

ARTIFICIAL INTELLIGENCE-BASED SOLUTIONS
FOR CLIMATE CHANGE: A REVIEW

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Abstract

Climate change poses a significant threat, resulting in damage to both urban and natural systems and causing global economic losses exceeding \$500 billion. Addressing these challenges could be partially facilitated by artificial intelligence (AI), which leverages internet resources to offer timely recommendations based on accurate climate change predictions. In this review, we examine recent research and applications of AI aimed at mitigating the adverse effects of climate change, focusing on areas such as energy efficiency, carbon sequestration and storage, weather and renewable energy forecasting, grid management, building design, transportation, precision agriculture, industrial processes, deforestation reduction, and resilient cities. Our findings suggest that improving energy efficiency can make a substantial contribution to minimizing the impact of climate change. Smart manufacturing practices, for instance, have the potential to decrease energy consumption, waste, and carbon emissions by 30–50%, particularly in buildings where energy consumption reductions of 30–50% are achievable. Approximately 70% of the global natural gas industry employs AI technologies to enhance the accuracy and reliability of weather forecasts. Integration of smart grids with AI can optimize power system efficiency, leading to potential reductions in electricity bills by 10–20%. Intelligent transportation systems hold promise in reducing carbon dioxide emissions by approximately 60%. Additionally, AI-driven management of natural resources and resilient city design can further advance sustainability efforts.

Keywords: Artificial intelligence · Climate change · Energy efficiency · Sustainability · Resource management

The emission of carbon dioxide resulting from industrial activities is a primary contributor to climate change, currently one of the most pressing challenges facing humanity. The consequences of climate change, including rising sea levels, increased frequency of natural disasters, diminished crop yields, and biodiversity loss, are well-documented. The widespread reliance on fossil fuels in manufacturing processes is

chiefly responsible for the significant carbon dioxide emissions. Therefore, it is imperative to focus on enhancing energy efficiency, promoting the development of renewable energy sources, and conserving energy to address climate change effectively.

The transition from fossil fuel-based energy systems to electrification holds promise for ecological protection and mitigation of climate change impacts. Artificial intelligence (AI) offers opportunities for automating discovery, distribution, and transmission operations through deep neural networks, thereby reducing energy consumption substantially. With the severity of climate change issues escalating, AI is increasingly viewed as a potential solution. AI technology has the capacity to seamlessly integrate with the expanding opportunities presented by the Internet of Things (IoT) and renewable energy within the energy industry. It can play a pivotal role in energy supply, decision-making optimization, and autonomous software control, thereby serving as a significant driving force in the energy sector.

Moreover, AI has proven indispensable in various aspects related to climate change mitigation, including solar radiation modeling, simulation, and optimization of renewable energy systems, urban power load forecasting, and urban building heat load forecasting. AI can contribute to climate change mitigation through multiple avenues, such as enhancing the prediction of extreme weather events, designing energy-efficient and environmentally friendly intelligent buildings, optimizing nutrient cycling and crop productivity to reduce fertilizer usage, implementing sustainable forest management practices to combat deforestation, deploying smart waste management systems, and fostering the development of resilient cities.

Current discussions on AI and climate change primarily focus on the technical aspects of AI, overlooking its applications in various fields impacted by climate change. This review aims to bridge that gap by examining the intersection of climate change and human social production and life across eight sections, exploring the utilization of AI in resource management, green energy efficiency, and sustainable development. Furthermore, the review explores the future trajectory of AI's sustainable development in the context of climate change. In summary, AI holds the potential to revolutionize our approach to climate change mitigation by offering new tools and insights to help us achieve a more sustainable future.

Using artificial intelligence in energy efficiency, carbon sequestration, and storage

In the modern era, energy-related issues have emerged as significant global concerns, driven by the steady expansion of the global economy and population growth, leading to a sharp increase in energy demand. Simultaneously, the imperative of utilizing energy judiciously while achieving sustainable development has become increasingly challenging. To address the escalating energy demand and mitigate adverse environmental impacts, effective measures are required to improve energy

efficiency and reduce energy wastage. Artificial intelligence (AI) technology has emerged as a promising new tool in the energy sector, offering opportunities and challenges for enhancing energy efficiency and promoting sustainable development.

