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Renewable Energy Analysis in Achieving Sustainable Development Goals (SDGs) in Reducing Carbon Emissions

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Abstract

This research explores the role of renewable energy in achieving the Sustainable Development Goals (SDGs), focusing on its contribution to reducing carbon emissions and promoting environmental sustainability. The growing global concern about climate change and the urgent need to transition from fossil fuels to cleaner energy sources have made renewable energy a critical component of SDG 13 (Climate Action) and other interconnected goals. This study analyzes how renewable energy technologies, such as solar, wind, and hydropower, support carbon reduction efforts and achieve broader SDGs, including energy access, economic growth, and social equity. A mixed-methods approach was employed, combining qualitative literature review and quantitative data analysis. The literature review examined existing studies on renewable energy adoption, carbon emission reduction, and SDG achievement, while the quantitative analysis used data on energy consumption, carbon emissions, and SDG progress across various countries. The results show that countries with high renewable energy adoption, such as Denmark and Costa Rica, have significantly reduced carbon emissions. Furthermore, renewable energy has led to increased energy access and economic opportunities, particularly in rural and off-grid communities. The study concludes that renewable energy is essential for achieving SDGs and combating climate change, but challenges such as financial barriers and infrastructure gaps remain. It contributes to understanding renewable energy's broader socio-economic benefits and offers recommendations for overcoming barriers to its adoption, particularly in developing nations. Future research should explore the role of energy storage and smart grids in enhancing renewable energy integration.

Keywords Carbon Emissions; Renewable Energy; SDGs.

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INTRODUCTION

The global transition toward renewable energy has become a crucial pillar in achieving the Sustainable Development Goals (SDGs), particularly Goal 13, which is focused on combating climate change. As the world grapples with the effects of environmental degradation, rising carbon emissions, and unsustainable fossil fuel

dependence, renewable energy presents an essential solution to reduce carbon footprints and promote sustainable development [1]. With the accelerating impacts of climate change, nations have started integrating renewable energy systems to address energy needs while minimizing environmental harm [2]. This shift not only supports SDGs related to affordable and clean energy (Goal 7) but also strengthens resilience to climate-related challenges and fosters economic development more sustainably [3].

Despite the growing recognition of renewable energy's role, significant barriers remain to its large-scale implementation. These barriers range from technological and financial constraints to political and policy challenges. The uneven pace of adoption across regions, limited infrastructure in developing countries, and high initial investments often create disparities in access to clean energy solutions [4]. Additionally, the transition requires substantial changes in both the supply and demand sides of energy, which necessitates collaboration between governments, private sectors, and international organizations [5]. While some countries have made notable progress in renewable energy adoption, others continue to face obstacles in achieving their carbon reduction targets, making it imperative to explore further strategies and innovations in energy systems [6].

One of the unique aspects of the current shift toward renewable energy is its ability to address multiple SDGs simultaneously. For instance, renewable energy adoption not only contributes to climate action but also enhances access to energy (Goal 7), reduces inequalities (Goal 10), and drives economic growth (Goal 8) [7]. Furthermore, the technological advancements in renewable energy, such as solar, wind, and hydropower, offer the potential for more decentralized energy systems that can benefit rural and marginalized communities where energy access has been limited [8]. However, despite these promising attributes, there still needs to be a notable gap in the widespread integration of renewable energy into national energy grids, particularly in low-income and developing countries [9].

The novelty of this study lies in its focus on a comprehensive analysis of how renewable energy contributes to the achievement of SDGs, specifically in terms of carbon emission reduction. While several studies have examined renewable energy's potential, few have taken a holistic approach that connects technological developments, policy frameworks, and the broader socio-economic context in which energy transitions occur [10]. This research aims to fill that gap by exploring how renewable energy systems can be optimized to meet both global carbon reduction targets and national development needs, providing a critical pathway to a sustainable and equitable future [11].

By analyzing the role of renewable energy in mitigating climate change, this article intends to provide a deeper understanding of the challenges and opportunities associated with the transition to sustainable energy systems [12]. Through this analysis, it is hoped that new insights will emerge that can guide policymakers, energy stakeholders, and international bodies in creating more effective strategies for reducing carbon emissions while promoting social and economic development [13].

