envelope design, green buildings can significantly reduce their carbon footprint and contribute to climate change mitigation efforts.

In addition to addressing climate change, green building technologies also offer a range of other environmental benefits. They promote resource conservation by minimizing water usage, reducing waste generation, and utilizing sustainable materials. Through efficient water management systems, rainwater harvesting, and graywater recycling, green buildings can decrease the strain on local water supplies and alleviate water scarcity concerns. Furthermore, green building practices encourage the use of environmentally friendly materials, such as recycled content, responsibly sourced timber, and low-emission products, thereby reducing the ecological impact of construction activities.

Green building technologies (GBTs) have gained increasing attention in recent years as a means to minimize the negative impacts of the construction industry on the environment, economy, and society[1]. Various studies have focused on understanding the barriers and drivers affecting the adoption of GBTs in different contexts. For example, research conducted in Ghana highlighted critical barriers hindering GBT adoption, such as cost and lack of awareness [2]. Similarly, experts in the United States emphasized the need to examine key issues influencing the progress of GBT adoption to ensure its continued success [3]. Strategies for promoting GBT adoption have also been explored internationally, recognizing its potential to enhance sustainability in the construction industry [4]. Despite the growing acceptance of green building, challenges persist, particularly in developing countries where adoption rates may be lower due to various barriers [5]. The diffusion of GBTs in new housing construction and the role of government policies in promoting their adoption have also been examined [6]. Understanding the influences of barriers, drivers, and promotion strategies is crucial for the successful implementation and wider adoption of GBTs, both in developing countries like Ghana and on a global scale [7]. The forces driving GBT adoption, including the need to mitigate environmental effects and promote sustainability, have been a subject of interest in numerous studies conducted across different countries [8].

THE PURPOSE OF THE REVIEW ARTICLE

The purpose of the review article titled "Green Building Technologies: A Review on Energy Saving Systems and Renewable Energy Integration" is to provide an overview and analysis of various energy saving technologies and renewable energy integration strategies in green building technologies. Purpose of this article:

1. Reinforcing existing knowledge: This review article aims to summarize and synthesize the current state of research and the use of renewable energy utilizing methods in power systems and green buildings.
2. Identify key technologies and methods: This document will identify and describe the best energy saving techniques in green buildings, such as building envelope, lighting quality, HVAC systems, and energy management and control.
3. Evaluation of benefits and issues: The assessment will evaluate the environmental, economic and social benefits of energy savings and the integration of renewable energy into green buildings.
4. The strength of green building is that it reduces natural resource consumption and also having less operating costs. It provides health, comfort and safety for all occupants /residents. It ensures energy optimization as well as reduction in energy consumption.
5. Obstacles in green buildings are the materials and technologies they utilize tend to cost more. Also, the materials may be less readily available and construction of buildings may take longer time. Additionally, funding for green building projects are more difficult to secure. At present it also have lack of standardization and certification. Due to limited availability of sustainable materials and technologies, green building projects are mostly avoided.
6. Demonstrate case studies and best practices: The literature review will show real examples of green buildings that have achieved energy efficiency, electricity and renewable energy.
7. Identify future directions and opportunities: This article will discuss new events, innovations and future directions in the field of green garden technologies.

In general, the purpose of this review article is to provide general information and new resources, developments, and applications.

Overview of the Scope and Structure of the Paper

The review paper titled "Green Building Technologies: A Review of Energy-Efficient Systems and Renewable Energy Integration" will cover a wide range of topics related to energy-efficient systems and renewable energy integration in the context of green building technologies. The paper will be structured as follows:

1. Introduction:
    - Briefly introduce the importance of green building technologies and the need for energy-efficient systems and renewable energy integration.
    - State the objectives and scope of the review paper.
2. Energy-Efficient Systems in Green Buildings:
    - Discuss various energy-efficient systems commonly employed in green buildings, including building envelope design, insulation techniques,

high-performance windows, lighting systems, HVAC systems, and energy management and control systems.
   - Provide an overview of each system, their benefits, and their role in reducing energy consumption and improving building performance.
3. Renewable Energy Integration in Green Buildings:
   - Explore different renewable energy technologies that can be integrated into green buildings, such as solar energy systems (photovoltaics and solar thermal), wind energy systems (small-scale wind turbines), geothermal energy systems (ground-source heat pumps), biomass and biofuel systems, and hydropower systems.
   - Discuss the benefits, challenges, and considerations associated with each renewable energy technology.
4. Energy Storage and Management in Green Buildings:
   - Examine energy storage technologies and their application in green buildings, including battery storage systems and thermal energy storage.
   - Discuss the role of smart grid integration and demand response strategies in optimizing energy management in green buildings.
   - Highlight the importance of energy management software and building automation systems in monitoring and controlling energy usage.
5. Case Studies and Best Practices:
   - Present real-world case studies of green building projects that have successfully implemented energy-efficient systems and renewable energy integration.
   - Analyze the strategies, technologies, and approaches used in these case studies and highlight their successes and lessons learned.
   - Identify best practices that can be applied to future green building projects.
6. Challenges and Future Directions:
   - Discuss the challenges and barriers associated with adopting energy-efficient systems and renewable energy integration in green buildings, such as upfront costs, technical complexities, and regulatory constraints.
   - Highlight potential solutions and policy initiatives to overcome these challenges.
   - Identify emerging trends, innovations, and future opportunities in the field of green building technologies.
7. Conclusion:
   - Summarize the key findings from the review paper.
   - Emphasize the significance of energy-efficient systems and renewable energy integration in achieving sustainable and environmentally friendly buildings.
   - Provide recommendations for further research, development, and implementation in the field.

The structure of the paper ensures a comprehensive exploration of energy-efficient systems, renewable energy integration, and their implications for green building technologies. It covers both theoretical aspects and practical applications through case studies and best practices, providing valuable insights for researchers, practitioners, policymakers, and stakeholders in the field.

ENERGY-EFFICIENT SYSTEMS IN GREEN BUILDINGS

Energy efficiency plays an important role in green buildings by reducing energy consumption and improving overall building performance. Below is a brief summary of the most common energy saving systems used in green buildings:

Building Structure: The building envelope, including walls, roof, windows and insulation, designed to reduce heat loss. insulation, good glazing systems and proper sealing to reduce heating and cooling loads.

Lighting: Energy efficient lighting uses technologies such as light-emitting diodes (LEDs), compact fluorescent lamps (CFLs), and conventional lighting. These systems improve lighting quality, reduce energy consumption, and often include controls such as motion sensors and dimmers for added efficiency.

HVAC Systems: Heating, ventilation and air conditioning (HVAC) systems make up a significant portion of a home's energy use. HVAC energy efficiency uses advanced technologies such as high efficiency pumps, speed variations and demand-driven ventilation to optimize energy use while maintaining people's comfort.

