

Global Pathways to Climate Resilience: The Role of Green Energy in Combating Climate Change

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Abstract

Climate change has emerged as one of the most pressing global challenges, demanding urgent and coordinated action from governments, industries, and communities. Rising greenhouse gas emissions, deforestation, and unsustainable energy consumption have exacerbated global warming, resulting in severe environmental, economic, and social impacts. Transitioning toward green energy systems—such as solar, wind, hydro, and bioenergy—offers a viable pathway to mitigate climate risks. Climate change poses a profound threat to ecological stability, economic growth, and human welfare. Rising global temperatures, shifting weather patterns, and intensifying natural disasters have made the transition to sustainable energy systems a global imperative. Green energy—derived from renewable and low-carbon sources such as solar, wind, hydro, geothermal, and bioenergy—offers a viable solution to mitigate greenhouse gas emissions while promoting sustainable development. This study explores the interconnection between climate change and green energy adoption, analyzing the innovative technologies, economic, and policy frameworks that can accelerate the global shift toward cleaner green energy sources. Emphasis will be placed on integrating renewable energy into national grids, enhancing energy efficiency, and fostering international partnerships for climate resilience. By bringing together researchers, policymakers, and practitioners, the event seeks to identify actionable solutions that align with the goals of the Paris Agreement and contribute to a sustainable, low-carbon future. Through an examination of case studies, global trends, and emerging innovations, the study identifies critical challenges and opportunities in achieving a net-zero future. The findings underscore the need of coordinated policy frameworks, investment in clean technologies, and public awareness to drive a sustainable transformation of the global energy landscape.

Keywords: Climate Change, Greenhouse Gas, Green Energy, Climate Resilience, Paris Agreement

Introduction

Climate change is widely recognized as one of the defining challenges of the twenty-first century. Climate change represents a global systemic challenge driven primarily by human activities such as fossil fuel combustion, deforestation, and industrial emissions and anthropogenic emissions of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). Climate resilience emphasizes robustness, recovery, and adaptation of systems under environmental perturbation. In mathematical terms, resilience can be framed as the ability of a dynamical system to return to a stable state following a perturbation. Renewable-rich power grids can enhance resilience to climate or extreme weather events, for example via grid modernization and control systems. The Intergovernmental Panel on Climate Change (IPCC, 2023) estimates that global CO₂ emissions reached 36.8 gigatonnes (Gt) in 2023, resulting in an average global temperature increase of 1.2°C since pre-industrial times. The urgency of addressing climate change is universally acknowledged, as its impacts—including extreme weather events, rising sea levels, and shifting temperatures—become increasingly severe. The combustion of fossil fuels has dominated energy supply since the Industrial Revolution, leading to a significant accumulation of CO₂ in the atmosphere. In response, the global community has increasingly turned toward green energy solutions. Green energy encompasses renewable energy sources like solar, wind, and

geothermal that produce minimal environmental impact and contribute to carbon neutrality. The shift to renewable energy is not only essential for the environment but also represents a significant economic opportunity. It has the potential to create millions of jobs and promote sustainable industrial growth. Additionally, transitioning to renewable energy provides a viable pathway to mitigate the effects of climate change and build resilience against climate-related hazards. This paper examines the global shift toward green energy as a critical strategy for mitigating climate change, analysing key technologies, international policy initiatives, and future prospects for achieving a sustainable energy transition and its impact on emissions, exploring the economic and environmental benefits, and discussing the necessary strategies and policies to accelerate global pathways to climate resilience.

2.1 Climate Change and Energy Systems

The Intergovernmental Panel on Climate Change (IPCC, 2023) identifies fossil fuel combustion as the largest source of anthropogenic greenhouse gas emissions, accounting for more than 75% of total emissions. According to the IPCC's Sixth Assessment Report (AR6) Synthesis Report, human influence has been the primary driver of climate change, leading to increased global surface temperatures during the warmest decade. Major human activities contributing to this include the heightened emissions of greenhouse gases (GHGs) and deforestation. The climate system is experiencing consistent warming, along with changes in precipitation patterns, rising sea levels, and the loss of ice in glaciers, ice sheets, and permafrost. However, the impacts of climate change can vary significantly by region due to both natural variability and local factors. This leads to areas that are particularly at risk, such as regions prone to drought, changes in tropical cyclone activity, and shifts in monsoon patterns. Scholars such as Stern (2021) argue that limiting global warming to 1.5°C requires an unprecedented decline in fossil fuel dependency and a rapid expansion of renewable energy infrastructure. Olabi and Abdelkareem (2022) also discussed renewable energy and climate and suggested that renewable sources are the most affordable method for replacing fossil fuels, which are limited in resources and have severe environmental impacts. The widespread use of renewable energy sources is hindered by several regulatory policies, technical barriers, and economic barriers.

