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POWERING A SUSTAINABLE FUTURE: RENEWABLE ENERGY AS THE ENGINE OF THE GREEN ECONOMY

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Abstract: This study explores the role of renewable energy within the context of the green economy. The main aim is to discuss the advantages renewable energy offers and clearly identify the challenges affecting its adoption. To achieve this, the paper reviews existing literature on renewable energy and applies a SWOT analysis to better understand internal strengths and weaknesses as well as external opportunities and threats. While renewable energy presents clear environmental benefits and potential for economic growth, significant issues like high initial costs, infrastructural limitations, and inconsistent energy supply remain major obstacles. The study first defines the green economy concept, then provides a detailed SWOT analysis specifically focused on renewable energy, and finally discusses how digital marketing and artificial intelligence could help overcome identified barriers. Findings highlight the importance of government support, technological improvements, and digital strategies for successful renewable energy adoption. The insights presented here may help policymakers, businesses, and researchers effectively navigate the transition to a more sustainable economy.

Keywords: Artificial intelligence, Digital marketing, Digital branding, Green financing, SWOT analysis

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1. Introduction

There is now a greater demand for sustainable and ecologically friendly alternatives as the use of fossil fuels has exacerbated climate change and global warming. Most people agree that the best way to replace fossil fuels soon is with renewable energy. Commercially viable renewable energy sources like solar, wind, and biomass have achieved significant progress. Technological advancements have enabled the effective utilization of renewable energy sources at reduced costs, contributing to this achievement (Sayed et al., 2023).

The world's population growth and civilizational progress have led to an exponential increase in the requirement for energy. Despite being unsustainable and having detrimental consequences on both the environment and human health, fossil fuels remain the main source of energy. Large volumes of greenhouse gases, such as carbon dioxide, nitrous oxide, and methane, are released when fossil fuels are burned. With the rapid development of industry and civilization, we anticipate an increase in these gases' emissions over time. Current and projected levels of greenhouse gases (assuming no adjustments to energy sources) lead to sea level rise, severe health issues, weather changes, and ecological changes. Fossil fuel-related health issues and climate change pose a hazard to humankind (Olabi and Abdelkareem, 2022).

Manufacturing companies have acknowledged the necessity of fostering a more sustainable environment inside their operational systems, prompting a shift towards a 'greener' approach. Industries anticipate the renewable energy transition as a fundamental strategy to mitigate the adverse impacts of non-renewable energy on the environment, highlighting the crucial role of renewable energy in enhancing environmental quality (Gyimah et al., 2022).

The green economy promotes long-term development by balancing economic growth and environmental protection. Its aims include lowering carbon emissions, reducing waste, preserving biodiversity, and driving economic growth. The green economy promotes the use of solar, wind, and hydroelectric power, as well as energy efficiency across society. It aims to decouple economic progress from environmental degradation so that it does not destroy the planet's resources. Sustainability, a core concept in the green economy, refers to meeting current demands while not jeopardizing future needs. Careful resource management, reducing fossil fuel consumption, and promoting circular economy strategies like recycling and reuse are examples of this. Sustainable green economy approaches include energy efficiency and clean technology innovation to reduce environmental impact.

Governments and international organizations may help progress the green economy by implementing sustainable policies. Carbon pricing, renewable energy subsidies, and green business regulations are some examples. The green economy fosters economic resilience and environmental conservation by integrating economic activities with environmental sustainability. The green economy generates jobs in clean energy, sustainable agriculture, and waste management; therefore, it promotes economic growth and environmental sustainability. A forward-thinking economy must adopt a more sustainable economic model to solve global concerns such as climate change, resource depletion, and environmental damage.

The literature lacks numerous studies in this field. The aim of this study is to fill the gap in the literature. Gasparatos et al. (2017) assessed the effects of various renewable energy paths on ecosystems and biodiversity, as well as the consequences of these effects for the transition to a green economy. The increasing use of renewable energy is now fundamental to green economy initiatives; yet, a growing body of material indicates that the renewable energy industry might impact ecosystems and biodiversity. Kolosok et al. (2022) elucidated the predictability of fluctuations in power output across the EU27 by mathematical modeling, focusing on predictors of net electricity generation from certain renewable resources for the years 2017–2020. A Markov switching regression model with three regimes was used to assess the impact of renewable energy deployment in the EU27, using selected predictors of clean energy output from hydro, geothermal, wind, and solar sources.

