

# **The Role of Renewable Energy in Achieving Sustainable Energy Goals**

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**Abstract:** *The global energy transition is being driven by the urgency to address climate change, reduce energy poverty, and create a more sustainable energy system. Renewable energy, with its potential to provide affordable, clean, and abundant power, plays a central role in achieving these objectives. Renewable energy sources, such as solar, wind, hydropower, geothermal, and biomass, are integral to meeting the United Nations Sustainable Development Goal 7 (SDG 7), which calls for universal access to modern, reliable, and sustainable energy. This paper explores the current state of renewable energy, its technological advancements, and the challenges that need to be overcome for large-scale deployment, with a focus on how renewable energy can contribute to achieving global sustainability targets. The transition to renewable energy is pivotal in addressing climate change, promoting economic growth, and ensuring sustainable development. In 2024, renewable energy sources accounted for 92.5% of new electricity generation globally, with China contributing nearly 64% of this capacity, primarily through solar installations. Despite this progress, the global renewable energy capacity reached 4,448 GW, falling short of the 11.2 TW target set for 2030, indicating the need for accelerated efforts to meet sustainable energy goals.*

**Keywords:** Renewable Energy; Sustainable Development Goals (SDGs)

## **I. INTRODUCTION**

The global energy landscape is undergoing a profound transformation. Fossil fuels, which have been the primary source of energy for over a century, are increasingly seen as both unsustainable and harmful to the planet due to their role in driving climate change through the emission of greenhouse gases (GHGs). In response, renewable energy sources—solar, wind, hydropower, geothermal, and biomass—are increasingly seen as essential for achieving a sustainable energy future.

The imperative to transition from fossil fuels to renewable energy sources has never been more urgent. Renewable energy not only mitigates greenhouse gas emissions but also fosters economic development and energy security. The United Nations Sustainable Development Goal 7 (SDG 7) aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. Achieving this goal necessitates a substantial increase in renewable energy adoption.

The shift to renewable energy is central to this goal. According to the International Renewable Energy Agency (IRENA), renewable energy can provide up to 90% of the world's energy needs by 2050 if adequately scaled. Achieving this vision requires overcoming technical, financial, and policy challenges, while harnessing the benefits of renewables in areas such as climate change mitigation, economic development, and social inclusion.

This paper examines how renewable energy contributes to the achievement of SDG 7 and other broader sustainability goals, exploring the role of specific renewable energy technologies, policy frameworks, socio-economic impacts, and the barriers to scaling renewable energy globally.



## **II. RENEWABLE ENERGY TECHNOLOGIES: CURRENT STATUS AND TRENDS**

The main renewable energy technologies—solar, wind, hydroelectric, geothermal, and biomass—each offer distinct advantages and challenges. Together, they form the backbone of efforts to achieve a sustainable global energy system. Understanding the current state of these technologies is crucial to assessing their potential for meeting energy demands while reducing environmental impacts.

### **Solar Energy**

**Solar Photovoltaic (PV)** technology converts sunlight directly into electricity through semiconductor materials. Over the past decade, the cost of solar panels has decreased significantly, making solar energy one of the most cost-competitive renewable energy sources available. In 2023, solar power became the cheapest source of electricity in many parts of the world, including in countries like India, China, and the United States.

Solar energy offers significant potential due to its abundance and scalability:

- **Rooftop Solar Systems** can be installed on homes, businesses, and industrial buildings, providing decentralized energy production and reducing reliance on central grids.
- **Utility-Scale Solar Farms** generate large amounts of electricity for grid systems and can be deployed in deserts or other regions with high solar insolation.

### **Advancements:**

- **Solar Efficiency Improvements:** Innovations such as bifacial panels (which capture sunlight from both sides) and perovskite-based solar cells have the potential to further increase the efficiency and affordability of solar energy.
- **Solar Storage Solutions:** One of the challenges with solar energy is intermittency—solar power generation depends on sunlight. Advanced energy storage solutions, such as lithium-ion batteries and pumped storage hydro, are becoming more widely used to store excess energy generated during the day for use during nighttime or cloudy periods.