2.2 Global Energy Transition

The International Renewable Energy Agency (IRENA, 2024) reports that renewables accounted for nearly 30% of global electricity generation in 2023, led by significant growth in solar and wind energy. However, the transition remains uneven across regions due to disparities in policy support, investment capacity, and technological readiness. Research by Sovacool et al. (2022) highlights the importance of integrating renewable technologies with modern grid systems and energy storage solutions to ensure reliability and efficiency.

2.3 Green Energy Technologies

Key renewable energy technologies include:

Solar Power: Photovoltaic (PV) technology converts sunlight into electricity with declining costs, making it one of the most rapidly expanding energy sources globally.

Wind Energy: Both onshore and offshore wind farms contribute significantly to clean electricity generation, supported by advancements in turbine efficiency.

Hydropower: The oldest renewable energy source, hydropower provides stable base-load energy but poses ecological challenges related to river ecosystems.

Bioenergy and Geothermal: Offer sustainable alternatives for heating, transport fuels, and industrial applications, though scalability and cost remain concerns.

2.4 Policy Frameworks

Global efforts such as the **Paris Agreement (2015)** and **United Nations Sustainable Development Goal 7** (Affordable and Clean Energy) emphasize the transition toward low-carbon economies. Nationally Determined Contributions (NDCs) submitted by countries set emission reduction targets, often linked to renewable energy expansion. Studies by Burke & Stephens (2020) note that strong policy incentives—such as feed-in tariffs, tax credits, and carbon pricing are crucial for accelerating renewable deployment. There is also a strand of work focusing on quantitative resilience metrics in ecosystems or infrastructures, such as the “flow-kick” framework for repeated disturbances. However, fewer papers explicitly link renewable energy share, emissions reduction and resilience metrics in a unified analytical model.

3. Methodology:

This research adopts a qualitative analytical approach, synthesizing secondary data from scientific reports, policy documents, and international energy databases. The analysis focuses on identifying global trends, evaluating case studies from selected countries, and comparing policy and technological progress. Data sources include IRENA, the International Energy Agency (IEA), and the IPCC. The approach allows for an integrated assessment of environmental, economic, and policy dimensions of the green energy transition.

4. Analysis and Discussion:

4.1 Global Trends in Renewable Energy Adoption

Between 2010 and 2023, global renewable energy capacity grew by more than 300%, driven primarily by declining technology costs and increasing policy support. Solar photovoltaic costs have fallen by nearly 85%, and wind power by around 60% (IRENA, 2024). Countries such as China, the United States, Germany, and India have emerged as global leaders in renewable energy deployment.

Despite progress, fossil fuels still account for about 60% of global electricity generation. Energy transitions are constrained by factors including infrastructure limitations, intermittent energy supply, and investment gaps in developing economies.

4.2 Case Study 1: India’s Renewable Energy Expansion

India provides an important example of large-scale renewable energy adoption. Through the **National Solar Mission**, India has become one of the top solar energy producers globally, achieving over 70 GW of solar capacity by 2024. The government’s target to reach 500 GW of renewable capacity by 2030 reflects its commitment to decarbonization. However, challenges such as land availability, grid stability, and financing remain significant barriers.

4.3 Case Study 2: European Union’s Green Deal

The **European Green Deal** aims to make Europe the world’s first climate-neutral continent by 2050. Policies under this framework include emissions trading reforms, renewable energy directives, and green hydrogen development. The EU’s comprehensive approach—combining economic stimulus with climate goals—demonstrates how policy integration can drive large-scale transformation.

4.4 Technological Innovations

Emerging technologies such as **energy storage systems**, **smart grids**, and **green hydrogen** are pivotal for achieving carbon neutrality. Battery storage allows renewable power to be used during non-generating hours, enhancing system reliability. Meanwhile, green hydrogen, produced using renewable electricity, offers potential for decarbonizing heavy industries and transportation sectors that are difficult to electrify.

