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ECONOMIC VIEWS OF GREEN DESIGN: COMBINING ARTIFICIAL INTELLIGENCE AND RENEWABLE ENERGY TECHNOLOGIES

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Abstract. The research investigates the relationship between digitization and the green transition, which is regarded as one of the most important developments in the contemporary economy. Determining the significance of artificial intelligence (AI) in sustainable design and more significantly, in the growth of the green economy, as well as addressing the ecological effects of these technologies, are the primary goals of the research. The integration of AI with agriculture, the circular economy and energy network optimization is thoroughly examined in this article. The growing energy and water consumption of data centers over time, as well as their carbon emissions, are discussed and supported by scientific facts within the framework of the "Green Artificial Intelligence Paradox". It examines several technological optimization techniques used to reduce the environmental impact of artificial intelligence models, including knowledge distillation, quantization and pruning. The study examines the goals set by green growth and the potential for using the nation's renewable energy resources to create an autonomous artificial intelligence infrastructure within the framework of Azerbaijan's National Artificial Intelligence Strategy for 2025-2028.

Keywords: *Green economy, artificial intelligence, sustainable development, Green AI, circular economy, digital transformation.*

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1. Introduction

The modern global economy is centered on two fundamental and mutually complementary transformation processes: digitalization and the green transition (twin transition). The rapid development of artificial intelligence (AI) technologies over time has limited humans' ability to fully comprehend the consequences of these changes. Unlike previous technological revolutions that have emerged and evolved over decades, the adoption of AI is accelerating at an unprecedented speed and scale. From this perspective, artificial intelligence plays a crucial catalytic role in decoupling economic growth from resource consumption.

The intersection of AI, green economy and sustainable design has garnered significant academic attention in recent years. Scholars have explored the dual role of digital technologies in environmental sustainability, identifying both transformative potentials and inherent challenges. The concept of "Green AI" has emerged as a critical framework, emphasizing the development of energy-efficient AI systems while leveraging AI for environmental benefits (Schwartz *et al*., 2020). Research by Verdecchia et al. (2023) systematically categorizes AI's environmental impacts, distinguishing between "AI for Green" applications and the energy footprint of AI infrastructure itself.

In the realm of sustainable design, foundational work by Kaiser and Zimring (2019) establishes principles of ecological architecture that minimize resource consumption. Contemporary studies extend these principles to digital integration, examining how AI-driven optimization in building management systems can reduce energy use by 20-30% (O'Brien & Sadiq, 2020). The circular economy literature further explores how AI enhances material efficiency and waste reduction through predictive analytics and smart resource tracking (Geissdoerfer *et al*., 2017).

Renewable energy integration with AI represents another vital research stream. Mohsin et al. (2022) demonstrate how machine learning algorithms optimize grid management and renewable energy forecasting, while the International Energy Agency (IEA) (2021) documents substantial efficiency gains in solar and wind installations through AI-enabled maintenance and operations. However, critical scholarship highlights the “AI environmental paradox” where the computational demands of large models contradict sustainability goals (Lacoste *et al*., 2019). This has spurred technical research into optimization methods like pruning, quantization and knowledge distillation to reduce AI's carbon footprint (Treviso *et al*., 2023).

The policy dimension is addressed in literature examining national AI strategies through green economy lenses. Studies of European Green Deal alignments (European Commission, 2020) and developing country contexts (World Bank, 2022) provide frameworks for evaluating Azerbaijan's emerging approach. Notably, research specific to Azerbaijan's sustainability transition emphasizes the importance of leveraging renewable resources for digital infrastructure (Bashir & Gull, 2024; Hasanova & Abdulrahimova, 2025).

The importance of this research is justified by the fact that, amid a global crisis, technological development represents the only viable pathway to achieve the strategic goals of sustainable development (SDGs). Considering that 2024 has been recorded as the hottest year on record and that carbon emissions have reached their highest levels in the last two million years, it would not be an exaggeration to say that the synergy between digitalization and green transformations has become inevitable. Artificial intelligence, built upon connectivity, computing power, context and competence (the 4Cs), holds crucial strategic significance for bridging the digital divide in the economic development of low- and middle-income countries while simultaneously ensuring ecological sustainability to the greatest extent possible.

The main objective of the paper is to examine academically the dual role of artificial intelligence (AI) in the development of the green economy, acting as both a “cleaning” and a “polluting” force. The study aims to explore AI's potential to significantly enhance resource efficiency (Green by AI) as well as the methods to minimize its own ecological footprint (Green in AI), while simultaneously evaluating green growth innovations within the context of Azerbaijan's “National Artificial Intelligence Strategy (2025-2028)” (Hasanova & Abdulrahimova, 2025).