Energy Management and Energy Management: Energy Management (EMS) and Building Automation Systems (BAS) centrally monitor, manage and optimize energy use in the home. These systems include a variety of devices, including meters, gauges and controls, to monitor energy use, adjust locations based on occupancy and environment, and identify areas for improvement.

Energy conservation in green buildings has many advantages, including:

Reduced energy use: Energy efficiency can reduce energy needs if it reduces operating costs and environmental impact.

Improve Indoor Quality: Proper design and installation of systems can improve indoor air quality, thermal comfort and lighting, creating a healthy and comfortable environment for residents.

Reduces carbon emissions: Energy efficient green buildings help reduce greenhouse gas emissions and mitigate climate change by reducing energy consumption.

Financial Savings: Energy efficiency can provide long-term savings due to reduced energy and operating costs.

Compliance: Many jurisdictions have energy regulations and certifications that promote or require energy efficiency in buildings.

Overall, energy efficiency is key to the success of green buildings, resulting in significant energy savings, better occupant comfort and the environment to create balance.

Green building technologies have received a lot of attention for their ability to address environmental sustainability and human health. New technologies such as machine learning, data processing, and parametric 3D modeling automate early design exploration and design decision making. In addition, the integration of human factors such as the behavior of people in power has become important in the field of design. Therefore, many design methods are important to produce solutions that include environmental sustainability and human health in society [9].

One of the keys to an energy efficient green house is choosing the right materials. The selection of building materials plays an important role in the efficient use of energy and in achieving sustainable development goals. Architects, designers, engineers and developers are constantly looking for new materials and technologies that provide energy efficiency, water conservation and water conservation benefits, improve indoor air quality, reduce cost of living, and endure. To aid the selection process, tools such as life cycle assessment help evaluate and select the right products [10].

Creating a robust environment and good electronic equipment requires “green building” guidance and practice. These systems involve the use of energy, water and new materials while minimizing waste generation and adverse effects on health and the environment. To limit these disadvantages, green building must be taught, clarified, understood and implemented [11].

Passive design has proven effective in reducing building budgets. A holistic design approach based on energy saving strategies can improve the energy efficiency of green buildings. However, green building assessment tools need to include more rigorous methods to allow comparison of different strategies. This can be done through further understanding and parametric research to increase the validity of this measurement tool [12].

In developing countries such as Turkey, the certification process of existing buildings plays an important role in promoting sustainable practices. Doing research to teach experts confirmed that existing buildings are important. Similar studies can be done in different countries to take into account different laws and conditions. The planning process and process can also be used to explore the certification process for innovation [13].

The energy efficiency of LEED certified buildings has been the subject of discussion. While some studies have found that LEED certification indicates energy efficiency, others have come to the opposite conclusion. The overall energy efficiency of LEED-designed buildings, especially those with lower certification levels, is questionable. Therefore, changes to the LEED energy and climate categories are intended to improve the actual energy efficiency of buildings [14].

Sustainable building renovations are affected by regulations that support business incentives and protect building codes. While traditional energy systems focus on improving heating and lighting and improving insulation, there is a growing trend towards a holistic approach and addressing social goals 10 questions concerning sustainable building renovation].

Examining the fees associated with green buildings shows a mixed picture. Although some studies show that green buildings cost less than traditional buildings, studies addressing this issue are scarce. The extent of this problem leads to more research and educational publications for a better understanding of the impact of green buildings (Green buildings cost premium: A review of empirical evidence).

Developing cognitive skills to help measure the performance level of green buildings. These methods use techniques such as Research Hierarchy Process (AHP) and fuzzy logic to analyze environmental, social and economic conditions. These expert systems combine conflict and knowledge to provide important tools for evaluating the performance of sustainable buildings (A knowledge-based expert system for assessing the performance level of green buildings).

The development of green buildings in China is due to the change in people’s thinking and progress. The government has implemented rules and regulations, specifications and policies to promote the safety of green buildings and encourage the construction industry’s interest in sustainable construction. However, the criteria of my country’s green buildings do not have a solid foundation and are affected, which indicates the need for further development and improvement (A Review of Green Building Development in China from the Perspective of Energy Saving).

Building Envelope Design and Insulation Techniques

The building envelope acts as the shell of the building, providing a barrier between the interior and exterior areas. It plays an important role in managing home comfort, energy efficiency and overall home performance. Constructing the building envelope and insulation process is key to building energy efficiency and sustainability. In recent years, the construction industry has increasingly focused on energy efficiency. The need to reduce energy consumption, combat climate change and reduce the environmental impact of buildings has led to a focus on optimizing the thermal performance of the house envelope. The building envelope consists of many components such as walls, roofs, windows, doors and floors. These components can be designed and manufactured to minimize heat transfer, control airflow, and provide adequate insulation. Buildings can significantly save energy and increase occupant comfort by using good design ideas and insulation techniques.

In the study, the thermal insulation properties of glass fiber boards used for the interior building envelope were investigated. The simulated results indicated that using glass fiber boards as insulation for the interior building envelope led to significant heating energy savings. However, it was found that the energy-saving percentages increased slowly when the insulation thickness exceeded 20 mm, suggesting that the glass fiber boards should not be excessively thick.

Authors conducted a multi-objective optimization study on building envelope design for life cycle environmental performance. They utilized a hybrid artificial neural network and genetic algorithm approach for optimization. The study considered environmental impact categories such as global warming, acidification, eutrophication, smog formation, and ozone depletion. The results revealed that the optimum design scenario included a fiberglass-framed triple-glazed window, approximately 60% south window-to-wall ratio (WWR), 10% north WWR, and R-17 insulation [15].

Authors conducted a comparative study of building envelope cooling loads in Al-Amarah City, Iraq. They found that combinations of "clay-insulation-fired clay bricks-cement mortar" for the roof and "cement mortar-thermo-stone bricks-cement mortar-gypsum mortar" for the external wall performed well in terms of cooling loads. The study provided recommendations for construction authorities in Al-Amarah City and individuals interested in energy-efficient buildings [16].

Authors analyzed climate adaptive energy-saving technology approaches to the residential building envelope in Shanghai. They proposed different combinations of envelope index levels for heating and cooling modes to conserve energy. The study suggested that an optimized energy technology approach could achieve thermal comfort with relatively low energy use [17].

Authors examined the role of the building envelope for energy efficiency in office buildings in India. The paper highlighted that different components of the building envelope have varying energy-saving potentials. It recommended specific building orientations and shapes to minimize heat transfer while maximizing daylight utilization [18].

