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Urban Planning and Green Building Technologies Based on Artificial Intelligence: Principles, Applications, and Global Case Study Analysis

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Abstract

The application of AI technology in urban planning covers multiple levels, such as data analysis, decision support, and automated planning. Urban research relies on AI technology to understand and summarize the law of urban growth and improve the analysis of the evolution trend of urban space. Planning and design use AI technology to explore the relevant factors affecting urban development and their weights and discuss the critical role of green building technology in the sustainable development of the construction industry. With the increase in global energy consumption and carbon emissions, traditional building methods can no longer meet environmental protection requirements and efficient use of resources. As a sustainable development solution, green building technology has been paid more and more attention to and adopted by people. These technologies focus not only on the energy efficiency and environmental impact of buildings but also on the resource utilization and environmental load of green buildings over their entire life cycle driven by machine learning. This paper details the basic principles and applications of green building technologies, including AI-driven reduction of negative environmental impacts, improvement of occupant health, efficient use of resources, and optimization of indoor environmental quality. This paper focuses on the critical role of the LEED assessment system developed by the U.S. Green Building Council in advancing green building practices. In addition, the paper analyzes vital points such as water use in green building design, machine learning-driven wind environment optimization, solar technology application, and practical application cases of these technologies on a global scale.

Keywords

Green Building; Environmental Protection Resources; LEED; Architectural Design Evaluation System.

1. Introduction

With the rapid advancement of artificial intelligence technology, the construction industry is undergoing unprecedented transformations. [1]The integration of AI signifies a significant technological leap forward and serves as a crucial catalyst for innovation and metamorphosis within the construction sector. AI technology is progressively reshaping every facet of the construction industry, from enhancing design precision to streamlining construction processes and enabling intelligent building operation and maintenance management. Green building technologies not only focus on the energy efficiency and environmental impact of buildings but also relate to the resource use and environmental load throughout the building life cycle.

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[2][3]The application of these technologies can not only reduce the operating costs of buildings but also reduce the dependence on natural resources, thus having a positive impact on the environment and social economy.

Green building technology is a design, construction, and operation method based on environmental principles and sustainable development. Its core objectives are minimizing the environmental impact by minimizing resource consumption, reducing energy use and emissions, and optimizing indoor environmental quality. In the context of global warming and increasingly severe ecological protection, applying green building technology can not only effectively respond to the challenge of climate change but also promote the sustainable development of the construction industry and promote the development of society in a more environmentally friendly and resource-saving direction.

2. Green Building Technologies

Green building is a construction approach that seeks to reduce the impact of buildings on the environment by considering all aspects of a project's life cycle from beginning to end and incorporating "green" design principles. [4]The goal of green building design is to create modern, eco-friendly house plans with healthy indoor environments for occupants while minimizing the use of non-renewable resources and harmful emissions throughout the entire lifetime of the structure. Green Building concepts can be applied at all levels, from one building to neighborhoods or cities. A building is considered green if it is designed, constructed, and operated using an approach that:

1. Minimizes negative environmental impact
2. Improves occupant health
3. Uses resources efficiently
4. Provides positive indoor environmental quality

It is durable, comfortable and secure.

What is the need for Green Building Technology?[5]

There is a growing concern among environmentalists and governments across the globe about the increasing levels of carbon dioxide (CO_2) in the atmosphere. Burning fossil fuels such as coal and oil has resulted in higher CO_2 levels and, thus, global warming, which could have catastrophic consequences for the planet. [6]To reduce CO_2 emissions, governments have started enacting laws to make buildings more environmentally friendly by using less energy through increased efficiency and renewable energy sources. These laws will force even existing buildings to become more efficient over time. This has created a demand for buildings that are environmentally friendly today, thus creating a market for green buildings.

Green buildings encompass two primary types: passive and active. Passive green buildings leverage natural elements such as wind, sunlight, and rain to enhance eco-friendliness. In contrast, active green buildings utilize advanced technologies to capture and use building-generated heat while minimizing carbon emissions. Additionally, there are advanced categories like Blue Buildings and Zero Energy Buildings, which harness renewable energy sources such as solar panels, wind turbines, and geothermal energy. [7]Organizations like the US Green Building Council (USGBC) classify these green building types into LEED Certified buildings, Energy Star buildings, and Naturally Occurring Net Zero Buildings.