### **Challenges:**

- **Intermittency:** Solar energy generation is highly dependent on weather and time of day. While storage technologies are improving, large-scale, affordable energy storage systems are still under development.
- **Land Use:** Large-scale solar farms require significant land, which can be in competition with agriculture, conservation, and other land uses. Solutions like rooftop solar and floating solar farms are being explored to mitigate this issue.

### **Wind Energy**

Wind energy, both onshore and offshore, is one of the fastest-growing sources of renewable energy. Wind turbines convert the kinetic energy of the wind into electricity, and the technology has reached maturity in many parts of the world, offering competitive costs with fossil fuel generation.

- **Onshore Wind:** These turbines are installed in locations with high wind speeds and are widely deployed in countries like the United States, China, and Germany. Onshore wind is already one of the most cost-effective renewable energy sources.
- **Offshore Wind:** Offshore wind farms, which are located in bodies of water such as oceans or large lakes, have higher and more consistent wind speeds, offering the potential for larger-scale generation. Offshore wind is experiencing rapid growth, particularly in Europe, with countries like the UK and Denmark leading the way.



**Advancements:**

- **Floating Wind Farms:** Floating wind turbines, which are not anchored to the seabed, allow wind farms to be located in deeper waters where wind speeds are higher, enabling more widespread deployment.
- **Wind Turbine Efficiency:** New turbine designs and innovations in materials are increasing the efficiency and reducing the costs of wind energy, making it a competitive alternative to fossil fuels.

**Challenges:**

- **Intermittency:** Like solar energy, wind energy is variable and depends on weather conditions. Effective grid management and storage solutions are necessary to ensure a consistent supply of power.
- **Environmental and Social Impacts:** Wind turbines can have visual impacts on landscapes and may affect bird populations. Offshore wind farms can also have environmental implications on marine ecosystems.

**Hydroelectric Energy**

Hydropower is the most established form of renewable energy, contributing nearly 60% of the world's total renewable electricity generation. Hydropower plants generate electricity by harnessing the kinetic energy of flowing water. There are two primary types of hydroelectric power plants:

- **Large-Scale Dams:** These involve the construction of large reservoirs to store water, which is then released to drive turbines.
- **Run-of-River Systems:** These are smaller-scale hydroelectric systems that do not require large reservoirs and are often used in remote areas.

**Advantages:**

- **Baseload Power:** Hydropower can provide a steady, continuous source of energy, making it a reliable option for baseload generation.
- **Flood Control and Water Management:** Dams can provide additional benefits, including water storage for irrigation and flood control.

**Challenges:**

- **Environmental and Social Impacts:** Large hydroelectric dams can cause significant ecological damage by disrupting river ecosystems, blocking fish migration, and displacing communities. Small-scale hydro projects have fewer negative impacts but still pose challenges in terms of water management and environmental preservation.
- **Limited Sites:** Many of the most suitable locations for large hydroelectric plants have already been developed, limiting further growth in some regions.

**Geothermal and Biomass Energy**

- **Geothermal Energy** harnesses the Earth's internal heat from deep within the crust to generate electricity or provide direct heating. Geothermal power plants are particularly effective in regions with high volcanic activity, such as Iceland, Indonesia, and parts of the United States.
- **Biomass Energy** involves using organic materials (e.g., wood, agricultural waste, algae) to generate electricity or produce biofuels for transportation. Biomass is considered carbon-neutral because the CO<sub>2</sub> released during combustion is balanced by the CO<sub>2</sub> absorbed by the plants during their growth.

**Challenges:**

- **Geothermal:** Geothermal resources are geographically specific, which limits where this technology can be deployed. It also requires significant upfront investment for drilling and plant construction.