Mealy and Teytelboym (2022) developed an original metric for comparing green production capacity across countries, established a new dataset of ecologically beneficial traded commodities, and demonstrated a method for discovering new green export possibilities. Mohsin et al. (2022) investigated the relationship between technological improvement, renewable energy, and green economic development (GEG). They used a data envelopment analysis (DEA) estimate technique to examine the association between government R&D investment, renewable energy deployment, and GEG in the Economic Community of West African States (ECOWAS) between 1990 and 2018. Wang et al. (2024) stressed the critical necessity to integrate sustainable energy and environmental policies into China's economic development framework, supporting a comprehensive policy plan that balances economic growth and environmental preservation.

This study delves into how renewable energy fuels the green economy through a comprehensive, multi-layered analysis. In Section 2, a SWOT framework is used to examine renewable energy's key strengths—such as its environmental benefits and economic promise—while also addressing challenges like intermittency and high infrastructure costs. Additionally, external influences, including policy support and market barriers, are explored. Moving to Section 3, the study highlights the connection between sustainable IT practices and green economic goals, showcasing how innovations like energy-efficient computing and AI-enhanced grid management can optimize system performance and scalability. Section 4 provides a global perspective on renewable energy adoption, pointing to surging investments—reaching $619 billion in 2023—and regional variations in capacity growth. Notably, China has emerged as a frontrunner in funding and deployment efforts. In Section 5, the SWOT analysis is expanded to focus on sector-specific opportunities and risks. This includes breakthroughs in energy storage as a key opportunity, while concerns like dependence on finite resources are identified as ongoing risks. The discussion is firmly rooted in real-world economic and ecological contexts. The study then turns to Section 6, where findings are consolidated. Here, the role of renewable energy in job creation and emissions reduction is weighed against persistent challenges such as financing gaps. To address these issues, integrated policy measures and technology-driven solutions are proposed. Finally, Section 7 reinforces the crucial role of renewable energy in sustainable development. The study calls for further exploration of topics like AI-driven energy system optimization and digital strategies to enhance public engagement. By bridging academic research with practical applications, this study aims to equip policymakers and industry leaders with actionable insights to drive a cleaner and more resilient economy.

2. Materials and Methods

Renewable energy's green economy function was assessed using SWOT analysis. SWOT analysis was chosen because it is straightforward and effective at identifying and analyzing internal and external issues that may affect global renewable energy adoption. SWOT analysis identifies strengths, weaknesses, opportunities, and threats.

Strengths of renewable energy include environmental advantages, economic possibilities, and energy independence. Secondary data from case studies, literature reviews, and global energy reports identifies characteristics. Renewable energy sources' irregularity, high upfront costs, and grid and building infrastructure integration issues are limitations. Government measures that support renewable energy and energy storage systems and AI-enhanced energy management present opportunities. Subsidized fossil fuels, political and economic instability, and resource scarcity for some renewable technologies may limit renewable energy use.

The study uses quantitative and qualitative methodologies. Qualitative research covers AI, green economy, and renewable energy literature. Government and business leaders' interviews assist stakeholders grasp green economy's potential and limitations. Quantifying the research's trends and effects employs statistical data on renewable energy investments, technical improvements, and energy output. This study uses the Green Economy, which promotes long-term economic growth and environmental protection. The global economy promotes renewable energy for growth and environmental protection. This technique relies on Sustainable Development Theory, which states that economic expansion must meet current demands without sacrificing future needs. Renewable energy aids economic progress and resource conservation. A technological advance shows AI and smart grids may help green economic revolution. Renewable energy sources may become more appealing than fossil fuels as technology improves efficiency and decreases prices. Environmental sustainability, economic growth, and renewable energy are linked by this notion. It methodically evaluates renewable energy's green economic potential and limits. Renewable energy market dynamics, technology, and policy may be studied using the framework.

2.1. Green Economy and Sustainable IT Strategies

In the past decade, green banks, village funds, and other entities have arisen as mechanisms for financing environmentally advantageous projects. Green banks and green bonds may have a significant influence in the advancement of renewable energy. Due to their favorable circumstances for renewable energy initiatives, green banks serve as a significant source of derivative instruments and an efficient means of promoting the benefits of clean energy. Green bond proponents assert that they will allocate the funding to provide sustainable, cost-effective resources to cover the program's operating expenses post-construction (Fang et al., 2022a). A fundamental premise of the "Green Economy" (GE) idea is that low-carbon energy technologies provide significant potential to fulfill socio-economic objectives in conjunction with environmental goals. The GE paradigm offers a comprehensive model for social well-being (Pahle, et al., 2016).

