

A Survey on the Role of Renewable Energy in Achieving Sustainable Development Goals

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Abstract

Renewable energy plays a critical role in advancing the United Nations Sustainable Development Goals (SDGs) by addressing interconnected environmental, economic, and social challenges. This study examines how renewable energy contributes to sustainable development through improved energy access, reduced greenhouse gas emissions, and enhanced economic opportunities. By reviewing global case studies and recent literature, the paper highlights the effectiveness of renewable energy technologies in promoting a cleaner and more equitable future. As the 2030 SDG deadline approaches, accelerating the transition toward renewable energy systems is essential for ensuring long-term sustainability, environmental protection, and inclusive development.

Key words: Renewable energy systems, Sustainable development goals (SDGs), Smart grid technologies, Energy economics, Carbon emissions reduction, Energy policy and governance

1. Introduction

Renewable energy plays a vital role in promoting sustainable development by addressing environmental, economic, and social challenges. As the world faces increasing concerns related to climate change, energy security, pollution, and resource depletion, renewable energy sources such as solar, wind, hydro, biomass, and geothermal energy have emerged as sustainable alternatives to fossil fuels. These energy sources are naturally replenished and produce minimal greenhouse gas emissions, making them essential for achieving the United Nations Sustainable Development Goals (SDGs). The Sustainable Development Goals, adopted by the United Nations in 2015, consist of 17 global goals aimed at ensuring peace, prosperity, and environmental protection by 2030 [1]. Renewable energy directly supports SDG 7 (Affordable and Clean Energy) and significantly contributes to several other goals including SDG

1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and Sanitation), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action). Rapid industrialization, population growth, excessive dependence on fossil fuels, and increasing levels of pollution have significantly contributed to climate change, environmental degradation, and the depletion of natural resources. Therefore, governments, industries, and communities must work together to implement sustainable approaches that protect the environment while also supporting economic and social development. In this context, the adoption and expansion of renewable energy sources such as solar, wind, hydroelectric, geothermal, and biomass energy represent one of the most efficient, reliable, and cost-effective solutions for achieving environmental sustainability. Unlike conventional fossil fuels, renewable energy sources produce lower greenhouse gas emissions, reduce air and water pollution, and help conserve finite natural resources. In addition, renewable energy technologies contribute to energy security, create employment opportunities, encourage technological innovation, and support the transition toward a cleaner and more sustainable global energy system. As a result, increasing the use of renewable energy plays a crucial role in mitigating environmental problems and achieving long-term sustainable development goals.

2. Renewable Energy and Sustainable Development Goals (SDGs)

2.1 SDG 7: Affordable and Clean Energy

Renewable energy forms the backbone of SDG 7, which focuses on ensuring access to affordable, reliable, sustainable, and modern energy for all. Technologies such as solar photovoltaics, wind turbines, hydropower, and bio energy systems generate clean electricity while reducing dependence on fossil fuels. Decentralized solutions, including solar microgrids, have significantly improved energy access in remote and rural regions.

2.2 SDG 1: No Poverty

Reliable energy access plays a crucial role in poverty alleviation by supporting income-generating activities, particularly in rural areas. The renewable energy sector creates employment in installation, operation, maintenance, manufacturing, and research. Additionally, lower energy costs contribute to improved living standards for low-income households [2].

2.3 SDG 2: Zero Hunger

Renewable energy enhances agricultural productivity through applications such as solar-powered irrigation, cold storage, and food processing. These technologies help reduce post-harvest losses and increase farm efficiency. Bio-energy and biogas systems further support sustainable agriculture and effective waste management.

2.4 SDG 3: Good Health and Well-being

The shift from fossil fuels to clean energy sources reduces air pollution, a major contributor to respiratory and cardiovascular diseases. Clean cooking technologies, including biogas and solar cookers, minimize indoor air pollution, improving health outcomes, particularly for women and children in rural households.

2.5 SDG 6: Clean Water and Sanitation

Renewable energy enables the operation of water treatment plants, sewage treatment systems, and desalination facilities. Solar-powered water pumps and purification systems enhance access to safe drinking water and sanitation services, especially in water-scarce regions.

2.6 SDG 8: Decent Work and Economic Growth

The renewable energy industry is a significant driver of job creation and economic development. It fosters green entrepreneurship, encourages local manufacturing, and supports sustainable industrial growth, contributing to long-term economic resilience.

2.7 SDG 13: Climate Action

Renewable energy is a key strategy in mitigating climate change by reducing greenhouse gas emissions. Transitioning from fossil fuels to clean energy sources supports countries in achieving their climate commitments under international frameworks such as the Paris Agreement [3].