The paper investigated the effect of the building envelope on thermal comfort and energy saving in high-rise buildings in hot-humid climates. The study established a thermal comfort zone for Malaysian residential buildings and provided recommendations for designers to optimize the design plan for high-rise buildings in hot and humid climates [19].

Authors compared Glaser and dynamic methods for analyzing technical solutions for insulating the opaque building envelope. The aim was to evaluate superficial and interstitial condensation, durability, and resistance to biological attack, freeze/thaw cycles, and corrosion. The advantages and disadvantages of both methods were highlighted [20].

The paper reviewed numerous studies on the optimization of building envelope design. They compared popular optimization algorithms, collected and summarized targeted objectives, and identified limitations in the research area while suggesting potential breakthroughs [21].

Authors conducted a study on the optimal design of residential building envelope systems in the Kingdom of Saudi Arabia (KSA). The study concluded that substantial savings in annual energy costs can be achieved in the KSA through aggressive promotion of energy efficiency programs for both existing and new buildings [22].

The paper analyzed 219,000 certified on-site air leakage measurements in France to improve building airtightness. They identified the most frequently identified and influential leaks, as well as the common use of last-minute corrections despite their impact on airtightness durability. The study confirmed the suitability of the multi-point testing method in the French context [23].

In summary, these studies cover various aspects of building envelope design and performance, including thermal insulation, environmental impact, cooling loads, energy-saving technologies, and airtightness. They provide valuable insights for improving energy efficiency and sustainability in building construction and operation.

High-performance windows and glazing systems

The efficient integration of window and glazing systems into buildings has many advantages. They provide cost savings and environmental benefits by reducing energy consumption for heating, cooling and lighting. In addition, this technology improves interior comfort by reducing air currents, reducing glare and increasing natural light, thereby improving occupant comfort, health and productivity.

Against this background, research and development continues to improve the efficiency and potential of the performance of window and glazing systems. This includes researching new materials, improving manufacturing processes and integrating technologies to increase energy efficiency and sustainability in buildings. The following documents illustrate the progress and potential applications of various new technologies in the glass field:

Authors have published an excellent review that provides a comprehensive review of innovations in glass technology. This article reviews current glass performance materials and technologies, providing in-depth information and practical examples [24].

It was proposed using laminated glass Luminescent Solar Concentrators (LSCs) to harvest solar energy in buildings. By integrating highly quantum efficient CuInS2/ZnS quantum dots into the polymer interlayer of laminated glass, they achieved an optical efficiency of 8.1% while maintaining good optical transmission [25].

It was focused on the development of environmentally friendly ultra-high performance concrete (UHPC) using glass powder. Their research shows that water fringes form around particles of cement and glass dust. Compared with traditional UHPC, UHPC has good performance, economy and environment [26].

Authors presented a comprehensive design and experimental study of a high-performance glass drain tube solar water heater. They demonstrate the use of machine learning-based high-throughput scanning (HTS) methods to optimize the design of solar panels to maximize heat output [27].

Authors are investigating the use of low-temperature lithium-doped SnO_2 as an efficient electron transport layer for high-performance switching and wearable perovskite solar cells. Their research shows that commitment strength varies widely between both rigid and flexible, pointing to the potential for data to be a useful source of power [28].

It was explored the development of scalable and layered engineered polymer films as selective heat spreaders for high-performance everyday radiant cooling. They provide a large-scale solution for large-scale applications by analyzing the impact of this thermal emitter option for global warming reduction and temperature control [29].

Authors review recent developments in flexible and self-contained glazing systems for low-energy building retrofits. They discuss electronic glasses such as electrochromic, liquid crystal and liquid crystal, and non-electric systems such as thermochromic, thermochromic and aerochromic glasses, solar temperature control and anything that provides daylight [30].

It was explored the use of widebandgap p-type nanocrystalline silicon oxide (p-SiOx) film as a window layer for high-performance thin-film silicon multi-junction solar cells. His research focuses on achieving high on voltage (Voc) and improving the blue spectral response in the top amorphous silicon cell, thereby maximizing the overall efficiency of the solar cell [31].

The authors reviewed recent work on the development of full-solid-state polymer electrolytes for high-performance lithium-ion batteries (LIBs). This article discusses the potential applications of polymer electrolytes in consumer electronics, electric vehicles and grid storage [32].

Together, this information provides a better understanding of glass use and its potential to transform energy use, renewable energy and building practices.

Efficient lighting systems and controls

The use of lighting and control plays an important role in optimizing energy use and promoting safety in many places, including residential, commercial and industrial areas. These systems and controls use technology and techniques to improve lighting, reduce energy waste and increase user comfort and productivity. By combining energy-saving devices such as light-emitting diodes (LEDs) with smart features such as built-in sensors, daylighting and dimming capabilities, Organizations and individuals can achieve significant energy savings when managing lighting. These systems support flexible and customizable lighting solutions that allow users to tailor lighting to specific needs and preferences.

Author's research compared green building standards in China, England, and the United States. The analysis focuses on five issues: energy saving, water saving, material saving, site selection, and indoor and outdoor environment. This article examines the tests and metrics used in each process to understand their similarities and differences [33].

In the paper Green Building Compliance and Energy Efficiency Retrofit Planning Research Center was studied. They developed a model that incorporates economic analysis to help policymakers make decisions. This study used an existing office building as the study and demonstrated the effectiveness of the model by achieving significant energy savings and completing the Energy Performance Certificate (EPC) validated assessment [34].

Authors discuss daylight efficiency and visibility measures of green offices in Malaysia. Their findings highlight the importance of considering interior design in addition to solar factor (DF) when evaluating daylight performance in tropical climates such as Malaysia. This study shows that