For an extended period, the term "green growth" was exclusively associated with the expansion of the eco-industry. However, the term now encompasses the growth of the entire economy. "Green growth is the process of promoting economic growth and development while simultaneously guaranteeing that the natural assets continue to provide the resources and environmental services that are essential for our well-being." In order to accomplish this, it is necessary to stimulate investment and innovation, which will serve as the foundation for long-term development and generate new economic prospects. Green growth is a qualitative development that is resilient in its ability to explain natural hazards, pure in its minimization of pollution and environmental damages, and efficient in its utilization of natural resources (Loiseau et al., 2016).

The green economy focuses on alternative, clean energy sources to power long-term growth instead of using up natural resources, which is not a forward-looking approach. New energy sources and sustainable development are both growing fields. Renewable energy sources are at the heart of a green economy. These sources can help keep life on Earth going by respecting and protecting all living things for future generations. The green economy is a method of economic growth that is founded on the concept of sustainable growth (Karakul, 2016). Green computing uses resources more effectively to maintain or increase performance. Power management, virtualization, sophisticated cooling, recycling, responsible electronic waste disposal, and IT infrastructure optimization are needed to provide sustainable IT services. These eco-conscious computing approaches aim to reduce environmental impact while maintaining the effectiveness of IT operations (Harmon and Auseklis, 2009).

The initial phase of sustainable IT initiatives has concentrated on reducing the expenses and ecological effects of data centers. In the past decade, as data centers have grown essential to IT strategy, green computing practices acknowledging the connection between IT-related energy use and overall business carbon emissions have gained widespread adoption. “Sustainable IT” is the evolving second wave of initiatives that extends IT and ICT sustainability outside the data center (Harmon et al., 2010).

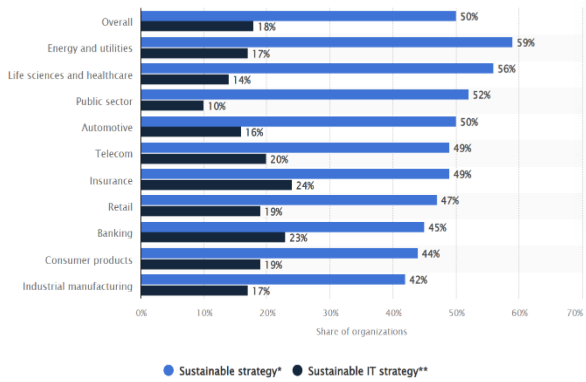

Figure 1. Sustainability strategies incorporating information technology (IT) in global organizations in 2021, categorized by sector (Sherif, 2023).

In 2021, 18 percent of participants in worldwide Capgemini research reported possessing a sustainable IT strategy with well-defined objectives and timetables inside their firm. In contrast, 50 percent of respondents report possessing an enterprise-wide sustainability plan. The insurance and banking sectors are at the forefront of sustainable IT strategy in Figure 1 (Sherif, 2023).

2.2. The Role of Green Financing, Digital Marketing, and Branding in Advancing Renewable Energy

Over the last decade, green finance organizations such as green banks and green bonds have emerged as critical tools for renewable energy initiatives. Green banks encourage renewable energy project development by providing funding tools that reduce risk and promote environmentally friendly energy alternatives. Green bonds have the potential to provide financing for sustainable energy infrastructure over time (Fang et al., 2022b).

The growth of renewable energy can be attributed to the influence of internet branding and marketing strategies. Content marketing, SEO, and social media can enable renewable energy companies to enhance their visibility, demonstrate their commitment to sustainability, and engage with environmentally conscious consumers. Implementing renewable energy in digital marketing could enhance brand loyalty while promoting environmental sustainability.

The integration of digital technologies has the potential to enhance sustainability within green economy businesses. In a competitive industry, the alignment of marketing strategies with environmental objectives could enable businesses to differentiate themselves. This strategy effectively attracts clients who prioritize environmental considerations. Businesses leverage branding to emphasize their environmental responsibilities and facilitate the transition to a sustainable economy, making it essential. The integration of interactive digital platforms, content-driven advertisements, and environmental messaging alongside renewable energy has the potential to influence customer behavior significantly.