3. Three Pillars of Sustainable Development

- Economic Dimension: Renewable energy fosters economic growth through job creation and reduced energy costs.
- Social Dimension: Improved energy access enhances education, healthcare, and quality of life.
- Environmental Dimension: Renewable energy reduces greenhouse gas emissions and protects ecosystems.

4. Challenges in Renewable Energy Adoption

Despite its benefits, renewable energy faces several challenges:

- High initial investment costs
- Infrastructure limitations
- Intermittency of solar and wind energy
- Limited energy storage capacity
- Policy and regulatory barriers
- Lack of technical expertise

Addressing these challenges requires coordinated efforts through policy support, technological innovation, and investment.

6. Case Studies and Literature Review

Bhattacharya and Patel (2020) highlight financial and infrastructural challenges in India's renewable energy sector [2]. The study emphasizes the role of policy in transitioning away from fossil fuels to meet increasing energy demands sustainably. Smart grid technologies, as discussed by Cohen et al. (2021), improve integration of renewable energy through artificial intelligence and advanced monitoring systems [4]. Key technological components include smart meters, Internet of Things (IoT) devices, and advanced power electronic converters, which facilitate real-time monitoring and control of energy flows. Additionally, infrastructure advancements—such as energy storage systems, vehicle-to-grid (V2G) integration, and decentralized energy production—further enhance grid flexibility.

Wang et al. (2022) demonstrate that renewable energy contributes to economic growth while reducing environmental degradation [3]. The findings indicate that greater reliance on clean energy lowers carbon emissions compared to fossil fuels and supports sustained

economic development through investments in green technologies and a diversified energy mix. Additionally, the research highlights the contribution of renewable energy to several SDGs, particularly those related to environmental sustainability and economic efficiency, and emphasizes the importance of supportive policy measures to accelerate the transition toward sustainable energy systems.

Wei and Huang (2022) analyze the contribution of renewable energy to sustainable development in ten Asian countries over the period 1990–2020 using advanced panel estimation methods, particularly the CS-ARDL approach. Their findings further show that financial development enhances renewable energy adoption and sustainability outcomes [5]. By applying robust econometric techniques, including co-integration and slope heterogeneity tests, the research provides strong evidence that transitioning to renewable energy is critical for sustainable development in emerging Asian economies. In Ukraine, decentralized renewable energy systems have improved resilience despite infrastructure challenges [6]. Reports from the State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) show that the country aims to increase the share of renewables in electricity consumption to around 27% by 2030, compared to approximately 14.3% in 2022. Although many energy facilities were damaged or located in conflict-affected regions, Ukraine has continued to promote the expansion of solar, wind, biomass, and bio-gas as part of its strategy to strengthen energy security and reduce dependence on fossil fuels. The study conducted by Noor, Khan, and Khan (2024) explores the impact of both renewable and non-renewable energy sources on sustainable development across South Asia. It aims to determine whether a

shift toward cleaner energy sources can better support long-term economic growth, environmental sustainability, and social well-being compared to continued reliance on fossil fuels [7]. Germany's energy transition policy, known as *Energiewende*, focuses on replacing nuclear and fossil fuels

with renewable energy. It demonstrates how strong policy support can accelerate sustainable energy transformation.

The research by Mahalik and Pal (2024) examines the role of various energy sources in advancing sustainable development, while also exploring how globalization shapes this relationship. Achieving a balance between energy use and sustainability-focused policies is emphasized as crucial for long-term economic stability and environmental health. Globalization has been shown to enhance renewable energy adoption through investment and technology transfer, although it may also increase fossil fuel dependence if not managed properly [8]. Ligus and Peternek (2024) propose a Sustainable Energy Development Index to assess regional progress in renewable energy adoption. This index incorporates multiple dimensions, including renewable energy output, financial and policy support, investment levels, and environmental outcomes. The proposed index serves as a practical tool for policymakers to identify underperforming areas, distribute resources more efficiently, and encourage more balanced renewable energy growth [9].

The study by Hoekstra, Van Veenstra, and Bharosa (2023) investigates the key enablers and challenges associated with building GovTech ecosystems, drawing on case studies from the Netherlands and Lithuania. GovTech involves the application of digital innovation and collaboration among governments, startups,

private sector organizations, and public institutions to enhance the delivery of public services and governance [10].

6 . Findings and Conclusion

The reviewed studies confirm that renewable energy is essential for achieving sustainable development goals. It promotes economic growth, enhances energy security, and reduces environmental degradation. However, challenges such as financial constraints, infrastructure limitations, and policy inefficiencies must be addressed. Technological advancements, including smart grids and energy storage systems, are critical for improving renewable energy integration [4]. Strong governance, international collaboration, and investment are necessary to accelerate the global energy transition. In conclusion, renewable energy is a cornerstone of sustainable development. Expanding its adoption is essential for achieving a low-carbon, resilient, and inclusive future by 2030.

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