In the energy sector, the integration of AI can enhance energy utilization efficiency by forecasting energy demand, optimizing energy production and consumption, and implementing intelligent control systems. This can lead to cost savings, reduced environmental pollution, and sustainable development outcomes. Consequently, the relationship between AI and energy efficiency has become a focal point of discussion within the research community, attracting attention from scholars and corporations alike. It is argued that the strategic application of AI technology can substantially enhance energy efficiency, support sustainable development goals, and pave the way for a more promising future for society.

Table 1 provides an analysis of the utilization of AI technology in enhancing energy efficiency, presenting the current status and efficacy of its deployment in the energy sector. AI has recently revolutionized the energy sector, offering new opportunities and challenges for improving energy efficiency and achieving sustainable development goals. A comprehensive review presented in Table 1 demonstrates that AI has been effectively applied in various areas of energy efficiency, such as fault detection and diagnosis, thermal comfort prediction and control, demand response, and energy storage optimization. These applications have shown promising results in increasing energy efficiency, reducing energy waste, and advancing sustainable development objectives. However, the successful implementation of AI in energy efficiency remains an ongoing process, heavily reliant on the accuracy of input data and the selection of appropriate AI algorithms.

Based on the insights provided in Table 1, research conducted in Italy and Japan indicates widespread adoption of artificial intelligence (AI) technologies in energy management systems, yielding favorable outcomes. Similarly, studies from the UK suggest that while the utilization of AI in predictive maintenance is still emerging, it has shown promising effectiveness. In contrast, countries like China and India employ AI for fault detection and diagnosis, as well as for integrating renewable energy and demand response strategies. Overall, the analysis in Table 1 suggests that most applications of AI in various aspects of energy efficiency are in their early stages, requiring further investigation into their efficacy. Therefore, there is a pressing need for additional research to evaluate the effectiveness of these applications.

Some scholars argue that the high costs associated with AI technology pose a significant barrier to its widespread adoption in energy efficiency initiatives. The development and deployment of AI-based systems entail substantial investments, which may exceed the financial capacity of certain organizations. Furthermore, the scarcity of data and proficient AI experts presents a notable challenge to the broader

implementation of AI in energy efficiency endeavors. Nevertheless, despite these hurdles, it is anticipated that the utilization of AI technologies in energy efficiency will escalate due to the growing imperative to reduce energy consumption, mitigate environmental impacts, and achieve sustainable development goals.

Conclusion

As the global economy expands and the population grows, there is a sharp rise in energy demand. Conventional methods of energy production have proven harmful to the environment, resulting in excessive emissions of pollutants that contribute to global warming and extreme weather phenomena such as tornadoes, hailstorms, and thunderstorms, posing significant risks to human settlements and lives. The emergence of artificial intelligence (AI) technology presents a promising avenue for addressing these challenges and mitigating their adverse environmental impacts within the energy sector. AI contributes to climate change mitigation by accurately predicting energy demand and improving energy efficiency, thereby reducing environmental pollution. Many countries leverage AI to enhance energy efficiency and minimize energy wastage.

Moreover, AI has revolutionized weather prediction technology, enabling more precise forecasting and modeling to better anticipate and respond to extreme weather events through early warning systems. By facilitating a deeper understanding of natural factors like climate and geography, AI aids in selecting optimal locations for renewable energy infrastructure, forecasting renewable energy production, adjusting grid output, and ensuring uninterrupted electricity supply. Additionally, AI optimizes residential architecture by determining ideal house orientations and window placements, thus reducing energy consumption and improving living conditions. Addressing traffic emissions is also crucial, and AI enhances bus systems by leveraging extensive data to develop neural networks that optimize routes, vehicle schedules, and passenger traffic.

In agriculture, AI plays a vital role in minimizing the environmental impact of agrochemical use through precision farming, which involves collecting and analyzing environmental data related to crop growth, enabling informed decision-making, reducing chemical usage, and increasing crop yields. In the industrial sector, where traditional hardware sensors may not provide sufficient information, AI empowers decision-makers to optimize industrial processes by analyzing data, creating models, and supplementing missing information from hardware sensors to conserve energy and reduce emissions. AI enhances our understanding of nature, enabling more accurate predictions of future deforestation and tree loss, thereby assisting governments in environmental protection and sustainable energy promotion. Moreover, by calculating pertinent data to ensure residents' safety, AI aids in developing sustainable and resilient cities by minimizing the damage caused by extreme weather events.

Overall, AI plays a crucial role in mitigating climate change by improving energy efficiency, providing decision-makers with accurate data, and enabling proactive measures to address environmental challenges effectively.

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