2.3. Renewable Energy

In 2023, global new investment in renewable energy reached roughly 619 billion U.S. dollars. This was an eight percent rise compared to the prior year. Global financing for sustainable energy has consistently risen over the past decade. In 2014, investments in clean energy amounted to 263 billion U.S. dollars, rising to a peak of 619.1 billion U.S. dollars in 2023. The substantial rise in investment money signifies considerable maturation within the business. Supportive policies for renewable sources, a rapidly growing sector, and the creation of publicly traded businesses that possess renewable energy assets (often referred to as yieldcos) have propelled the consistent increase in clean energy investment. China is the leading country in renewable energy investment, allocating 273 billion U.S. dollars in 2023 in Figure 2 (Fernández, 2024).

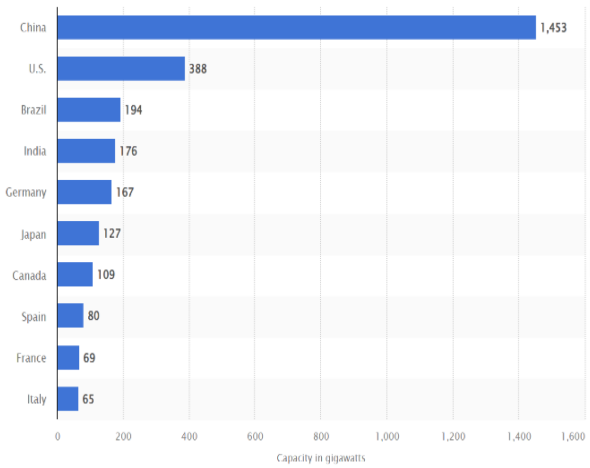

Figure 2. Countries with the most installed renewable energy capacity globally in 2023 (Fernández, 2024).

Renewable energy sources have been vital for humanity since the inception of civilization. For ages, biomass has been utilized for heating, cooking, steam generation, and power production, alongside hydropower and wind energy for propulsion and subsequently for electricity generation. Renewable energy sources mostly rely on energy fluxes inside the Earth's biosphere, derived from solar insolation and geothermal energy. Biomass energy, which is the development of plants fueled by solar radiation, may be distinguished (Turkenburg and Faaij, 2000).

Renewable energy sources and sustainable development are two distinct yet closely connected factors. The economy utilizes resources and energy in production by extracting them from the environment to provide essential commodities and services for society; therefore, these activities lead to emissions and pollution in the environment. Consequently, as industry persists, environmental contamination also continues. The environment, contaminated by these activities, must be safeguarded to ensure that future generations may utilize it for their own requirements (Guney, 2019).

Development requires energy, and sustainability requires sustainable energy systems. Renewable energy sources have reached double-digit percentages in power production in several countries in recent decades, but many other nations and industries, such as transportation, are only beginning to integrate renewable energy. To transition to renewable energy, resource evaluations, appropriate technologies, and systems are needed to integrate sources and meet demand at the right time (Østergaard et al., 2020).

2.3.1 Artificial intelligence in renewable energy

Artificial intelligence (AI) primarily concentrates on the creation of intelligent devices and software tailored for specific issues. Artificial intelligence seeks to comprehend human cognition in order to develop intelligent beings capable of effectively addressing difficult issues, despite the challenges inherent in deciphering the intricate workings of the human brain. Artificial intelligence is employed in nearly all forms of renewable energy (wind, solar, geothermal, hydro, ocean, biomass, hydrogen, and hybrid) for design, optimization, estimate, management, distribution, and policy formulation (Jha et al., 2017).

Rising demand, efficiency, insufficient analytics for management, and variable supply and demand dynamics are causing energy industry difficulties. Energy forecasting, efficiency, and accessibility are crucial AI-integrated renewable energy technologies (Chen et al., 2021). Artificial intelligence can solve various renewable energy problems. Based on system needs and design, many techniques are offered. The use of these systems is difficult, but new technologies and algorithms can help. Machine learning can help maximum power point tracking (MPPT) systems minimize input noise and improve performance. Hybrid MPPT systems use machine learning and classical methods to track better.

Inverter issues may be resolved using machine learning, guaranteeing a constant power supply despite renewable energy fluctuations (Srivastava, 2020). Renewable energy systems are more complicated due to their unpredictability. Model-based solutions may struggle to meet future renewable energy system analytical, scheduling, and control demands. Power system operators now have considerable data from smart meters and enhanced sensing instruments thanks to smart grid technologies. Data availability encourages AI to derive relevant insights from complicated, nonlinear issues without assumptions or simplifications (Hu et al., 2022).