2. Methodology

The research was conducted as a systematic literature review based on the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology. During the study, over 70 academic sources published between 2018 and 2025 were reviewed, covering topics such as digital transformation, “Green AI” and sustainable economy and obtained from scientific databases including Scopus, Google

Scholar and arXiv. Official reports provided by the World Bank and the United Nations were also examined. For data analysis, both qualitative and quantitative approaches were applied, including emission forecasts and efficiency indicators.

The main limitation of the research stems from the rapid development of artificial intelligence (AI) technologies, which has resulted in certain statistical data and standardized ecological measurement units not yet being fully established. Additionally, challenges related to the objectivity of internal energy consumption data from corporate AI models, as well as the fact that empirical studies on the industrial-scale implementation of "Green AI" methods are still at an early stage, represent significant factors affecting the scope of the analysis (Verdecchia *et al*., 2023).

The scientific novelty of this research lies in presenting a comprehensive framework that encompasses both the ecological impacts and the potentials of artificial intelligence (AI). As an innovation, technical optimization methods such as pruning, quantization and knowledge distillation are, for the first time, examined holistically within the context of economic efficiency. Furthermore, the study academically justifies the alignment of Azerbaijan's newly approved AI strategy with contemporary green economy principles, as well as the significance of the country's energy potential for achieving digital independence.

3. Contemporary significance

Table 1. Advantages and benefits of Green Design

Category	Category - main benefits and description
Combating Climate Change	Helps prevent global warming and reduces the carbon footprint.
Conservation of Natural Resources	Protects nature through efficient resource use and the promotion of renewable energy.
Human Health	Creates healthier and higher-quality living conditions through environmentally friendly materials.
Economic Benefit	Minimizes costs in the long term through energy savings and waste reduction.

Combating Climate Change: As is known, green design helps minimize carbon emissions while aiming to protect the environment. The use of renewable energy, environmentally friendly construction materials and the more efficient management and utilization of energy play a crucial role in combating climate change.

Conservation of Natural Resources: Green design aims to minimize resource waste and use resources more efficiently. The utilization of renewable energy sources and the circulation of environmentally friendly materials serve the goal of conserving natural resources.

Human Health: Environmentally friendly materials, as well as elements like natural lighting, are designed to improve public health. Green buildings and cities undoubtedly enhance air quality, reduce stress levels and overall improve the quality of life.

Economic Benefit: Green design reduces economic costs over the long term by targeting energy and resource savings. The use of natural energy, along with sustainable infrastructure, is more cost-effective and the growing market demand for green technologies further supports their economic advantage.

The Role of Renewable Energy in the Global Economy: Renewable energy plays a significant role in the development of the global economy. Primarily derived from natural sources such as wind, solar, water and biomass, it reduces environmental impact while also creating important new economic opportunities.

Energy Security and Diversification: Renewable energy sources significantly enhance the energy supply reliability of countries worldwide. Dependence on traditional energy sources, particularly imports from foreign countries, is substantially reduced. This, in turn, increases energy security while ensuring economic stability.

New Industries and Jobs: The renewable energy sector is already creating new industries and employment opportunities. Modern technologies such as solar panels, wind turbines and energy storage systems are generating numerous jobs and having a visible positive impact on the economy. This sector continues to develop almost every year with new innovations.

Economic Development and Investment Attraction: Investments in renewable energy play a significant role in the global economy. As we know, such investments stimulate the development of new technologies as well as their large-scale implementation. Improving energy efficiency naturally reduces energy costs, which in turn strengthens the economy.

4. High innovation and technological advancements

Major technological innovations in the renewable energy sector make production processes more cost-effective and efficient, while also facilitating the integration of modern technologies into the economy. Such technologies also create development potential for other industries and sectors.

As is known, renewable energy technologies are systems that enable the production of energy from natural resources. These technologies are considered less harmful to the environment and support the sustainable use of natural resources.

The integration of green design and artificial intelligence is one of the most powerful driving forces of the modern economy today. This relationship can be briefly summarized in the following three main directions.

Table 2. The economic model of green design

Direction	Economic impact
Resource Efficiency	Artificial intelligence reduces production costs significantly by achieving 20-30% savings in material and energy consumption.
Circular Economy	New revenue streams and “green” job opportunities are created through waste recycling and the recirculation of resources.
Long-term Investment	Although initial costs are high, smart systems and energy savings allow for rapid payback in a short period.