4.5 Economic and Social Implications

The transition to green energy has profound socio-economic implications. According to the ILO (2023), renewable energy industries could create over 24 million new jobs by 2030. However, the shift away from fossil fuels also necessitates careful management of workforce transitions, regional inequalities, and energy affordability. Social acceptance, public awareness, and equitable policy design are essential to ensure a just transition.

5. Challenges and Barriers:

Despite global progress, several barriers persist:

Financial Constraints: Developing nations face limited access to green finance and high initial investment costs.

Policy Uncertainty: Inconsistent regulatory frameworks can deter investors and slow project implementation.

Technological Gaps: Limited research capacity and infrastructure can hinder local innovation.

Energy Storage and Grid Integration: Managing intermittent renewable energy remains a technical challenge.

Global Inequality: The divide between high-income and low-income countries in technology access and adaptation capacity continues to widen.

6. Future Prospects/Policy Recommendations/Policy Implications:

6.1 Future Prospects

Looking ahead, the path to climate neutrality will require:

Accelerated Renewable Deployment – Expanding solar and wind energy to meet 70–80% of global electricity demand by 2050.

Green Hydrogen Development – Scaling production for industrial and transport sectors.

Carbon Capture and Storage (CCS) – Complementing renewables for hard-to-abate emissions.

International Cooperation – Strengthening technology transfer and climate finance mechanisms.

Public Engagement and Education – Encouraging behavioral change and community participation in sustainable energy adoption.

6.2 Policy Recommendations

To accelerate the transition to climate resilience, the following policy actions are recommended:

Triple Global Renewable Capacity: Implement policies to achieve the global goal of tripling renewable energy capacity by 2030.

Phase Out Fossil Fuel Subsidies: Redirect financial support from fossil fuels to green energy infrastructure and research.

Implement Carbon Pricing: Establish effective carbon pricing mechanisms to internalize the environmental costs of emissions.

Strengthen International Cooperation: Enhance global collaboration to support vulnerable nations in developing resilient, clean energy systems.

6.3 Policy Implications

From the above analysis, we derive several policy implications:

Set explicit resilience targets: Countries and regions should define resilience indices.

Prioritise early action: The largest marginal benefits come from early increases in renewable share. Delay increases cost more (both in investment and in climate damage).

Invest in grid and storage alongside renewables: Deploying green energy alone is not sufficient; system flexibility, storage, grid resilience amplify benefits.

Promote equity and justice: As renewable systems grow, ensure that the benefits (resilience, energy access) are equitably distributed; neglecting social dimensions undermines resilience.

Mobilise finance: International climate finance should prioritise renewable deployment in vulnerable regions, recognising the dual benefits of mitigation + resilience.

Strengthen modelling capacity: National and regional authorities should invest in advanced modelling (uncertainty, storage, grid dynamics) to support informed decision-making, reflecting modelling challenges in the literature.

Monitor and adjust: Because of uncertainty (technological, climatic, economic), policies should include monitoring, feedback and adaptive governance to shift trajectories if needed.

7. Conclusion:

Climate change demands immediate and collective action. The transition to green energy represents both a necessity and an opportunity to redefine global development in sustainable terms. While technological innovations and falling costs have made renewables increasingly competitive, achieving a low-carbon future requires political will, financial commitment, and societal transformation. Coordinated international efforts rooted in science, equity and innovation will be essential to safeguard the planet for future generations.

The results underscore that renewable energy is a vital lever for climate resilience but that complementary measures (grid, storage, policy, equity) are required for maximal effect. Global pathways should aim for rapid renewable scale-up in the near term, supported by investment in modernization and international cooperation. Future research should refine the model dynamics, incorporate temporal transition models, account for uncertainty and behaviour, and calibrate parameters using empirical data across regions. Researchers have proposed a conceptual mathematical framework linking green energy share, emissions reduction and resilience of energy systems to climate change. While stylised, the model makes explicit the trade-offs and diminishing returns inherent in renewable deployment and shows how resilience targets can inform renewable share targets.

The role of green energy in combating climate change and fostering global climate resilience is not merely significant; it is essential. Quantitative data confirms its growing dominance in the energy sector, its economic viability, and its substantial impact on reducing global carbon emissions. By transitioning to a green energy-based global economy, we can mitigate the worst impacts of climate change and build sustainable, resilient systems capable of coping with future climate challenges. The pathways are clear, the technology is available and affordable, so the time to act is now.

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