2.4. SWOT Analysis: Harnessing Renewable Energy for A Green Economy

This section uses SWOT analysis to assess renewable energy's impact on sustainability. Environmental benefits and economic growth potential are underlined, along with cons such as high starting expenses and inefficiency. Advances in technology and favorable government policies provide opportunities, while economic and political uncertainty and subsidized fossil fuels pose risks. Table 1 details renewable energy's potential and obstacles in developing a green economy.

3. Results and Discussion

This section summarizes the research's key results, with a focus on the role of renewable energy in powering the green economy. The research uses a SWOT analysis paradigm to assess renewable energy's strengths, weaknesses, opportunities, and threats in terms of sustainable development. The findings emphasize major environmental benefits, such as lower greenhouse gas emissions and pollution, as well as economic benefits including job creation, technical breakthroughs, and energy independence. However, constraints like high initial prices, infrastructural limits, and the intermittent nature of renewable energy sources such as solar and wind need breakthroughs in energy storage and grid integration. Artificial intelligence (AI) plays a crucial role in renewable energy management because it optimizes energy production, improves forecasting, and increases system dependability. Government initiatives, such as subsidies and carbon pricing, are also important in encouraging renewable energy adoption. The study underlines that renewable energy offers enormous potential for long-term economic development; nevertheless, reaching this potential involves overcoming technological, economic, and social difficulties via innovation, cooperation, and deliberate policy.

4. Conclusion

The shift to a green economy, supported by renewable energy, offers a difficult but vital approach to tackling critical global issues such as climate change, environmental degradation, and economic inequality. The potential of renewable energy to diminish greenhouse gas emissions, enhance energy independence, and foster economic growth is well recognized, although the path is laden with challenges. The substantial initial capital expenditures necessary for renewable infrastructure development, the sporadic characteristics of energy sources such as solar and wind, and the technical difficulties related to the integration of these sources into current energy grids all constitute considerable obstacles that must be overcome for a successful transition.

The integration of artificial intelligence (AI) into renewable energy systems represents a significant advancement in addressing these difficulties. Artificial intelligence can optimize energy generation, augment efficiency, and boost energy storage systems, therefore rendering renewable energy sources more dependable and accessible. Machine learning methodologies can enhance maximum power point tracking (MPPT) in solar panels and provide more accurate predictions of energy output, hence diminishing reliance on meteorological conditions. Moreover, AI's function in smart grids can enhance demand-response systems, resulting in more efficient and dependable electricity distribution. As AI technology progresses, its capacity to transform the renewable energy sector becomes more apparent, providing a means to surmount the technical obstacles that presently impede widespread use. Notwithstanding the possible advantages, there are concerns that warrant consideration. Fossil fuels, frequently subsidized, continue to compete robustly with renewable energy, particularly in areas where economic considerations may hinder the use of green technologies. Moreover, the restricted accessibility of specific raw materials essential for renewable technologies, such as lithium and cobalt for batteries, may engender risks within supply chains.

Table 1. SWOT analysis of renewable energy as a catalyst for a green economy

Strengths	Weaknesses
Environmental Advantages: Renewable energy sources, including wind, solar, and hydro, generate negligible greenhouse gas emissions relative to fossil fuels, aiding in climate change mitigation and pollution reduction.	Solar and wind energy are intermittent and dependent on weather conditions, making power delivery difficult without storage.
Economic Growth: Investment in renewable energy supports a green economy, job development, and technological innovation.	Despite lower renewable energy prices, infrastructure like solar farms, wind turbines, and energy storage requires significant upfront costs.
Energy Independence: Countries may gain energy security and price stability by reducing fossil fuel imports.	Infrastructure Limitations: Integrating renewable energy sources into the grid involves infrastructure and technology improvements, which may be difficult and expensive for some places.
Sustainability: Renewable energy is plentiful and self-renewing, making it a good long-term energy source.	Land and resource requirements: Large renewable energy facilities, notably solar and wind, require a lot of land, which may harm ecosystems and populations.
Opportunities	Threats
Technological advancements in energy storage, smart grids, and AI-driven energy management provide prospects to surmount existing restrictions and enhance the integration of renewable energy.	Economic and political uncertainties: Economic recessions or changes in governmental objectives may diminish financing, support, or incentives for renewable energy initiatives.
Government Policies and Incentives: Numerous governments are implementing policies, subsidies, and incentives to advance renewable energy, facilitating industry expansion and fostering private investment.	Competition from Fossil Fuels: Fossil fuels continue to get subsidies in several areas, rendering them artificially inexpensive and perhaps hindering the development of renewable technology.
Escalating energy need: With the surge in global energy requirements, particularly in emerging areas, renewable energy presents a sustainable solution to fulfill this need.	Resource Scarcity in Technology: Specific renewable technologies, such as battery storage, depend on limited resources (e.g., lithium, cobalt), potentially resulting in supply chain vulnerabilities.
Climate Commitments: International accords, such as the Paris Agreement, exert pressure on nations to decrease emissions, therefore establishing renewable energy as a viable way to fulfill these obligations.	Public Opposition: Certain renewable initiatives, especially wind farms, may encounter resistance from local people because of apprehensions over land utilization, visual effects, or possible environmental consequences.