2.1. Green Building Technology Principles

The United States Green Building Council has formulated the "Green Building Assessment System" (LEED), which can be implemented, and believes that the pursuit of green building is how to achieve the whole life cycle from the production, transportation, construction, construction to operation and demolition of building materials. The building causes the least harm to the environment while allowing users and residents to have a comfortable living quality. [8-10]Through more careful and comprehensive consideration in all stages of the life cycle, such as design, construction, use, maintenance, and demolition, the practice aims to improve the efficiency of the use of land, energy, water, materials, etc., while reducing the negative impact of buildings on people's health and the surrounding environment.

Given the relative shortage of land and resources, China proposes "energy-saving housing and public buildings" as the goal of green buildings to solve the problem of excessive resource consumption and increasing resource shortage during the rapid development of industrialization and urbanization in China. [11]This is a sustainable building concept with Chinese characteristics, which realizes the sustainable development of buildings by saving energy, land, water, and materials.

In China, data centers are expected to expand exponentially in the next five years. According to Technavio, China's data centres' annual growth rate (CAGR) was about 13 percent between 2016 and 2020. Currently, the internet data centers in the United States are more than 17 million square meters or about 45 percent of the world's total. China's internet data centers are approximately 2 million square meters, representing only 6% of the world's total. Japan's share is approximately 300 million square meters, about 8 percent[12].

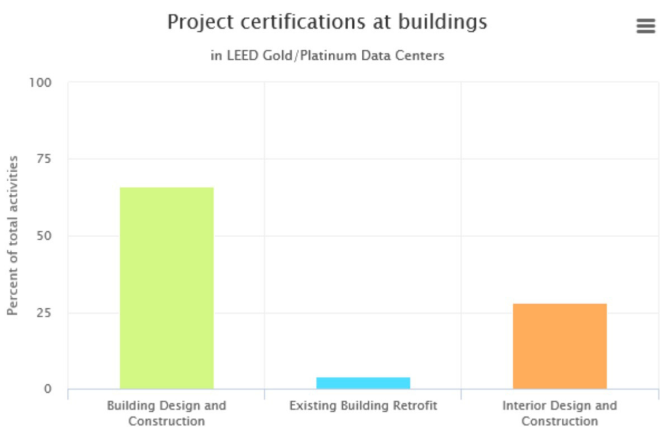

Figure 1. China LEED Certification Data

The LEED language for data centers aims to remove barriers and help project teams meet the specific needs of their sites:

Data centers can more easily evaluate their energy models and estimate equipment energy savings. PUE allows owners, developers, contractors, and LEED [13]reviewers to readily observe energy and cost savings. The commissioning credits require a commissioning agent with experience overseeing data center design and construction. [14]This ensures a fair commissioning process suited to the unique design elements of data centers. Indoor Environmental Quality (EQ) credits address data centers' low occupancy rates. After decades of practice, green buildings have gradually developed some essential design ideas, principles, and methods. Green building design is an architectural development concept controlled by ecological ethics and aesthetics. Green building design in practice should follow the following principles:

1. Principle of harmony

As a result of the influence of human behavior, architecture, due to the actual effects of consumption, disturbance, and influence in its space selection, construction process, and the life-span process of use and demolition, its system harmony, system harmony, and relationship harmony have become a vital harmony principle especially emphasized by green buildings[15].

2.2. Machine Learning and Building Resource Management

In recent years, with the rise of artificial intelligence (AI), AI technology has been applied to several fields, including facial recognition for smartphone cameras (Zhao et al., 2003), fraud detection in credit card payments (Ngai et al., 2011), vehicle and pedestrian recognition in autonomous vehicles (Goodfellow et al., 2016). Online product recommendation and advertising (Turbanetal., 2018) and BEM research is no exception. More and more scholars have applied artificial intelligence methods to BEM research, among which machine learning is the most widely used. Machine learning (ML) is a popular field of artificial intelligence because of its ability to extract and generate knowledge from raw data that can be used to solve problems intuitively in a way similar to humans. Tom Mitchell proposed a definition of ML in 1997: [16]"A computer program learns task T from experience E and uses P to measure performance." And T's performance P improved with experience E."