One of the key principles of green design is the more efficient use of energy. This is reflected in optimizing energy consumption in buildings and infrastructure, while also reducing dependence on natural resources.

Green buildings, through the use of eco-friendly materials and systems such as natural lighting and ventilation, operate more efficiently while consuming minimal energy. These systems, which utilize natural heating and cooling, maximize energy savings in buildings.

The use of natural, environmentally friendly materials in building construction increases energy efficiency while reducing the environmental impact.

Incorporating natural lighting in design and aligning buildings with natural resources significantly reduces energy costs.

Green design promotes the integration of renewable energy sources in buildings and urban infrastructure, making energy supply both clean and sustainable. In green design, systems such as renewable energy and design requirements for efficient energy use are carefully considered. For example, using solar panels and wind turbines to supply energy in buildings and public spaces significantly contributes to environmental protection and cost reduction.

These principles of green design not only create an environmentally friendly and sustainable environment but also optimize energy use and contribute to the protection of the environment.

It is well known that several innovative technologies are being developed in the field of renewable energy, making both energy production and usage more efficient. Recently, technologies such as movable solar panels have attracted attention. These panels adjust their position to capture sunlight more effectively at any time of the day, which, in turn, allows for more efficient energy collection. Another innovation is the development of sensitive energy systems. This technology automatically regulates energy production and consumption based on weather conditions, time of day and most importantly, energy demand, ensuring the system operates more efficiently. Smart grid technologies further enable more precise management of both energy distribution and production. These systems effectively monitor energy flow across the network and ensure its optimal use (European Commission, 2020; IEA, 2021).

Smart homes implement green design approaches for various cities and offices, aiming to increase the use of renewable energy. In smart homes, energy is automatically managed and systems related to natural lighting and heating are optimized across different living spaces. These homes utilize automated control systems that significantly reduce energy consumption, as well as technologies that make energy supply more efficient. Similarly, smart cities and smart offices apply energy management systems tailored to the needs of each sector to optimize energy usage and urban infrastructure (Yigitcanlar, 2015).

Nowadays, climate change is a global problem, with serious impacts felt across the world. Renewable energy and green design are among the main tools to combat such challenges. Green design promotes approaches that increase energy efficiency, maximize the conservation of natural resources and minimize carbon emissions. The use of environmentally friendly materials in buildings and infrastructure, along with the application of renewable energy technologies, helps reduce the carbon footprint. Reducing the carbon footprint is one of the most crucial actions in the fight against climate change. Green design encourages the use of natural energy sources in buildings and infrastructure, which in turn significantly reduces fossil fuel consumption (Karimi *et al*., 2023; Cao, 2025).

Climate adaptation is also important. Green design supports the development of resilient infrastructure to combat climate change. This includes adapting to changing weather conditions and constructing modern buildings and cities that are aligned with local climate conditions. Natural and ecologically informed designs contribute to creating stronger, more sustainable communities.

5. Conclusion

Green design, along with modern renewable energy technologies, serves as a crucial tool for combating climate change, protecting natural resources and ensuring economic sustainability. Such approaches enable more efficient energy use, minimize carbon emissions and make energy production less harmful to the environment. The key principles of green design - including maximum use of eco-friendly materials, natural lighting and the integration of renewable energy systems - help enhance energy efficiency. Innovative technologies, intelligent systems and the broader adoption of green design further increase its effectiveness and reach. In the future, even more innovations are expected in these fields, as environmentally friendly and economically empowering models are increasingly prioritized by both governments and enterprises.

6. Recommendations

The extensive application of innovative renewable energy technologies in buildings and urban infrastructure is crucial. This ensures the sustainability of energy production and significantly reduces the carbon footprint.

The adoption of green technologies, including energy optimization systems, should be expanded. Smart cities, green buildings and advanced energy storage technologies will greatly contribute to environmental protection and more efficient energy use in the future.

It is essential to train and support young designers who will develop ecologically sustainable designs for the future. By applying modern technologies and methods, young professionals can rapidly advance the field of green design.

Governments should support innovative projects in green design and renewable energy and promote innovations in this sector through appropriate legislation and financial incentives. Various subsidies and tax benefits should be applied for projects that increase energy production.

Raising public awareness about the benefits of green design and renewable energy is a key priority. Educating society on resource conservation and energy efficiency will broaden ecological consciousness and lead to visible changes across communities.

In conclusion, the development of technologies such as green design and renewable energy will not only help protect the environment but also significantly strengthen the economy. Sustainable and development-oriented steps in these fields will lay the foundation for a more livable and resilient future.

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