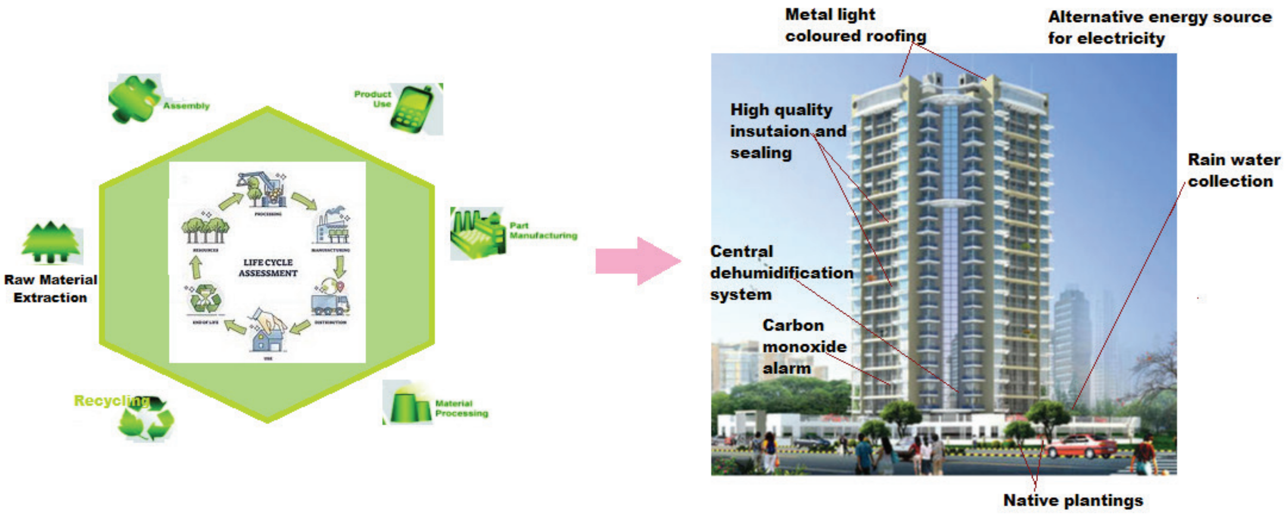

Figure 1. Green building with advanced solutions.

interior design plays an important role in promoting the quality of solar energy, which is often beyond the control of the designers and depends on the preferences and attitudes of the end users [35].

This study estimates the impact of the three assessments on green design and building performance, demonstrating the quality of performance measured by standard measurement-based methods in promoting good design [36].

The article talks about the purpose of certification in certifying the compliance of products with certain environmental standards. It discusses various certifications that take into account various lifestyles and behaviors such as energy use, recycling content and emissions, as well as certifications that focus on a single behavior such as water, electricity or chemical emissions that affect indoor quality (IEQ) [37].

This study compares green production facilities with managed estates and examines differences such as exterior design, lighting, cleanliness, furniture and privacy. The findings show that green buildings outperform controls in these areas, emphasizing the importance of safety design in green buildings [38].

Authors demonstrate the energy efficiency of the electronic control system. Experimental results show that significant energy savings can be achieved compared to conventional metal halide lighting while increasing reliability and reducing maintenance. The study shows potential benefits for future deployment across the region, including reductions in greenhouse gas emissions [39].

Authors provide a comprehensive review of design trends in green building assessment tools. This study demonstrates the effectiveness of architectural design as an energy saving strategy in reducing home energy consumption. The authors recommend including a weight scale in green building assessment tools so that different strategies can be better compared [12].

Authors present a lighting system that uses artificial neural network (ANN) and internal pattern control (IMC) for lighting control and daylighting. This study demonstrates the effectiveness of the system through simulation results and experimental setup and demonstrates its effectiveness in providing personalized lighting to facilities [40].

Table 1. Review on efficient lighting systems and controls

Study	Ref	Key Findings
Optimizing lighting performance	Beccali et al. [41]	- 81% of users felt safe in the test area - 80% were satisfied with the project - All samples were interested in using the new features in good lighting
Green building certification process	Aktas & Ozorhon [13]	- Provides guidance for effectively documenting existing buildings in developing countries
Intelligent indoor lighting systems	Pandharipande & Caicedo [42]	- Examined centralized and distributed architectures for lighting control - Identified challenges for future lighting design
Integration of green buildings	Balaban & de Oliveira [43]	- Reduction in energy consumption and CO2 emissions - Improvement in indoor and outdoor air quality, thermal comfort, and natural light
IoT-based green building management	Tushar et al. [44]	- Low-cost IoT sensors can create energy -saving measures and reduce energy consumption
Fuzzy logic controller for energy saving	Liu et al. [45]	- Fuzzy Logic Controller reduces lighting energy consumption - Smart LED lighting provides energy -efficient and personalized lighting
Comparative study on indoor environment quality	Pei et al. [46]	- Green buildings outperform traditional buildings in terms of satisfaction and meeting IEQ targets - Comparison of indoor temperatures and thermal comfort in different climatic zones
Green revolution and key success factors	Jagarajan et al. [47]	- Identifies current trends, practices, and challenges in the green building field - Identifies key success factors for green retrofit projects
Green building approach and assessments	T. Ahmad et al. [48]	- Design method for sustainable buildings validated through case studies - Simulation experiments facilitate green building design
Comparative analysis of green building assessments	Awadh [49]	- Critical review of LEED, BREEAM, GSAS, and Estidama assessments - Focus on energy and water standards

Renewable Energy Integration in Green Buildings

There are many benefits to integrating renewable energy technology into green buildings. It reduces dependence on non-renewable energy sources, thereby reducing greenhouse gas emissions and mitigating the impact of climate change. It also improves energy security by diversifying energy sources and promoting self-sufficiency. In addition, renewable energy can lead to long-term savings by reducing energy costs and capital gains from excess energy production.

However, there are many challenges in integrating renewable energy into green buildings, including rising costs, the re-disruption of some renewable energy sources, and the need for energy-saving solutions. Meeting these challenges requires innovation, technological progress, policy support and financial support.

The academic paper examines the accuracy of Building Modeling (BIM) and sustainable buildings, drawing on academic studies and real-world applications. It provides construction professionals and researchers with essential guidance to align BIM development with sustainable building design principles [50].

It was observed that currently, BREEAM is the only tool that provides a complete assessment of the four dimensions of sustainability. To improve the results of green measures for sustainability measures, more research should focus on business and economics [51].

The review builds on research presented at the Sustainable Energy, Water and Environmental Systems Development (SDEWES) conference, discussing and expanding the series more broadly contexts. It emphasizes advances in technology and their role in achieving sustainable development [52].

The findings of this review highlight the importance of government intervention in promoting green building. It also highlights the potential for research to expand understanding of green building support [53].

Energy efficiency in buildings can be achieved by four things Important: Build a Passive House for zero energy use, use a low energy building when using equipment, adopt energy efficient equipment to reduce energy needs, work on electrical equipment and many applications continue to their participation [54].

This study provides a comparison of different evaluation methods for green buildings and suggests research for further development. Research studies can be useful to business professionals and researchers interested in developing green building measures [55].

The review explores the potential of using cloud-based BIM technology and managing big data to improve building stability. However, problems with the availability of computer hardware and the complexity of BIM models have prevented the widespread use of green BIM applications [56].

The article provides an insight into the factors affecting greenhouse application adoption. It enhances the understanding of policy makers and advocates while providing a basis for further research to delve deeper into the subject and expand the knowledge base [57].

Solar Energy Systems: Photovoltaics (PV) and Solar Thermal

Solar energy systems, particularly photovoltaic (PV) and solar energy technologies, have emerged as solutions to meet the growing global demand for clean and stable energy. Solar energy takes energy from the sun and converts it into usable electricity or heat, providing environmental benefits and reducing reliance on fossil fuels.