As one of the recent technological developments, ML has been widely used to solve BEM-related problems, which has significantly impacted BEM research methods and changed the boundaries of BEM. Many scholars have reviewed the literature on applying BEM in specific fields. Foucquier et al. (2013) reviewed the application of ML in building energy modeling and energy performance prediction, focusing on analyzing equations simulating building thermal behavior and other mathematically related equations. Deb et al. (2017) focused on time series prediction techniques for building energy consumption and comprehensively reviewed existing ML techniques for predicting time series energy consumption. Prediction of energy consumption (Kuster et al., 2017; Amasyali and ElGohary, 2018), specific ML technology applications, such as artificial neural network (ANN) applications (Yildiz et al., 2017; Rodrigues et al., 2018) and energy efficiency assessment (Goudarzi and Mostafaeipour, 2017) are also reviewed[17].

However, the current review focuses only on applying specific ML techniques to particular aspects of BEM. A more precise description of ML-BEM boundaries and a comprehensive review of ML-BEM are needed. In particular, with the increasing demand for building energy, higher requirements are put forward for BEM (Danishetal., 2019), and the need for more systematic and efficient building energy management (Tronchinetal., 2018) further highlights the need for a comprehensive review. At the same time, a deep understanding of ML-BEM is crucial to improving its efficiency and formulating comprehensive and effective policies. Based on the technology maturity (HypeCycle) model, this paper analyzes the current development of ML-BEM[19]. It predicts its future development trend will make building energy management more forward-looking.

Therefore, the primary purpose of this study is to (1) understand how ML technology can reconstruct the boundaries of BEM throughout the building life cycle; (2) Analyze the overall research status in the field and establish the ML-BEM comprehensive framework; (3) Describe the knowledge evolution of ML-BEM and predict its future development trend based on the Hype Cycle model.

3. The Comfort Principle

Comfort requirements, resource occupation, and energy consumption constantly contradict building construction, use, and maintenance management. [20-23]In green buildings, the principle of comfort is emphasized not on the premise of sacrificing the comfort of the building but to meet the comfort requirements of human habitation as the setting conditions, the application of thermal storage and thermal insulation performance of materials, improve the thermal insulation and thermal insulation performance of maintenance structures, the use of solar energy for winter heating, summer cooling, through shading facilities to prevent overheating in summer, and ultimately improve the comfort of the indoor environment.

5. Economic principles

The construction, use, and maintenance of green buildings is a complicated technical system problem and a social organization system problem. [24]Although green buildings with high investment and technology can reflect the high-end level of human science and technology development, it is not only high technology that can realize green buildings' function, efficiency, and quality. Suitable technology, local materials, and construction experience with regional characteristics are also the development methods for green buildings.

3.1. Critical Points of Green Building Design

The design of green buildings has been misunderstood from the initial greening and beautification design of a building area to the multi-system design that everyone now recognizes; after more than ten years, the cognition level of builders, designers, and users has been improved, and building materials, building technology and supporting products are also changing with each passing day[25].

Building energy-saving design has long been included in the scope of the construction drawing review; many mandatory code provisions have been able to ensure that buildings meet the national energy-saving standards; our majority of designers should not only meet the minimum requirements of the code but should pay more attention to cutting-edge scientific and technological information, master new materials, new technology, in the green design bold attempt, the courage to innovate.

The design process of green buildings involves many majors, focusing on planning, construction, water supply and drainage, electrical, [26]HVAC, and other majors, as well as a whole system design. In this system, when the planning site is determined, the success or failure of green building design, the architecture profession plays a pivotal role. The following links must be focused on and controlled through study and work practice in the architectural design process.

A)Water system

Green buildings to achieve water-saving goals, it is necessary to improve the utilization rate of water resources, that is, reuse wastewater and rainwater, the water environment system from the original "supply-discharge" model for technical improvement, add the necessary storage and treatment facilities, and form a "supply - discharge - storage - treatment - reuse" water resources recycling mode.

Community building planning needs to consider tap water, sewage, and rainwater and may include direct drinking water, municipal recycled water, groundwater and surface water introduction, transportation, discharge, and treatment. The collection, utilization, and discharge of rainwater are closely related to green building planning. For example, the floor area of the roof, green space, road, etc., and its surface paving materials directly affect the rainwater runoff and infiltration amount. Suppose the purpose is to increase the rainwater infiltration amount. In that case, it is bound to choose pavement, square, and other paving materials with good water permeability, improve the green space matrix, and increase its water storage capacity. Roof greening will also store part of rainfall, reducing the runoff of roof rainwater, and the runoff coefficient can be reduced from 0.9 to about 0.3.