Governments must implement proactive measures, including legislation that provides equitable conditions for renewable energy, enabling it to compete on par with fossil fuels.

The public's view and adoption of renewable energy initiatives pose a significant obstacle. Although renewable energy is often regarded as advantageous for the environment, extensive initiatives, such as wind farms and solar installations, can encounter resistance from local people. This may arise from apprehensions over land utilization, visual appeal, or possible ecological repercussions, highlighting the necessity for meticulous planning and community involvement in the establishment of renewable energy infrastructure.

The societal implications of a green economy are substantial. Transitioning to renewable energy enables countries to generate employment, foster technical innovation, and diminish dependence on fossil fuel imports, thereby enhancing energy security. This transformation must be meticulously handled to guarantee inclusivity and equity. Employees in conventional energy industries may experience displacement, necessitating the implementation of policies to facilitate their assistance through retraining and transition initiatives.

The development of a green economy ultimately depends on the collaborative efforts of governments, corporations, and individuals. Political will, global collaboration, and investments in renewable energy technology are essential for attaining a sustainable and fair future. As the world progressively adopts renewable energy sources, there exists a chance to establish a more resilient, equitable, and successful global economy that operates in conjunction with the environment.

In conclusion, the green economy and the fight against environmental issues of the twenty-first century depend heavily on renewable energy. Although there will be long-term benefits to the change, there will also be financial, technological, and societal challenges. Climate change is effectively addressed, greenhouse gas emissions are decreased, and sustainable economic growth is encouraged by renewable energy. It has a special opportunity to increase energy independence, provide employment that benefits the environment, and raise living standards worldwide.

More digitally literate individuals are needed in the energy sector as artificial intelligence (AI) applications spread quickly across several industries. At this critical juncture, AI may hasten the shift to a new energy system. Energy systems may improve planning and optimization and boost efficiency by utilizing AI to supplement data collection. Machine learning may enable AI-driven predictive maintenance and automation, which might improve system reliability. To optimize these systems' potential for sustainable energy solutions, they must be included in energy production processes.

The development of the green economy will depend on the commitment of political leaders, international cooperation, and advancements in energy technology. Governments, businesses, and individuals must deal with this shift. Investments in renewable energy can create a future in which environmental degradation won't be a determining factor in economic success. A fairer society and a better world would be left for future generations.

This study has explored how renewable energy can effectively drive sustainable economic growth while addressing significant environmental concerns. Moving forward, several promising areas deserve further investigation to build on the insights presented here:

- *Energy Management Systems Enhanced by Artificial Intelligence:* Future studies could look deeper into how AI can practically improve renewable energy systems particularly by using predictive maintenance and optimization to boost reliability, efficiency, and overall performance.
- *Exploring New Models in Green Financing:* There is room to better understand how public-private collaborations or innovative financing approaches can help overcome investment barriers. Understanding these dynamics more clearly could significantly speed up renewable energy projects worldwide.
- *Understanding Consumer Behavior through Digital Marketing and Branding:* Another interesting research avenue is exploring how digital marketing, branding, and online engagement influence consumers' decisions to adopt renewable energy. Such insights could guide effective strategies for increasing public awareness and participation.

Overall, this research serves as a practical reference point for academics, policymakers, and industry professionals. The proposed future directions aim to address existing gaps, helping stakeholders better understand and leverage renewable energy as a key component of a sustainable economy.

Author Contributions

The percentages of the authors' contributions are presented below. All authors reviewed and approved the final version of the manuscript.

	K.G.N.	S.A.
C	50	50
D	50	50
S	60	40
L	40	60
W	45	55
CR	60	40
SR	60	40
PM	50	50

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Since no studies involving humans or animals were conducted, ethical committee approval was not required for this study.

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