PV systems use semiconductor devices to convert sunlight directly into electricity. The photovoltaic effect occurs when photons from sunlight strike electrons in atoms, creating an electric current. Over the years, photovoltaic technology has developed rapidly, becoming more efficient and effective. It is now used in many applications, from small plants to large solar power plants.

Solar energy plays an important role in achieving net zero energy buildings and many technologies are applied to realize its potential. The performance of solar thermal, PV and PV thermal (PV/T) systems was comparatively evaluated. The study shows that buildings with high-quality photovoltaic systems are the closest to achieving zero energy balance. However, results vary depending on the definition and boundary of the net zero energy building and the energy design of the building [58].

In West Africa, authors conducted a GIS analysis to identify areas with significant potential for PV and solar power (CSP) production. These efforts aim to support ongoing on-grid and off-grid electrification policies by identifying suitable areas for solar power distribution [59].

Authors provide an overview of the development of PV-CSP hybrid systems. They describe the research status and performance of hybrid systems from a global perspective and highlight the advantages and limitations of the technology based on the literature review. The integration of solar energy, especially photovoltaics, into the grid is crucial for energy management [60].

Authors provide an overview of the integration and compatibility issues of solar and power grids. This review aims to contribute to integrated solar systems studies in new projects and to provide a better understanding of researchers and researchers working in this field [61].

Accurate estimation of solar energy and radiation is essential for the efficient operation of smart grids. Authors present a comprehensive review of theoretical forecasting methods for solar products and photovoltaic power generation. They also explored the use of solar forecasting for energy management in smart grids [62].

These studies contribute to the advancement of solar technology and its integration into applications ranging from net zero energy buildings to grid management. By exploring opportunities, challenges, and technology predictions, scientists and engineers can improve solar energy use in the future.

Wind Energy Systems: Small-scale Wind Turbines

Small wind turbines play an important role in the use of wind energy in the region. Unlike large wind farms, which are often located in remote areas, small wind turbines are designed to be installed in regions, businesses and communities. These compact wind turbines have the advantage of producing clean and renewable energy in areas with good wind resources, giving individuals and businesses the opportunity to reduce their dependence on electrical wiring.

Small wind turbines are characterized by their small size and low power output compared to large wind turbines. They are usually designed to generate electricity from a few kilowatts to several hundred kilowatts, making them suitable for powering individual homes, remote areas, or for specific uses such as using water or charging batteries.

In recent years, there has been interest in home energy management (HEMS), which means that HEMS solutions have limitations that affect their effectiveness. One of the best ways is to use a battery energy storage system (BESS) to solve the energy uncertainty [63].

Experimental and numerical studies help isolate vertical axis wind turbines and clarify their location and aeroacoustic characteristics. Useful information is also obtained from the installation of small wind turbines in different countries and studies related to them.

Authors conduct an in-depth study to evaluate the wind energy potential and wind turbine performance of small turbines in Incek district of Ankara. The study measured the energy and energy density values for each season and month, showing that the highest energy level occurred in

Table 2. Review on Solar & Wind energy systems

Ref	Key Findings	Solutions
Good et al. [58]	Buildings with high-quality photovoltaic (PV) systems come closest to achieving zero energy balance, but results depend on nZEB definition, boundary conditions, and energy system design (2015)	Improving the performance of PV systems in buildings to optimize energy balance
Yushchenko et al. [59]	GIS analysis identifies areas in West Africa with significant potential for PV and CSP production to support on-grid and off-grid electrification policies (2018)	Utilizing the identified areas for solar power deployment in alignment with electrification policies
Ju et al. [60]	PV-CSP hybrid systems have advantages and limitations; integration into the grid is crucial for energy management (2017)	Further development and integration of PV-CSP hybrid systems for improved energy management in the grid
Nwaigwe et al. [61]	Integration and compatibility issues of solar and power grids need to be addressed for effective solar-grid integration (2019)	Conducting studies to better understand integration challenges and facilitate seamless solar-grid integration in new projects
Wan et al. [62]	Accurate solar energy and radiation forecasting is crucial for efficient operation of smart grids; applications in energy management explored [2015]	Advancing theoretical forecasting methods for solar energy and incorporating solar forecasting into smart grid energy management
Hemmati [63]	Home energy management systems (HEMS) incorporating small-scale wind turbines and battery energy storage systems (BESS) can address energy uncertainties (2017)	Implementing HEMS with small-scale wind turbines and BESS to optimize energy management and address energy uncertainties
Tummala et al. 67]	Experimental and numerical studies help categorize vertical axis wind turbines and provide insights on positioning and aeroacoustic aspects (2016)	Utilizing knowledge gained from studies on small wind turbines to inform positioning and optimize aeroacoustic characteristics
Bilir et al.[64]	Evaluation of wind energy potential and performance of small-scale wind turbines in the İncek region, Ankara, Turkey (2015)	Assessing energy and power density values, evaluating small wind turbine models for optimal performance in the region
Ribeiro et al. [65]	Characteristics such as location, area, and shape have significant impacts on energy production from small-scale solar and wind power systems in Brazil (2016)	Conducting comprehensive studies on the influence of location, area, and shape on energy production to optimize small-scale solar and wind power systems
Gökçek & Gökçek [66]	Techno-economic analysis of wind-powered small-scale seawater reverse osmosis systems (WP-SWRO) for freshwater production (2016)	Assessing the technical and economic aspects of WP-SWRO systems to determine their viability and potential benefits for producing freshwater in arid and coastal areas

March, around 98 W/m². These findings indicate that large wind turbine installations may not be possible in the region and may require evaluation of three different small wind turbine models [64].

The study explores the effects of location, size and shape of small solar and wind power in Brazil. The results show significant changes in power generation based on these characteristics, with differences in some cases greater than 200%. This highlights the importance of understanding the role of location, area, and shape in determining electrical properties [65].

Wind-powered seawater desalination systems offer an effective solution for the production of drinking water in dry and coastal areas, including islands. This research Contributes to Economic Research Small wind seawater reverse osmosis (WP-SWRO) research was conducted. By evaluating its technical and economic aspects, the applicability and benefits of this new system can be determined [66].

Energy Storage and Management in Green Buildings

The integration of energy storage and management in green buildings has many benefits. It increases energy efficiency by enabling buildings to operate independently in the event of a power outage or power outage. It also provides sustainable and reliable energy by facilitating the integration of renewable energy sources. In addition, energy storage and energy management help reduce energy costs, increase energy efficiency and contribute to the overall sustainability and environmental performance of the greenhouse.

As the transition to renewable energy continues, the importance of energy storage and management in green buildings will increase. Advances in electrical equipment such as batteries and water pumps and the development of efficient energy management systems will further strengthen the use of electricity and energy in green buildings, bringing us closer to the future and providing less carbon.