Sewage and stormwater generally rely on gravity to transport water, so the design of sewage pipelines must match the site's elevation design. Green space has the function of storing rainwater to increase rainwater infiltration and trap rainwater pollutants. Therefore, the terrain of green space in green buildings should be designed lower than roads, squares, etc., better to play the function and comprehensive benefits of green space.

The sewage and stormwater pipelines outside the buildings also need to be unified with the site road planning to facilitate the excavation and future maintenance of the pipelines. The water quality of rainwater runoff from roads and parking lots is poor, and appropriate pollution interception measures, such as low-potential green space and ecological retention systems, should be considered when collecting rainwater.

B) Wind environment

Creating a good ventilation convection environment and establishing a natural air circulation system embody green design principles. Here, optimizing the design of natural ventilation is often overlooked. Especially for residential communities, to obtain higher economic benefits, developers usually pursue higher building density and floor area ratio, as well as floor spacing, as long as it meets the minimum sunshine spacing required by the code.

Green building technical standards

Green buildings are not one type of building. By analyzing green culture, philosophy, and concepts, we understand that green building is both a way of life and an idea. It does not necessarily refer to any particular type of building but covers all kinds of buildings, including residential, production, living, and public activity Spaces. From the perspective of a single green building, its green connotation is a series of things, including culture, ecology, environmental protection, and so on.

For buildings with high ventilation requirements, ensure each has a specific windward side. The wind shadow area behind the building is about three times the height of the building, which is far greater than the sunshine distance. If the building is placed in the same line only considering the sunshine distance, it will make the rear building have no direct windward side, which is very unfavorable to the ventilation of the back building. However, if the blind pursuit of wind shadow spacing contradicts the principle of land saving, this is a contradiction, and a reasonable trade-off should be made in the design process.

It is of practical significance to solve the problem of natural ventilation of buildings in cold winter and hot summer areas to reduce the power consumption of air conditioning. According to the local wind rose, the building group's architectural form design, orientation, and layout achieve maximum natural ventilation. The building's height, length, and depth significantly impact natural ventilation, and the rational arrangement of trees can also enhance the building's natural ventilation. A simple rectangular body so that its long doors and Windows as far as possible towards the summer of the dominant wind direction, the ventilation effect is better when the building plane is "concave" shape or "L" shape, should be as far as possible to make its concave part facing the summer of the dominant wind direction; The depth of the building plane should not be too large, which is conducive to the formation of drafts. Under normal circumstances, the plane depth does not exceed five times the net height of the floor, which can obtain a better ventilation effect. The depth of buildings with unilateral ventilation should be 2.5 times the net height.

The one-frame building is conducive to natural ventilation; the smallest shape coefficient and various energy-saving indicators are easy to meet. The main room is on the summer windward side, and the lee side is in the auxiliary room. The inner gallery type of building is deeper and saves land, but only one side of the room is oriented well, which makes it challenging to organize indoor drafts and is not conducive to heat dissipation. The relative setting of doors and Windows can make the ventilation line short and straight, reduce the airflow roundabout path and resistance, and ensure the wind speed. If the corridor is long, the air vent can be set up in the appropriate part of the middle, or the stairwell can be used to make the air vent, which can form a draft, thereby improving the ventilation effect.

3.2. Application of Solar Energy Technology

The application of solar energy technology in buildings mainly involves two aspects: photoelectric and photothermal. Photoelectric technology is primarily based on photovoltaic cells to provide electrical energy for the building's use, and it also uploads electricity to the

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national grid. Here, we mainly talk about the application of photothermal technology in buildings.

Many years ago, the market accepted the domestic solar water heater. Residents' enthusiasm for spontaneous installation and use is high, and the use effect is good. Since then, the application of solar thermal technology has had a good market prospect and mass foundation. However, the thermal efficiency of early products could be higher, and the installation of non-standard, disorderly, security risks and other problems have put forward a new topic - building integration.