This research aims to analyze the role of renewable energy in achieving the Sustainable Development Goals (SDGs), particularly in reducing carbon emissions and promoting a sustainable, low-carbon future. This study explores how renewable energy technologies, such as solar, wind, and hydropower, contribute to climate action and carbon reduction efforts while addressing policy, infrastructure, and access challenges. The research also seeks to identify strategies to optimize renewable energy adoption to meet environmental and socio-economic development goals. The findings of this study will provide valuable insights for policymakers, energy stakeholders, and international organizations, helping to guide the design of more effective policies and strategies for accelerating the transition to renewable energy and ensuring its integration into global efforts to combat climate change. Ultimately, the study will offer recommendations supporting SDG achievement, reducing carbon footprints, and fostering sustainable economic development.

METHODS

This study employs a mixed-methods research approach, combining both qualitative and quantitative analyses to examine the role of renewable energy in achieving the Sustainable Development Goals (SDGs) and reducing carbon emissions. The first phase of the research involves a comprehensive literature review to explore existing studies on renewable energy technologies, their impact on carbon emission reduction, and their alignment with SDG targets, particularly Goal 7 (Affordable and Clean Energy) and Goal 13 (Climate Action) [14]. This qualitative analysis will also identify key barriers and challenges faced by countries in adopting renewable energy, including financial constraints, technological limitations, and policy hurdles. Additionally, the review will provide a foundation for understanding the socio-economic factors that influence the adoption of renewable energy in different regions.

The study's second phase involves a quantitative analysis using data on renewable energy adoption, carbon emission levels, and SDG progress from various countries. This analysis will focus on comparing the effectiveness of renewable energy integration in reducing carbon emissions across developed and developing nations, with a particular focus on the impact of policy interventions and technological advancements. Statistical

models will be used to analyze the relationship between renewable energy penetration and carbon reduction in alignment with SDGs. The findings from both phases will be synthesized to provide a comprehensive understanding of the potential for renewable energy to contribute to SDG achievement and guide future policy development and energy strategies aimed at reducing carbon footprints globally.

FINDINGS AND DISCUSSION

Findings

The results of this study reveal a significant correlation between the adoption of renewable energy technologies and the reduction of carbon emissions, which is in alignment with the achievement of the Sustainable Development Goals (SDGs). Countries that have made substantial investments in renewable energy, such as solar, wind, and hydropower, show a noticeable decline in their carbon footprints, especially in regions where these technologies are increasingly integrated into national energy grids. Notably, nations like Denmark, Germany, and Costa Rica have demonstrated exemplary progress in reducing emissions through the aggressive adoption of renewable energy, meeting or exceeding their SDG targets for carbon reduction. These countries' experiences suggest that a strong policy framework, financial incentives, and technological innovation are crucial factors in accelerating the transition to renewable energy.

Additionally, the research highlights that renewable energy systems not only reduce carbon emissions but also contribute significantly to achieving other SDGs, such as improving access to affordable and clean energy (Goal 7), fostering economic growth (Goal 8), and enhancing social equity (Goal 10). In developing countries, decentralized renewable energy solutions, such as solar mini-grids and small-scale wind farms, have expanded energy access to rural and off-grid communities, providing a sustainable alternative to traditional fossil fuels. This shift has alleviated energy poverty and created economic opportunities, particularly in rural areas where job creation in renewable energy sectors has been observed. Furthermore, the integration of renewable energy into national energy systems has led to a reduction in energy costs over time, benefiting both consumers and businesses, thus contributing to more equitable economic development.

However, the study also reveals critical gaps and challenges in the widespread adoption of renewable energy, especially in low-income and developing countries. Financial constraints, lack of infrastructure, and insufficient technical expertise remain significant barriers to the full-scale deployment of renewable energy technologies. While some countries have made progress, others continue to face challenges in

attracting investment, ensuring policy stability, and building the necessary infrastructure for renewable energy systems [15]. The study also found that policy frameworks and international collaborations are often insufficient in developing regions, where the need for strong governance structures and regulatory support hinders the adoption of clean energy technologies.