- **Biomass:** Biomass can contribute to deforestation if not sustainably sourced. Furthermore, the combustion of biomass may release particulate matter and other pollutants unless managed carefully.

### **III. CONTRIBUTION OF RENEWABLE ENERGY TO SUSTAINABLE DEVELOPMENT GOALS**

Renewable energy plays a crucial role in achieving India's Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action).

#### **Reducing Greenhouse Gas Emissions**

The expansion of renewable energy has significantly reduced greenhouse gas emissions, which are responsible for global warming and climate change. Replacing fossil fuels with renewable energy sources such as solar, wind, and hydropower can significantly lower carbon dioxide (CO<sub>2</sub>) emissions. As per the Intergovernmental Panel on Climate Change (IPCC), transitioning to 100% renewable energy by 2050 could prevent the emission of up to 70% of global CO<sub>2</sub> emissions from the energy sector. In 2024, renewable power capacity increased by 700 GW globally, with a substantial portion attributed to Asia, including India. This growth aligns with India's commitment to climate action and emission reduction targets.

#### **Promoting Energy Access and Equity**

Renewable energy has enhanced energy access, particularly in rural and remote areas. Initiatives like the 'PM Surya Ghar Muft Bijli Yojana' aim to install solar panels in households, providing up to 300 units of free electricity monthly, thereby improving energy equity. Access to affordable and reliable energy is crucial for economic development, healthcare, education, and overall well-being. In regions without reliable grid infrastructure, solar home systems and mini-grids powered by wind and solar offer a cost-effective and sustainable alternative, improving living standards and enabling economic development.

#### **Economic Growth and Job Creation**

The growth of the renewable energy sector also stimulates local economies, particularly in rural areas where large-scale solar farms or wind installations are often located. Additionally, renewable energy projects can attract investment and create long-term economic opportunities.

The renewable energy sector has become a significant source of employment and economic growth. In 2023, the sector generated over 1 million jobs, with hydropower being the largest employer. Projections indicate a need for 8.5 million jobs by 2050, highlighting the sector's potential to drive economic development.

#### **Enhancing Energy Security**

Renewable energy enhances energy security by reducing reliance on imported fossil fuels, which can be subject to price volatility and supply disruptions. Countries with abundant renewable resources—such as wind, solar, and geothermal energy—can become energy-independent, providing more stability to their economies.

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### **IV. CHALLENGES TO SCALING RENEWABLE ENERGY**

While the potential for renewable energy to drive global sustainability is clear, there are several challenges that must be addressed for its widespread adoption:

#### **4.1 Technological and Infrastructure Barriers**

The integration of renewable energy into existing energy systems requires significant investment in grid infrastructure, storage systems, and smart grid technologies to handle the intermittent nature of solar and wind energy. The development of reliable and scalable energy storage technologies, such as lithium-ion batteries, is critical to ensuring a stable supply of renewable energy.



#### **4.2 Political and Economic Factors**

Government policies are crucial in shaping the future of renewable energy. Countries with supportive policies, such as subsidies for clean energy projects, renewable energy targets, and carbon pricing, are more likely to successfully transition to renewable energy. In contrast, nations that continue to subsidize fossil fuels or lack clear renewable energy policies may hinder progress toward SDG 7.

#### **4.3 Financing and Investment**

Renewable energy projects require significant capital investment, which can be a barrier in developing countries with limited access to financing. International financial institutions, such as the World Bank and the Green Climate Fund, play a crucial role in funding renewable energy initiatives, but private sector investment is equally important for scaling renewable energy technologies.

### **V. CONCLUSION**

Renewable energy is central to achieving a sustainable energy future. It offers a pathway to reduce carbon emissions, expand energy access, stimulate economic growth, and enhance energy security. While the transition to renewable energy faces technological, political, and financial challenges, the potential benefits far outweigh these hurdles. With continued innovation, supportive policies, and strategic investments, renewable energy will play a key role in achieving the global sustainable energy goals set by the United Nations and securing a cleaner, more equitable future for all.

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