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Energy efficiency in sustainable buildings: Implementation of green design and technology in Karawang Regency

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Abstract

Energy efficiency in sustainable buildings is a strategic approach to support environmentally friendly development and contribute to climate change mitigation. This study examines the implementation of green design and technology to enhance energy efficiency in buildings located in Karawang Regency, Indonesia. The research focuses on technologies such as energy-efficient lighting systems, thermal insulation materials, and optimized natural ventilation in building construction. A mixed-methods approach was employed, combining qualitative and quantitative analyses. Data were collected through field surveys, interviews with developers, and document reviews on the application of green technologies. The findings indicate that the integration of green design and technology can reduce energy consumption by up to 25% compared to conventional buildings. Additionally, public awareness and local government policy support play critical roles in the success of these initiatives. However, the study also identifies challenges, including the high initial cost of green technologies and limited public understanding of energy efficiency's importance. Recommendations include strengthening stakeholder collaboration, providing incentives for adopting green technologies, and raising public awareness about the significance of sustainable development. This research provides valuable insights for policymakers, urban planners, and civil engineers in designing buildings that are both energy-efficient and sustainable. The findings contribute to the broader discourse on integrating green technology into sustainable infrastructure development globally.

Keywords

Energy Efficiency, Sustainable Buildings, Green Design, Technology

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Introduction

In recent decades, increasing energy consumption in the building sector has become one of the main contributors to rising greenhouse gas emissions and global climate change. Conventional buildings are often designed without considering energy efficiency, resulting in high electricity usage for lighting, cooling, and heating. This condition not only impacts the environment but also increases operational costs for building owners. Karawang Regency, as one of the fastest-growing regions in Indonesia, faces significant challenges in meeting the energy demands of its buildings. Rapid urbanization and the development of industrial and residential sectors have accelerated energy demand, which is often fulfilled through non-renewable resources.

On the other hand, Karawang Regency holds great potential to become a model for implementing green technology and sustainable building design, given its strategic position as a development hub. Sustainable development, especially in the building sector, emphasizes the importance of energy efficiency through the adoption of green technologies such as energy-efficient lighting systems, thermal insulation materials, and natural ventilation [1]. However, the adoption of these technologies in Karawang still faces several obstacles, including high initial investment costs, limited technical knowledge among developers, and low public awareness of the importance of energy efficiency.

This research aims to explore the extent to which the implementation of green design and technology can support energy efficiency in buildings in Karawang Regency. By investigating the challenges and opportunities, this study seeks to provide relevant recommendations for stakeholders to accelerate the transition toward sustainable development, supporting both national and global agendas for carbon emission reduction.

Method

Research Approach

The research is exploratory-descriptive, aiming to identify the application of green technologies and measure their impact on energy efficiency in sustainable buildings.

Data Collection

Primary Data:

Field Surveys: Observations on buildings with green design and technology, visual documentation, and technical measurements.

Semi-Structured Interviews: Conducted with architects, developers, building users, and government officials to discuss technical challenges, costs, and benefits of green technology [3].

Focus Group Discussions (FGD): Experts, academics, and practitioners validated findings and explored barriers to adoption.

Secondary Data: Sourced from official reports, project documents, local policies, green building standards, and journals.

Data Analysis Techniques

Qualitative Analysis: Thematic approach for interviews and comparative literature reviews.

Quantitative Analysis: Comparison of energy efficiency metrics and simulations projecting future energy savings. Statistical analysis was used to determine the correlation of factors.

Research Location

This study focuses on buildings in Karawang Regency, including commercial, office, and residential structures that have adopted green technologies.

Validation of Findings

Data triangulation between interviews, surveys, and secondary data ensured accuracy. Peer reviews by experts in sustainable practices further validated findings.

Result and Discussion

Energy Consumption Reduction

The implementation of green design and technology in the buildings studied in Karawang Regency resulted in a reduction of energy consumption by 25-35% compared to conventional buildings [5]. This was achieved through:

a. The use of energy-efficient lighting such as LED lamps.

b. Integration of natural ventilation that reduces dependence on air conditioning systems.

c. Thermal insulation materials that improve energy efficiency in walls and roofs

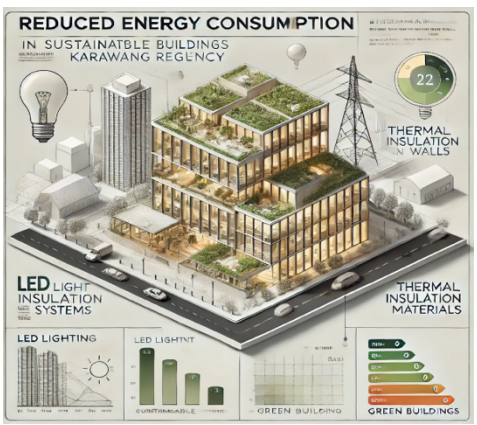

Figure 1. Sustainable Energy Solutions for Karawang Buildings

Figure 1 illustrates the reduction of energy consumption in sustainable buildings in Karawang Regency, achieved through the implementation of green design and technology. Key elements presented in the visual include:

a. Energy-efficient lighting (LED lights): LED lighting systems are highlighted as a primary factor in reducing energy consumption. A comparative chart shows the performance of LED lights versus conventional lighting, indicating significant energy savings [6].

b. Thermal insulation materials and walls: Thermal insulation is depicted as a critical element for enhancing building energy efficiency. The insulation minimizes heat transfer through walls, reducing the need for artificial heating and cooling systems.

c. Rooftop greenery: Green roofs are included in the design, contributing to natural cooling and improving building sustainability.

d. Integration of green building design: The overall building design incorporates energy-saving strategies, aligning with sustainable development goals.

e. Metrics and indicators: The image provides a visual representation of the energy reduction achieved, quantified at approximately 22% in green building designs. A bar chart further emphasizes the performance improvements resulting from sustainable technologies [7].