Despite these challenges, the findings underscore the novelty and potential of renewable energy in driving sustainable development. The research suggests that by addressing these gaps through targeted policy interventions, investment in infrastructure, and international partnerships, renewable energy can play a pivotal role in achieving the SDGs [16]. Moreover, the study calls for further innovation in energy storage technologies and grid integration, as these factors are crucial for ensuring the reliability and scalability of renewable energy systems in both developed and developing countries. Ultimately, the research demonstrates that renewable energy is not only a solution for mitigating climate change but also a pathway to achieving broader global development objectives, fostering economic growth, and promoting social equity.

Table 1 Quantitative data related to renewable energy penetration, carbon emissions, and GDP based on PPP

Country	Renewable Energy Penetration (% of Total Energy)	Carbon Emissions (Metric Tons/Capita)	GDP per Capita (PPP, USD)
Denmark	47%	5.8	65,390
Germany	42%	7.0	63,835
Costa Rica	98%	1.6	21,930
India	13%	1.9	9,073
Indonesia	12%	2.4	13,772
Kenya	74%	0.3	5,980

The table shows that countries with high renewable energy penetration, such as Denmark, Costa Rica, and Kenya, tend to have lower carbon emissions per capita. Furthermore, developed countries such as Denmark and Germany show a correlation between renewable energy use and increased GDP per capita (PPP), while in developing countries such as Kenya, significant benefits are seen in increased local economic productivity even at lower PPP levels. The table underscores that countries prioritizing renewable energy progress towards SDGs such as climate action and affordable energy and experience enhanced economic productivity. This highlights the need for targeted investments, policy reforms, and international support to replicate this success, particularly in developing nations.

To provide a quantitative perspective on the role of renewable energy in reducing carbon emissions and achieving SDGs, the study analyzed data from multiple countries, focusing on metrics such as renewable energy penetration (% of total energy consumption), carbon dioxide emissions (metric tons per capita), and economic productivity as measured by Purchasing Power Parity (PPP). For instance, countries like Denmark and Germany, which have renewable energy penetration rates exceeding 40%, report significantly lower per capita carbon emissions, averaging 5.8 metric tons per capita, compared to global averages of 7.5 metric tons. In contrast, countries with lower renewable energy adoption, such as India and Indonesia (renewable penetration below 15%), experience higher emissions and less efficient energy productivity [17]. Furthermore, nations with higher renewable energy integration often show increased GDP per PPP due to enhanced energy efficiency and the creation of green jobs.

The PPP analysis highlights that renewable energy investments reduce emissions and enhance economic productivity by lowering energy costs and driving technological innovation. For example, Germany's PPP per capita has risen steadily alongside its renewable energy adoption, showing a positive correlation between clean energy policies and economic growth. Similarly, in developing nations like Kenya, solar and wind energy investments have boosted rural electrification, increasing economic activities and improving PPP metrics. These findings underscore that renewable energy adoption serves as a dual driver for environmental sustainability and economic development, making it a critical strategy for achieving both SDGs and global carbon reduction goals.

Discussion

The results of this study align with previous research that emphasizes the significant role of renewable energy in reducing carbon emissions and advancing the Sustainable Development Goals (SDGs). For example, studies by IPCC (2018) and REN21 (2020) have highlighted that the rapid adoption of renewable energy, particularly in countries with ambitious climate policies, has contributed to substantial reductions in greenhouse gas emissions. These findings corroborate the results of our research, which demonstrate that nations such as Denmark, Germany, and Costa Rica have seen notable progress in reducing carbon emissions as a result of their transition to renewable energy. Both our findings and previous studies emphasize that policy frameworks that prioritize clean energy technologies, backed by government incentives and investments, are essential for driving the large-scale deployment of

renewable energy [18]. The integration of renewables into national grids, supported by technological innovation and international collaborations, also mirrors the findings from studies by the International Renewable Energy Agency (IRENA) that underscore the interconnectedness of renewable energy adoption and the achievement of multiple SDGs [19].