In the search for zero-energy buildings, the development of thermal storage devices has been beneficial. However, current research shows that no single material can meet all building requirements in terms of thermochemical energy storage. In addition, the use of small quantities of thermochemical solutions requires careful consideration of different tanks and different heat sources. More research work is needed to improve quality, efficiency, design and performance.

This comprehensive review aims to evaluate various thermal energy storage (TES) technologies related to different building types.

Emphasis is placed on the analysis of the combination of storage features and residential features. This study presents TES contracts applicable to residential and commercial buildings. However, more research is needed, particularly on changing materials and thermochemical storage, to improve understanding and improve performance [68].

The document provides an overview of TES in buildings, focusing on well-known, covert and thermochemical energy storage methods. Integrating TES into the building provides heating and cooling. Passive systems in the building envelope, active systems using phase change materials (PCMs), adsorption systems and seasonal storage methods are all evaluated for effective thermal management in the building [69].

The research focuses on energy storage such as hydrogen, batteries and flywheels in renewable energy systems, particularly photovoltaic and wind farms. The marketing of different storage devices has also been explored. Behaviors of battery and flywheel storage systems in photovoltaic and wind energy applications are examined using Matlab/Simulink and the results are presented [70].

The study presents occupancy based demand response strategies to improve thermal comfort in microgrids used for renewable energy and energy storage. Comparing ideas demonstrating the integration of renewable energy with responsiveness to practical needs, thereby reducing energy costs while increasing thermal comfort for the inhabitants The concept has proven robust, providing consistent improvements under different conditions, including different dwell times and weather conditions [71].

These studies contribute to the development of energy technology and its application in achieving zero energy buildings. By addressing limitations, exploring solutions, and optimizing performance, researchers and practitioners can reopen the way for effective energy management and benefit in the future.

Battery storage systems & Thermal energy storage

Energy saving plays an important role in smart buildings, reducing costs, changing the maximum and making it easier. This review presents research on the sizing, design and performance of electrical and thermal energy storage in smart buildings. The performance of framework, control and optimization is evaluated through simulations, experiments and calculations.

Optimum Sizing and Operation of Energy Storage Systems:

New methods are proposed to optimize the sizing and operation of electrical and thermal energy storage systems in smart buildings. This system demonstrates the ability to reduce annual energy costs by more than 80% and lifecycle costs by 42%. Simulations are presented and experimental results prove the effectiveness of the proposed system and controller [72].

Metaheuristic Optimization of Operational Planning: The metaheuristic optimization method achieved the best results in providing integrated operational plans for batteries, electronic devices and electrical equipment for the electrical building. Although computational methods can produce optimal solutions, they often require significant computation time. The application of meta-heuristic optimization techniques solves this problem by increasing the efficiency of the transition and improving energy management [73].

A method has been developed to evaluate the basic performance of a building electrical system (BES) for use in products such as time, energy and power. The size and type of generator is affected by the analysis. In addition, the ability to integrate flexible measures into the urban space is explored, providing a better perspective for planning and energy management [74].

This overview covers a variety of TES systems used in a variety of applications, including seasonal TES, TES at solar facilities, and TES for home solar energy use. Active TES systems such as thermoclines, packed beds, fluidized beds and moving beds and passive TES systems used in buildings, textiles and vehicles are investigated [75].

Author proposes a new thermal energy storage system for smart buildings based on phase transfer data. A two-phase electricity generation system has been designed to reduce energy consumption and energy conversion while maintaining home comfort. Simulation studies demonstrate the feasibility and effectiveness of thermal energy storage systems in solving peak shaving and energy conversion problems [76].

Author addresses the optimization of electrical and thermal energy management for residential energy centers, including demand fulfillment and energy storage. Create an optimization problem to reduce total energy costs, including customer preferences for hot water and hot air. In addition, various optimization targets are used to determine the customer›s contribution to CO_2, NOx and SOx emissions [77].

These efforts contribute to the development of energy storage in smart buildings for cost savings, peak management and improved energy efficiency. By optimizing system size, uptime, and control strategies, researchers and engineers can improve the performance and sustainability of smart buildings.

Smart Grid Integration and Demand Response

The integration of smart grid and demand response plays an important role in grid reform and energy efficiency. With the increasing popularity of electronic devices, the need to effectively manage and integrate electronic devices and needs has become more important. Smart grid technology has the ability to integrate energy sources, advanced metering and smart communication to facilitate real-time monitoring, control and optimization of the grid.

Implementing buildings and their systems with smart grids requires solving many problems, including interoperability data exchange and smart grid relationship issues . Asset HVAC and building management. As new management and communication technologies emerge, public policy and business models struggle to keep up with the rapid growth of smart technology [78].

The paper presents a new way to solve demand response generation using edge-cloud integrated solution and reinforcement learning techniques. The simulation results show the effectiveness of the management strategy and the performance of the learning process in buildings of different sizes. In addition, cost analysis demonstrated the potential return on investment for institutions participating in demand fulfillment programs [79].

The study focuses on demand response algorithms for residential buildings using the technology education model. A comparison with baseline conditions shows a reduction in energy consumption, energy production costs and carbon emissions. The results show the effectiveness of rule-based and predictive algorithms in optimizing the desired input [80].

The document presents users of Demand Response Management (DRM): Related products: Green Smart and Green Awareness. Algorithms based on the Customer Discomfort Index are designed to measure annoyance reduction [81]. The efficiency and effectiveness of the DRM scheme has been analyzed using bed.

The level of consumer demand, especially during peak hours. To overcome this challenge, a flexible multi-use pricing system has been proposed to reduce external competition and increase the efficiency of DR [82].

The document presents a Summary of four projects in the US, UK and China focused on commercial buildings and Microgrid. The current state of practice in automated demand response (ADR) is discussed along with limitations in current research and development. This article also summarizes the main research points in modeling, optimization and management of ADR implementation as well as early work in these areas [83].

Energy Management Software and Building Automation Systems

Energy management software and building automation systems play an important role in increasing energy efficiency, increasing efficiency and reducing building costs. With the increase in energy saving and safety, this technology has become important in the control and management of energy systems in buildings.

Energy management software allows home owners and facility managers to monitor, analyze and manage energy use in real time. It provides insight into energy usage patterns, identifies areas of inefficiency, and enables energy savings. Energy management software integrates information from a variety of sources such as sensors, meters and energy sources, helping to make decisions to achieve energy efficiency goals.

Authors present the Internet of Things (IoT) framework for smart energy in buildings. The researchers not only developed the framework, but also improved the IoT network structure and management. Real-world testing is done to verify the effectiveness of their solutions. The results show that the planning process can save a lot of energy, improve home/office skills and contribute to global growth [84].