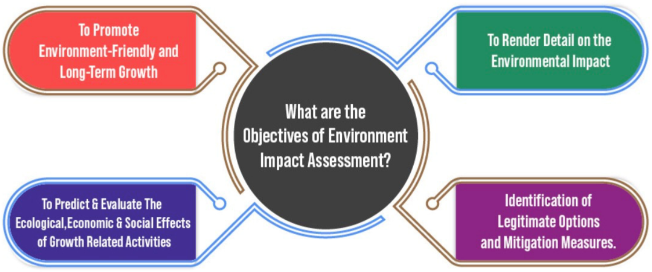

Figure 2. Evolution and History of Environmental Impact Assessment

Architectural integration emphasizes that solar energy products and architectural engineering design should be unified planning, synchronous design, and synchronous construction and put into use simultaneously as architectural engineering. Its advantage is that the effective hours of sunshine can be calculated in the planning stage, and the parts of the building roof and wall that can be installed with the collector are arranged in the area where the maximum sunlight can be obtained while avoiding the sunlight blocking off the back building due to the installation of the collector.

All-glass solar heat collecting vacuum tubes are famous in the domestic market, and the mature collectors abroad are flat collectors. Flat plate collector has the advantages of long life, high stability, and recyclability. Still, due to the slightly higher cost of flat plate and vacuum tube collectors, the performance of some cheap flat plate collectors could be better, making its development lag. Still, the development of flat plate collectors in the solar energy industry will be unstoppable.

The national standard GB50364-2005, "Technical Specifications for the Application of Solar Water Heating System for Civil Buildings," will divide solar water heating systems into three kinds of systems according to the range of heating water: central heating water, central-distributed heating water, distributed heating water; According to the operation mode of the system, it is divided into three kinds of systems: natural circulation system, forced circulation system and direct flow system. At the beginning of the design, it shall cooperate closely with Party A and the manufacturer to choose a suitable, reliable, and effective system for integrated design.

At the beginning of the planning and construction program, it is necessary to cooperate with water supply and drainage closely, electrical and other professionals, accurately calculate the collector area required by the building, reasonably determine the size and roof form of the building, and provide reasonable and safe initial conditions for the installation of light and heat, photoelectric heat collection components, so that it can be integrated into the building and become a constituent element of the building, rather than an unsightly building appendage.

4. The Role of Artificial Intelligence and Machine Learning for Green Buildings

The discussion of a sustainable environment is a long-standing issue and is essential in architecture, urban planning, and landscape architecture. More and more scholars are engaged in related work and are committed to exploring new directions. Therefore, the discussion of the sustainable development of the built environment, the analysis of its practical results, and the prospect of trends can resonate with the current architecture, urban, and landscape architecture researchers.

To select the key and cutting-edge sustainable built environment issues, the United Nations Sustainable Development Goals and the concept of the built environment are compared, and it is found that they all contain the content of health promotion, climate action, green travel, ecological landscape, which can be summarized into public health, energy carbon emissions, climate environment, ecosystem, and green travel. At the same time, the statistics of China National Knowledge Network and Web of Science show that in the past five years, the research on big data and machine learning (ML) has increased in these five topics, and it is necessary to carry out in-depth research on these topics.

Of course, machine learning is not omnipotent, and the volume and quality of data significantly affect the reliability and accuracy of the results. At this stage, researchers use machine learning more as a tool for data analysis to help quickly identify critical information and discover the rules.

4.1. Public Health Issues have Substantial Interpretative Needs

Typical studies on the built environment and public health at home and abroad have diversified discussions on public health topics, covering infectious diseases, chronic diseases, health behavior habits, mental health problems, and other aspects, especially exploring chronic diseases, behavior habits, and psychological issues. In short, the interpretation and exploration of the relationship between the built environment and health is still a hot topic at present and in the future, and the research on this topic will face the situation of more diversified data and more complicated models. Existing studies have limited explanatory degree mining of machine learning, and there are few applications of explainable machine learning, especially causal mechanism mining based on clinical experiments. There is an urgent need to incorporate explainable machine learning algorithms for pathology to help people tease out relationships and make decisions.

4.2. The Issue of Energy Carbon Emissions Pays More Attention to the Forecasting and Decision-Making Process

The research on built environment and energy mainly focuses on regional scale, urban scale, and building scale, including fuel consumption, energy consumption, power grid load, etc. Research on carbon emissions is mainly done at the national, city, and household levels, using various machine-learning methods to calculate carbon emissions. Machine learning algorithms are primarily used to predict the results, and the cost and time of formula calculation are saved through "brute force cracking" of algorithms and data. In the face of more sophisticated systems, interpretability methods can also help people catch the clues behind the data. This topic has more predictive and less explanatory applications, but exploring explanatory methods has achieved initial results. In addition, finding a balance between development and protection is another primary application of machine learning under this topic, and reinforcement learning based on the decision process and combined with various deep learning algorithms can effectively facilitate this process, improving the efficiency and rationality of decisions related to energy carbon emissions.