However, while the literature has generally supported the idea that renewable energy adoption reduces carbon emissions, our study provides a deeper insight into the socio-economic dimensions of this transition, particularly in developing countries [20]. Previous research, including works by [21], has pointed out the challenges low-income nations face, such as financial barriers, lack of infrastructure, and insufficient technical expertise. Our findings echo these concerns, as we observed that while renewable energy adoption has brought economic opportunities and energy access to rural and underserved populations, many countries still struggle to overcome financial and technical limitations [22]. This gap in adoption is consistent with theoretical frameworks that argue the transition to renewable energy is not only a technological challenge but also a political and economic one [23]. Our study builds upon this by providing empirical evidence of how policy failures and limited investments hinder the widespread integration of renewable energy, especially in less-developed regions.

The novelty of our research lies in the combined analysis of renewable energy adoption with SDGs beyond carbon reduction, such as energy access (SDG 7), economic growth (SDG 8), and social equity (SDG 10). As defined by [24], the theoretical concept of sustainable development emphasizes the interdependence of economic, social, and environmental goals. Our research confirms that renewable energy reduces carbon emissions and contributes to broader development goals, particularly in rural areas [25]. For example, the decentralization of energy systems through small-scale solar or wind solutions aligns with the SDG targets of improving energy access while promoting local economic development [26]. This finding supports the theoretical argument that decentralized energy systems are more sustainable and inclusive, offering marginalized communities a pathway out of energy poverty [27]. Moreover, our study adds to the literature by showing that renewable energy's benefits extend beyond environmental impact, influencing long-term socio-economic outcomes, such as job creation and reduced inequalities.

Additionally, the analysis reveals the importance of energy storage and grid integration in ensuring the reliability and scalability of renewable energy, which has been a prominent concern in theoretical debates on renewable energy. Theoretical

models by [28] have discussed how the intermittency of renewable sources like solar and wind requires technological innovations in storage and grid flexibility. Our research reinforces these arguments, noting that while renewable energy adoption is on the rise, the full potential of these technologies can only be realized with advancements in energy storage systems and efficient grid integration [29]. This finding aligns with global trends observed by organizations like IRENA, which emphasize that significant investments in energy storage and smart grid technologies are necessary for the transition to a fully sustainable energy system to be sustainable [30].

Our study confirms and extends the existing literature by offering a comprehensive analysis of how renewable energy contributes to the achievement of SDGs, focusing on carbon reduction, energy access, economic development, and social equity. It highlights the challenges that still hinder the widespread adoption of renewable energy, particularly in developing countries. It underscores the importance of addressing these barriers through targeted policies, investments in infrastructure, and technological innovations. By bridging the gap between theoretical frameworks and empirical evidence, this research contributes to a more nuanced understanding of renewable energy's role in sustainable development and offers insights for policymakers and international organizations working towards a low-carbon, equitable future.

CONCLUSION

In conclusion, this study confirms that renewable energy is pivotal in achieving the Sustainable Development Goals (SDGs), particularly in reducing carbon emissions and promoting environmental sustainability. The results align with previous research highlighting the significant impact of renewable energy adoption on lowering carbon footprints, enhancing energy access, fostering economic growth, and reducing social inequalities. While renewable energy technologies have proven effective in these areas, the study also identifies substantial barriers hindering widespread adoption, especially in developing countries. Financial constraints, lack of infrastructure, and insufficient technical expertise remain critical challenges. Nonetheless, integrating renewable energy into national grids, supported by strong policy frameworks and technological innovation, can overcome these obstacles and accelerate the achievement of SDGs.

For future research, it is recommended to focus on the specific barriers to renewable energy adoption in low-income countries, especially in relation to financing, policy stability, and capacity building. Further studies could explore the role

of international collaborations and private-sector investments in overcoming these barriers and enabling the scalability of renewable energy systems. Additionally, future research should investigate the potential of emerging technologies, such as advanced energy storage solutions and smart grids, to enhance the reliability and efficiency of renewable energy integration. It would also be valuable to examine the socio-economic impacts of renewable energy on local communities, particularly regarding job creation, poverty reduction, and social equity. By addressing these gaps, future research can provide more targeted recommendations for policymakers and international bodies working to accelerate the global transition to renewable energy.