In another study, authors examined the relationship between BIM and green buildings. They conducted an extensive literature review and reviewed various types of BIM software. Their research provides a better understanding of the link between BIM and green buildings, illustrated by a taxonomy called the “Green BIM Triangle” (Lu et al. [50]).

Authors compare different greenhouses. They found that environmental issues were more prominent in the new home curriculum, while the community development curriculum focused on social issues. Among the assessment methods, BREEAM has been identified as the only tool that can evaluate all four aspects of sustainability [51].

The authors recommend further research on business and economics studies to develop the potential of green measures for sustainability measures.

Zhou and Li examine smart home energy management HEMS by analyzing various configurations and programs. At HEMS, they also explored the use of renewable energy sources such as solar, wind, biomass and geothermal energy. They also explored different strategies for home appliances to reduce energy costs and increase energy efficiency.

Authors propose a smart negotiation system for IoT-based energy management in smart cities. They propose a framework and software model for edge computing IoT-based systems. They also show how to use energy efficiency using deep learning. Their research demonstrates the effectiveness of the planning process [85].

The authors review the challenges and opportunities of IoT in smart buildings. They identified the lack of common standards, inconsistent cybersecurity solutions, and lack of vertical implementation as barriers to IoT deployment [86].

The authors discuss the technologies and challenges associated with the Internet of Things in the smart home. Li and Chen made a comparison of green building assessments. They discover the comparison rules, the number of evaluation methods, advanced evaluation methods and the current state of the comparison content. This work identifies research opportunities for future development and provides insight for industry professionals and researchers interested in green building evaluation processes [55].

Serale and Fiorentini focused on model predictive control (MPC) and its potential to improve the energy performance of buildings and HVAC systems. They have published dictionaries and taxonomy to provide a better understanding of the engineering disciplines involved in the design and management of buildings. This article discusses the design of MPC and reviews the different methods available. The benefits of MPC application in energy efficiency improvement are highlighted [87].

Ahmad and Mourshed a review of the latest in building energy metering and environmental monitoring. They discovered a lack of interoperability between hardware and software, which led to vendor crash issues. This paper provides an overview of available technologies, their drivers, benefits, limitations, and factors affecting their selection. It also recommends future research in this growing area [88].

Together, these efforts contribute to energy management, green building applications, smart grid integration and IoT solutions in the built environment. They provide information on the validity of proposed methods, critical evaluations of current methods, and recommendations for future research and development.

CASE STUDIES AND BEST PRACTICES

Research papers and best practices for green buildings provide insight and examples of successful green building design. These studies present new ideas, concepts and designs that work across a variety of building types, including residential, commercial and institutional buildings. By studying real-world examples, business stakeholders can learn from the experiences of others and gain inspiration for their own greenhouse.

Case studies demonstrate the use of environmentally friendly materials, energy efficiency, water conservation, waste management strategies and other good practices. They suggest that this process can reduce environmental impact, improve energy efficiency, improve indoor environmental quality and provide cost savings over the life of the building.

Showcase of Green Building Projects with Energy-Efficient Systems

Authors presents a methodology for assessing process quality and factors that affect the success of green building projects. Business experts validated the principle through interviews and focus group discussions that provided insights into assessment, project lifecycle stages, green technologies, commissioning, recommissioning and project delivery systems [89].

Analysis of the Indian Green Building Movement sheds light on green building in India and its contribution to environmental protection. The document outlines the design and certification process regarding the positive effects of green buildings on nature and human health [90].

"China›s Green Building Industry" explores the role of the International Association of City and County Management (ICMA) in China's green building industry and its work with local governments. This study examines the evolution of green laws and regulations in China, assesses the progress of the green building industry and identifies the main drivers behind its growth [91].

Authors specializes in integrating BIM applications into green building projects and addresses Leaders in Energy and Environmental Design (LEED) certification. This study aims to create a model that supports holistic and systematic green BIM applications by clarifying business processes and planning [67].

The study explores the different types of organizations involved in green infrastructure development and offers a networking perspective to foster effective collaboration for new results [92].

Authors examined office tenants› willingness to pay for green features, particularly for the public, energy, and IT sectors of buildings [93]. This regional and public interest study offers policy makers and architects a perspective on the importance of various green building projects.

Authors focuses on sustainable buildings in the United Arab Emirates (UAE) in terms of energy efficiency and performance. Although the UAE ranks high in green building practices, the document addresses the challenges and opportunities associated with energy efficiency, renewable energy and the use of recycled materials [94].

Authors reviews economic studies on the costs associated with green buildings. Despite the importance of the subject, the article highlights the limited number of publications on the subject, emphasizing the need for more research in this area [95].

Authors discusses the planning and implementation of five green stars that meet the Green Rating criteria for the General Habitat Assessment (GRIHA) Council in India. This article examines architectural, civil, electrical, mechanical and landscape design efforts to achieve a five-star green rating and net zero energy performance in the field [96].

These studies and analyzes contribute to knowledge and understanding of various aspects of green building practice, including performance evaluation, policy implementation and evaluation. yes, new links, fees and training materials in different regions.

Table 3. Review on showcase of green building projects with energy-efficient systems

Ref	Key findings	Problems identified	Solutions
Sabbagh et al. [97]	- Examined the potential and limitations of the green building industry in the Arab world	- Limited adoption of green building practices in the Arab world	- Proposed a theoretical framework considering environmental, social, and economic factors to facilitate the transition to sustainable development
Ismaeel [98]	- Explained how to measure green building performance	- Identified potential improvements to existing green building assessment methods	- Proposed enhancements such as interactive decision-making tools, software management, and improved user relationships
Wang et al.[99]	- Presented methods and techniques for dynamic energy performance assessment of green buildings	- Identified a significant performance gap in HVAC systems	- Highlighted the importance of effective HVAC control to improve energy performance
Ornetzeder et al. [100]	- Examined the relationship between energy use and the health of people in the workplace	- Highlighted the possibility of achieving high health and wellness with low energy consumption in office buildings	- Advocated for considering various physical and social factors in achieving health and wellness in office buildings
Shen et al. [101]	- Examined the impact of various factors on the green building industry in Thailand	- Explored the importance of business needs, technological advances, government support, education, and community involvement in the green building market	- Provided information to help stakeholders develop strategies to promote UK businesses in emerging green building markets
Sun et al. [102]	- Examined the cost-effectiveness of active and passive design strategies for retrofitting buildings in tropical climates	- Identified lighting and lighting control as the least effective retrofit strategies	- Emphasized the integration of active and passive strategies to improve energy efficiency in tropical climates
Zhou [103]	- Examined green building technology in China, focusing on energy efficiency and cost reduction	- Highlighted the impact of luxury and high-end materials on the effectiveness of green projects	- Demonstrated the scale and potential of China›s home energy services
Kim et al. [104]	- Examined zero-energy housing development in South Korea	- Highlighted the importance of renewable energy systems in zero-energy buildings	- Advocated for post-occupancy monitoring and a holistic approach to design, development, and maintenance of zero-energy dwellings
Zhang et al. [105]	- Explored the effectiveness of green buildings from the perspective of members› perception, support, and commitment	- Identified the need for policy changes to strengthen green building practices in Australia	- Highlighted the importance of stakeholder engagement and support from the construction industry
AL-Dabbagh [106]	- Discussed Dubai and UAE›s efforts to promote green buildings and eco-cities	- Addressed challenges related to sustainable urban development	- Proposed strategies for urban planning, transportation, quality of life, and renewable energy to achieve sustainable development in the UAE
Homayouni et al. [107]	- Identified three paths to design and construct a high energy building [HEE]: routing data, driving process, and driver›s association	- Highlighted the importance of shared goals, owner involvement, and collaborative discussions in successful HEE projects	- Provided insights for integrating electronic devices and further research on additional elements in the design and development of HEE projects
Zou [108]	- Compared the certification choices of Chinese builders for LEED and 3-star systems	- Examined regional differences in certification choices based on economic indicators	- Explored the impact of international investors and construction companies on certificate preferences