4.3. Climate and Environmental Issues should be Both Predictive and Explanatory.

Research on climate, air quality, and heat island effects in the built environment mainly focuses on spatio-temporal changes and driving force analysis. With the gradual improvement of data monitoring and quantification systems, multivariate data processing, multi-scenario estimation, and impact factor analysis are becoming more and more abundant. Although applying traditional statistical analysis, spatial analysis, and spatial models is relatively mature, machine learning still shows its strengths and potential for predictive and explanatory problems. In this topic, the application of machine learning is reflected more in the link between prediction and simulation. The development of explanatory ability is relatively slow. The complexity of the climate environment makes it challenging to collect data, and the data foundation for establishing explanatory machine-learning models needs to be stronger. On the other hand, combining the original climate model and various machine learning algorithms has yet to mature, and more exploration and practice are still needed. With the diversification of data and monitoring means, machine learning methods will be increasingly involved in data processing and prediction simulation, and the scenarios for interpretation and application will be more diverse.

4.4. The Ecosystem Issue is in the Preliminary Stage of Interpretative Exploration.

The development of measurement, modeling, and remote sensing technology has made people's cognition of ecosystems and organisms more comprehensive and detailed, and machine learning is involved in the analysis of ecological evolution drivers, species distribution, ecological footprint, and biomass, providing the ability to predict and explain. At present, prediction estimation and simulation work are the mainstream of this topic. In terms of interpretation, the quantification of driving force analysis is relatively simple, and the understanding of the model is relatively preliminary in identifying important factors that still need more exploration and mining.

4.5. Green Building Issues are Mature and Cutting-Edge in Application.

Machine learning has accumulated fruitful results in the research and application of green building. It has made pioneering exploration and breakthroughs in data processing, prediction, simulation, decision-making, and interpretation, covering topics including but not limited to travel behavior, travel safety, traffic flow, travel tools, congestion risk, road networks, etc. It is easy to speculate that research on sustainable transportation has been a hot spot in the past, present, and future. Facing various scenarios in the future, the application of machine learning still has more significant potential and more possible exploration directions. Machine learning has become an indispensable part of the sustainable, intelligent transportation system, and the two are interdependent and jointly promoted. Predictions and interpretations will become more refined and in-depth, providing the basis for thoughtful decisions.

5. Optimal Application of Green Building Technology

5.1. Energy-saving Technology

Applying energy-saving technology in green buildings is a crucial strategy to reduce energy consumption and carbon footprint. Through the use of advanced insulation materials and building design, such as high-efficiency glass and insulated walls, it is possible to reduce heat loss inside buildings and improve energy efficiency significantly. According to the International Energy Agency, effective energy conservation measures can reduce building energy consumption by up to 30%, saving significant operating costs and positively impacting the environment.

For example, the Empire State Building in New York City achieved more than $4.4 million in annual energy savings by updating its window glass. This technological innovation not only improves the energy efficiency of the building but also earns it the leading LEED certification, showing the practical application and success stories of energy-saving technology on a global scale.

5.2. High-efficiency Building Facade Design

High-efficiency building facade design: Optimizing the building's external structure and material selection effectively controls the entry of heat and light, thereby reducing the heating and cooling load and indoor lighting needs. According to the US Department of Energy, using highly reflective roofs and transparent exterior materials can reduce the operating time of cooling equipment and save an average of 20 percent of the building's energy consumption per year.

For example, the Shinjuku NS building in Tokyo, Japan, uses a unique exterior design and natural ventilation system that effectively reduces the need for air conditioning and improves indoor air quality and employee comfort. These practical examples demonstrate the critical role of highly efficient building facade design in improving energy efficiency and reducing environmental impact.

5.3. Renewable Energy Integration

Renewable energy integration is a crucial strategy to achieve self-sufficiency in green buildings, providing a clean and continuous source of energy for buildings by applying solar panels, wind turbines, and geothermal energy. According to the International Energy Agency, the cost of renewable energy technologies is falling every year globally, and renewables are expected to account for nearly half of global electricity consumption by 2030.