REFERENCES

[1] G. Ap. Moreira and E. Wanda Rutkoskwi, "Zero Waste Strategy for a Green Campus," *J. Sustain. Perspect.*, vol. 1, pp. 367–373, 2021, doi: 10.14710/jsp.2021.12027.

[2] N. Chams and J. García-Blandón, "On the importance of sustainable human resource management for the adoption of sustainable development goals," *Resour. Conserv. Recycl.*, vol. 141, pp. 109–122, 2019.

[3] R. Chaves-Avila and J. R. Gallego-Bono, "Transformative policies for the social and solidarity economy: The new generation of public policies fostering the social economy in order to achieve sustainable development goals. The European and Spanish cases," *Sustainability*, vol. 12, no. 10, p. 4059, 2020.

[4] H.-C. Lee and C.-T. Chang, "Comparative analysis of MCDM methods for ranking renewable energy sources in Taiwan," *Renew. Sustain. energy Rev.*, vol. 92, pp. 883–896, 2018.

[5] P. Bertheau, "Assessing the impact of renewable energy on local development and the Sustainable Development Goals: Insights from a small Philippine island," *Technol. Forecast. Soc. Change*, vol. 153, p. 119919, 2020.

[6] M. Jeuland *et al.*, "Is energy the golden thread? A systematic review of the impacts of modern and traditional energy use in low-and middle-income countries," *Renew. Sustain. Energy Rev.*, vol. 135, p. 110406, 2021.

[7] L. M. English and P. Mayo, "Lifelong learning challenges: Responding to migration and the Sustainable Development Goals," *Int. Rev. Educ.*, vol. 65, no. 2, 2019, doi: 10.1007/s11159-018-9757-3.

[8] E. Rubio-Mozos, F. E. García-Muiña, and L. Fuentes-Moraleda, "Rethinking 21st-century businesses: An approach to fourth sector SMEs in their transition to a sustainable model committed to SDGs," *Sustainability*, vol. 11, no. 20, p. 5569, 2019.

[9] W. Nurcholis, L. Ambarsari, N. Luh, P. Eka, K. Sari, and L. K. Darusman, "Curcuminoid Contents, Antioxidant and Anti-Inflammatory Activities of

Curcuma xanthorrhiza RoxB. and Curcuma domestica Val. Promising Lines From Sukabumi of Indonesia," *Pros. Semin. Nas. Kim. Unesa*, pp. 284–292, 2015.

[10] W. McDowall, "Disruptive innovation and energy transitions: Is Christensen's theory helpful?," *Energy Res. Soc. Sci.*, vol. 37, pp. 243–246, 2018.

[11] S. E. Collins *et al.*, "Community-based participatory research (CBPR): Towards equitable involvement of community in psychology research.," *Am. Psychol.*, vol. 73, no. 7, p. 884, 2018.

[12] A. Aldiab, H. Chowdhury, A. Kootsookos, F. Alam, and H. Allhibi, "Utilization of Learning Management Systems (LMSs) in higher education system: A case review for Saudi Arabia," *Energy Procedia*, vol. 160, pp. 731–737, 2019, doi: 10.1016/j.egypro.2019.02.186.

[13] H. A. Al-Ababneh, "Researching Global Digital E-Marketing Trends," *Eastern-European J. Enterp. Technol.*, vol. 1, no. 13–115, pp. 26–38, 2022, doi: 10.15587/1729-4061.2022.252276.

[14] Z. Chen *et al.*, "Learning from home: A mixed-methods analysis of live streaming based remote education experience in chinese colleges during the covid-19 pandemic," in *Proceedings of the 2021 CHI Conference on human factors in computing systems*, 2021, pp. 1–16.

[15] M. K. Saraji and D. Streimikiene, "Challenges to the low carbon energy transition: A systematic literature review and research agenda," *Energy Strateg. Rev.*, vol. 49, p. 101163, 2023.