CHALLENGES AND FUTURE DIRECTIONS

Awareness and Lack of Awareness

Many individuals and organizations are unsure of the benefits and potential of green building technologies, refusing to accept them.

1. Perception of high cost: Green building technologies often require upfront investment, and the perception that they are more expensive than alternatives can hinder mass adoption.
2. Limits of Expertise: Successful application of green technology requires expertise in design, construction and maintenance. A lack of professionals can hinder their adoption.
3. Regulatory requirements: Inappropriate or outdated regulations may not encourage or support the use of green building technologies, making it difficult for manufacturers and stakeholders to adopt them.
4. Resistance to Change: Business development has historically attracted attention, and resistance to change can be a major barrier to the adoption of new technologies and practices.

Technical and Economic Challenges of Grid Integration of Renewable Energy

1. Intermittent and variability: Renewable energy sources such as solar and wind have intermittent and volatility, which complicates grid integration. The balance between energy supply and demand gains importance.
2. Project limitations: Existing project plans may not be able to sustain high levels of renewable energy generation. Upgrading and expanding the grid to adapt to renewable energy can be expensive and difficult.
3. Energy Storage: Efficient and cost-effective renewable energy storage is critical to balancing supply and demand. Developing sustainable energy technology is a major challenge.
4. Competitive pricing: While renewable energy costs are falling, they may still be higher than conventional electricity in some areas. It is necessary to achieve cost parity or cost advantage for mass adoption.
5. Integration planning and management: The integration of renewable energy into existing power systems requires careful planning and management to ensure sustainability, reliability and efficient use of resources in the grid.

Possible Solutions and Future Developments in this Area

Policy and regulatory support: Governments can play an important role in supporting the integration of green building technology and renewable energy by promoting policies, incentives and regulations that encourage adoption.

1. Awareness and Education: Educating individuals, professionals and stakeholders about the benefits and possibilities of green and renewable energy technologies can help overcome barriers and promote greater adoption.
2. Research and Development: Continuous investment in research and development is essential to solve business problems, increase efficiency and reduce costs in green building technology, aging and renewable energy systems.
3. Collaboration and knowledge sharing: Promoting collaboration among business stakeholders, sharing best practices, and promoting knowledge exchange can drive innovation and good practice.
4. Technological advances: Advances in energy storage, smart grid technology and building automation systems can improve renewable energy integration and optimize the performance of green building technologies.
5. Financial systems: Creating new financial systems, such as green bonds or incentives for energy efficient buildings and renewable energy projects, can make them effective and practical.
6. Circular Economy Approach: Using circular economy methods can improve resources, reduce waste and use renewable materials in construction in line with technology green goals.
7. International cooperation: Collaboration, collaboration and learning from successful examples of countries can lead to the adoption of green building technology and the integration of renewable energy worldwide.

Overall, tackling problems, tackling challenges, and promoting policies and partnerships are critical to fostering a pervasive and successful green infrastructure.

Further Research and Call to Action

To continue to develop green building technology and renewable energy, the following measures should be taken:

1. Further research: more research is needed to solve business problems, improve performance and evolve green building technology and new solutions for the integration of continuous power.
2. Promote Education and Knowledge: There is a need to increase knowledge and understanding of the benefits and potential of green building among individuals, professionals, policy makers and stakeholders.
3. Strengthen policy support: The government should develop support, policy and incentives to promote the use of green building technology and the integration of renewable energy.
4. Promoting collaboration and knowledge sharing: Collaboration and international collaboration between industry stakeholders, researchers, policy makers can drive innovation, best practices and the implementation of effective solutions.
5. Scale implementation: Promote the deployment of green building technologies and renewable energy through incentives, financing and capacity building initiatives.

CONCLUSION

Various findings and opinions emerged from the study of literature on green building aspects reveals the following facts in accordance with green building technology for sustainable development

- Green building technology provides significant benefits in terms of energy efficiency, environmental sustainability and health benefits.
- Barriers to the adoption of greenhouse technologies such as lack of knowledge, perceived high cost, management challenges and resistance to change.
- Grid integration of renewable energy presents challenges related to interconnection, grid layout, energy storage and price competition.
- Solutions such as policy support, education and knowledge, R&D, collaboration, technological progress, financial exploitation and circular economy can solve these problems.
- Reducing environmental impact: Green buildings reduce resource use, reduce carbon emissions and promote. culture leads to environmental protection and prevention of climate change.
- Energy Efficiency: Green building technologies reduce power consumption and carbon footprint by prioritizing energy-efficient design, high-efficiency HVAC systems, advanced lighting controls and the integration of renewable energy sources.
- Health and Wellbeing: Green buildings emphasize good indoor air quality, good lighting and design for health, and comfort and working environment for occupants.
- Economic benefits: Green building technology provides long-term savings by reducing energy and water use, lowering operating and maintenance costs, increasing property values and increasing the number of people in production.
- Sustainable Urban Development: Green buildings contribute to sustainable urban development by promoting compact and walking environments, reducing urban heat island and improving utilization resources.
- With green building technology, a transition to a better and more efficient environment, contribute to the goal of global security, and create a sustainable, healthier, better environment for present and future generations are possible.
- Finally, the use of green building technologies and the integration of renewable energy are essential for sustainable development. Tackling challenges requires collaboration between scientists, policymakers, business professionals and individuals to raise awareness and implement solutions. By doing this we can create a safe and sustainable future for all.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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