For example, certain commercial buildings in Berlin, Germany, have successfully achieved their goal of generating more than 30% of their annual electricity consumption from renewable sources by installing solar panels and heat pump systems. This integration not only helps to lower the carbon emissions of the building but also significantly reduces energy dependence, positively contributing to sustainable development.

5.4. Water Resources Management

Green buildings manage and use water efficiently through rainwater harvesting systems, efficient taps, and innovative irrigation technology. According to the report of the United Nations Environment Programme, the problem of water scarcity is increasing worldwide, and water management strategies for green buildings can significantly reduce freshwater consumption and improve the sustainable utilization of water resources.

For example, the Docklands area of Melbourne, Australia, managed to achieve water savings of more than 40% and reduce the city's flooding risk by establishing a large-scale rainwater harvesting system. These examples show that effective water management can help protect the environment, reduce building operating costs, and contribute to sustainable urban development.

Material use

In designing and constructing green buildings, choosing sustainable materials is an important measure to reduce carbon footprint and environmental impact. According to the US Green Building Council, the use of materials in buildings worldwide accounts for about half of global raw material consumption. Using recycled and low-carbon materials can significantly reduce resource consumption and the generation of construction waste.

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For example, a high-rise office building in Amsterdam, the Netherlands, used a large amount of renewable wood and recycled glass to reduce the cost of building materials and the environmental load. This sustainable material choice contributes to the overall building quality and positively contributes to environmental protection and social responsibility.

5.5. Environmental Quality

Green buildings improve occupants' and staff's living and working environment by optimizing indoor air quality control and natural ventilation design. According to the World Health Organization, indoor air pollution is one of the major global health threats, and environmental quality control strategies for green buildings can effectively reduce indoor pollutant concentrations and protect people's health and comfort.

For example, some residential communities in Vancouver, Canada, have successfully improved indoor air quality and reduced the incidence of respiratory diseases among residents by installing high-efficiency air purifiers and green plant walls. These technological innovations enhance the sustainability of buildings and provide a healthier and livable living environment for city dwellers.

5.6. Technology and Engineering Innovation

Technology and engineering innovation play a crucial role in driving the development of the green building industry, optimizing building design and operational efficiency through simulation and data-driven decision support systems. According to the International Institute of Architects report, data-driven design optimization and intelligent building management systems are becoming significant trends in the future construction industry, improving buildings' energy efficiency and operational efficiency through real-time monitoring and intelligent adjustment.

For example, some commercial office buildings in London, UK, achieved more than 10% annual savings by introducing intelligent lighting systems and automated energy efficiency monitoring equipment, significantly improving employee efficiency and productivity. These innovative technologies promote green building development and encourage the construction industry to move toward an intelligent and sustainable direction.

6. Conclusion

As global energy consumption and carbon emissions continue to rise, the construction industry faces increasing challenges. Traditional building methods need to be revised to meet environmental sustainability requirements. As a result, green building technology has become a key solution, gaining significant attention and adoption due to its emphasis on energy efficiency, resource conservation, and environmental management throughout the building life cycle. The artificial intelligence technology combined with remote sensing technology and digital elevation model (Democratic Party) technology, through machine learning algorithms and extensive data analysis, optimizes the data acquisition and processing process and improves construction exploration's efficiency, accuracy, and safety. Regarding topographic and geomorphic analysis, the AI algorithm systematically analyzes high-resolution images, automatically identifies key topographic and geomorphic features such as active faults, and provides a scientific basis for project site selection and planning. Regarding geological structure identification, AI technology uses computer vision and deep learning algorithms to automatically identify geological fault structures and improve the accuracy and efficiency of geological investigation.

This paper outlines green building technologies, including minimizing environmental impact, enhancing occupant health, optimizing resource use, and ensuring superior indoor environmental quality. It explores the development and application of green building technologies globally, highlighting their role in mitigating the effects of climate change and promoting sustainable development. Regarding environmental monitoring, AI technology establishes the correlation between environmental parameters and pollutant concentrations through deep learning and pattern recognition to achieve real-time monitoring and prediction. Regarding disaster early warning, AI technology combines remote sensing technology to create a multi-scale monitoring and early warning system to meet the needs of dynamic monitoring and real-time early warning of floods. Based on case studies, including advances in artificial intelligence technology-driven applications and energy-efficient design, green building practices' practical implementation and benefits are highlighted. The study discusses the prospects and challenges of adopting green building technologies in promoting environmentally responsible global construction practices.

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