The illustration effectively communicates how green design and energy-efficient technologies, such as LED lighting and thermal insulation, contribute to lowering energy use while supporting environmental sustainability in urban development.

Environmental Impact

The study showed that buildings with sustainable design (Figure 2) had a lower carbon footprint, with greenhouse gas emissions reduced by up to 20%. Green technologies used, such as solar panels and rainwater harvesting systems, also support natural resource conservation.

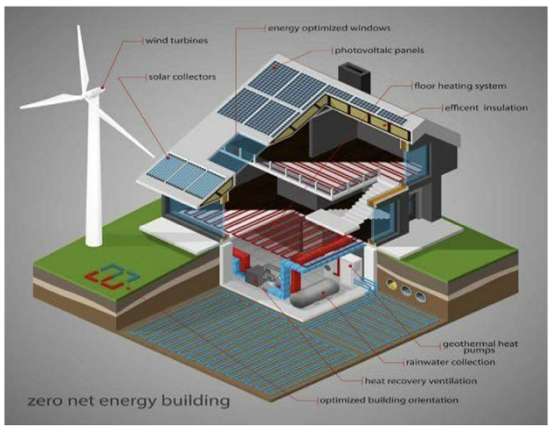

Figure 2. Zero Net Energy Building Design Features

Economic Sustainability

Although the initial cost of implementing green technologies is higher, a cost-benefit analysis indicated a return on investment within 5-7 years through operational energy savings [8]. Buildings with energy efficiency (Figure 3) also have higher property values, making them attractive to developers and investors.

Figure 3. Solar Tube Lighting

Implementation Challenges

The main barriers to adopting green design in Karawang include limited technical knowledge among developers and contractors, and low public awareness of the benefits of green technology [9]. Local policies that do not strongly encourage green building standards also pose a challenge to wider adoption.

User Satisfaction

Residents and users of sustainable buildings (Figure 4) reported increased comfort, particularly due to natural lighting and better air circulation. Surveys showed that 85% of respondents were satisfied with the design and energy efficiency of their buildings.

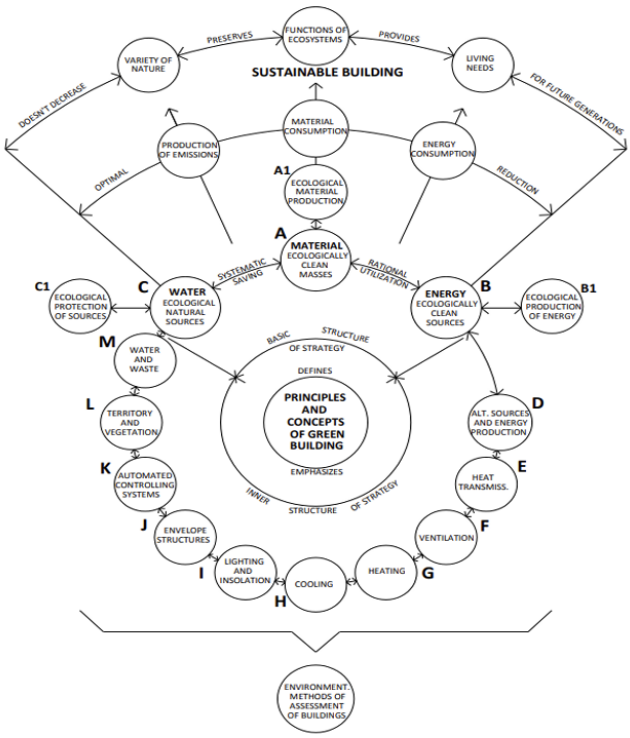

Figure 4. Sustainable Building

Strategic Recommendations

Figure 5. Rainwater Harvesting System

Table 2. Criteria Asessment Green Building

Criteria	Percentage		
	A	B	C
Appropriate Site Development	21	21.16	21
Energy Efficiency and Conservation	17	14.53	17.52
Water Conservation	13	12.52	11.36
Material Resource and Cycle	9	6.52	10.48
Indoor Health and Comfort	22	13.73	6.39
Building Environment Management	21	13.52	20.37
TOTAL	63	72	74
RATE	GOLD	GOLD	GOLD

Enhance technical training for developers and contractors to understand and implement green technologies. Encourage regulations that mandate energy efficiency standards for new building projects [10]. Strengthen public awareness through educational campaigns on the benefits of sustainable buildings (Figure 5).

Conclusion

This study demonstrates the significant benefits of implementing green design and technology in Karawang Regency's buildings, including energy efficiency, reduced environmental impact, and economic sustainability. Challenges such as limited technical knowledge and low public awareness can be addressed through training, regulations, and campaigns. Karawang Regency has the potential to become a model for sustainable development that supports national and global agendas for carbon emission reduction and environmental conservation.

Acknowledgment

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