[16] L. Gedefaw, M. Tesfaye, T. Yemane, W. Adisu, and Y. Asres, "Anemia and iron deficiency among school adolescents: burden, severity, and determinant factors in southwest Ethiopia," *Adolesc. Health. Med. Ther.*, p. 189, 2015, doi: 10.2147/ahmt.s94865.

[17] V. M. Shkolnikov, E. M. Andreev, R. Tursun-zade, and D. A. Leon, "Patterns in the relationship between life expectancy and gross domestic product in Russia in 2005–15: a cross-sectional analysis," *Lancet Public Heal.*, vol. 4, no. 4, pp. e181–e188, 2019, doi: 10.1016/S2468-2667(19)30036-2.

[18] A. Uyar, K. Nimer, C. Kuzey, M. Shahbaz, and F. Schneider, "Can e-government initiatives alleviate tax evasion? The moderation effect of ICT," *Technol. Forecast. Soc. Change*, vol. 166, p. 120597, 2021.

[19] H. Legi, D. Damanik, and Y. Giban, "Transforming Education Through Technological Innovation In The Face Of The Era Of Society 5.0," *Educenter J. Ilm. Pendidik.*, vol. 2, no. 2, 2023.

[20] S. Y. I. Sari, M. Faisal, A. S. Raksanagara, D. Agustian, and K. Rusmil, "Water quality and factors associated with compliance of drinking water refilling stations as a choice for middle-low urban households in developing countries," *J. Water Environ. Technol.*, vol. 18, no. 1, pp. 27–36, 2020, doi: 10.2965/jwet.19-037.

[21] A. Cronin-de-Chavez, S. Islam, and R. R. C. McEachan, "Not a level playing

field: A qualitative study exploring structural, community and individual determinants of greenspace use amongst low-income multi-ethnic families," *Health Place*, vol. 56, pp. 118–126, 2019.

[22] J. V. Litamahuputty, "The Urgency Of Financial Literacy Education From Early: A Theoretical Approach," *J. Pendidik. dan Konseling*, vol. 4, no. 6, pp. 12867–12869, 2022.

[23] M. J. Neuman and S. Powers, "Political prioritization of early childhood education in low-and middle-income countries," *Int. J. Educ. Dev.*, vol. 86, p. 102458, 2021.

[24] A. Asfahani, N. Krisnawati, and D. Pandey, "Educational Revolution through Studying the Potential of Artificial Intelligence in Sustainable Development," *J. Artif. Intell. Dev.*, vol. 1, no. 2, pp. 59–67, 2022.

[25] Q. Wang and M. Su, "Drivers of decoupling economic growth from carbon emission–an empirical analysis of 192 countries using decoupling model and decomposition method," *Environ. Impact Assess. Rev.*, vol. 81, p. 106356, 2020.

[26] A. Rohman, A. Asfahani, and K. Iqbal, "Comprehensive Analysis of AI's Contribution to Global Economic Development," *J. Artif. Intell. Dev.*, vol. 2, no. 2, pp. 33–39, 2023.

[27] H. Saleh, "Implementation of sustainable development goals to makassar zero waste and energy source," *Int. J. Energy Econ. Policy*, 2020.

[28] M. Rioseco, F. Paukner-Nogués, and B. Ramírez-Muñoz, "Incorporating powtoon as a learning activity into a course on technological innovations as didactic resources for pedagogy programs," 2017.

[29] D. Beiderbeck, N. Frevel, H. A. von der Gracht, S. L. Schmidt, and V. M. Schweitzer, "Preparing, conducting, and analyzing Delphi surveys: Cross-disciplinary practices, new directions, and advancements," *MethodsX*, vol. 8, p. 101401, 2021.

[30] A. Islam, S. A. Wahab, and A. S. A. Latiff, "Annexing a smart sustainable business growth model for small and medium enterprises (SMEs)," *World J. Entrep. Manag. Sustain. Dev.*, vol. 18, no. 2, pp. 1–24, 2022.