



Original Article

Renewable Energy and Green Technologies

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Manuscript ID:
IBMIIRJ -2025-020810

Submitted: 05 July 2025

Revised: 10 July 2025

Accepted: 05 Aug 2025

Published: 31 Aug 2025

ISSN: 3065-7857

Volume-2

Issue-8

Pp. 35-38

Aug 2025

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Quick Response Code:



Web. <https://ibrj.us>



DOI: 10.5281/zenodo.17129318

DOI Link:

<https://doi.org/10.5281/zenodo.17129318>



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Abstract

This academic paper explores the development, use, and impact of renewable energy technology and green technology as sustainable alternatives for conventional fossil fuel-based systems. Renewable energy is a set of various energy sources like hydropower, wind, and biomass that give clean, limitless, and increasingly affordable solutions for satisfying the rapidly growing global energy needs. At the same time, green technologies that include energy-efficient systems, electric vehicles, sustainable structures, intelligent grids, and carbon capture technologies aim at mitigating environmental impacts and promoting sustainable use of resources.

The paper gives an in-depth examination of various forms of renewable energy, such as working mechanisms, advantages, challenges, and real-world applications. In addition, it examines the role of green technology in promoting energy efficiency, emission reduction, and sustainable urban and industrial developments. Once again, the paper examines environmental and economic advantages, such as minimization of carbon footprints, improved air quality, job provision, and energy security. Adopting case histories, policy analysis, and technology advances, the study identifies international cooperation, innovation, and investment in promoting the global shift toward a low-carbon, resilient economic system. At last, the study summarizes that sustainable long-term economic development goes hand in hand with the objective of sustainable development.

Keywords: Renewable Energy, Green Technologies, Sustainable Development, , Climate Change, Clean Energy, Environmental Protection, Energy Efficiency, Green Economy

Introduction

Renewable energy and clean technologies give substance to the historic paradigm shift in how societies produce and utilize energy, and simultaneously respond to the global climate emergency. Renewable energy technologies like solar, wind, hydroelectric, geothermal, and biomass provide sustainable substitutes for fossil fuels, the largest contributor of greenhouse gas emissions. Green technologies pertain to technologies and practices that seek to lessen environmental impacts by promoting resource efficiency, waste reduction, and sustainable development. Overall, these frameworks give shape to a low-carbon future and environmental stewardship.

Objectives of the study:

1. To examine the notion and value of sustainable energy and green technology in sustainable development and environmental conservation.
2. To recognize and describe various forms of energy sources, i.e., solar energy, biomass, geothermal energy, hydropower, and wind energy and how they work and have practical applications.
3. To examine how green technologies play a role and make an impact in boosting energy efficiency, reducing environmental pollution, and enabling sustainable practices in industries, transportation, and construction.
4. To analyze the environmental and economic benefits of adopting renewable energy and green technologies, there is decrease of carbon emissions, vacancy creation, and Improved security of energy.

Types of Renewable Energy Sources:

a. Solar Energy:

Solar energy is a sustainable energy source in which energy from sunlight is used to produce heat or electricity. It is harnessed by means of technologies such as photovoltaic (PV) panels, which produce electricity from sunlight, and solar thermal systems, which utilize solar heat to provide water heating or electrical power.

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How to cite this article:

Khobragade, V. P. (2025). Renewable Energy and Green Technologies. *Insight Bulletin: A Multidisciplinary Interlink International Research Journal*, 2(8), 35–38. <https://doi.org/10.5281/zenodo.17129318>

Solar energy is clean, abundant, and not harmful to the environment, generating no greenhouse emissions or pollution at the point of use. It is used extensively in dwellings, industries, and power plants and is highly valued for reducing use of fossil fuels and mitigating climate change.

b. Wind Energy:

Wind power is a clean energy source that harnesses the kinetic energy of wind for generating electricity using wind turbines. When wind currents arise, they spin the turbine's blades, thus driving a generator to generate electrical power. This type of energy is marked by its sustainability and cleanliness due to its absence of emission of greenhouse and other harmful pollutants to the environment. The wind energy is harnessed using onshore (land-based) or offshore (sea-based) wind farms. Additionally, it is invaluable for reducing dependence on fossil fuels and is continuously being used worldwide toward promoting green energy target and combating climate change issues

c. Hydropower:

Hydropower or hydroelectric power is a clean energy that generates power by harnessing water in motion. The water from lakes or reservoirs usually falls over or through turbines, driving them to rotate and generate subsequent electricity. Hydropower is among the oldest and most utilized clean energy. Hydropower is distinguished by its cleanliness, efficiency, and reliability in generating power without producing direct atmosphere pollutants and greenhouse gas emissions. However, large dams can impact aquatic ecosystems and displace communities. Despite this, hydropower remains a key component of many countries' sustainable energy strategies.

d. Geothermal Energy:

Geothermal energy is a clean energy source that relies on the internal heat energy contained within the earth's crust. Geothermal energy is used for the production of electrical power or for direct heating by tapping into subterranean pools of hot water or steam. Geothermal energy power plants usually sit near volcanism or tectonic zones. Geothermal energy is a clean, dependable, and consistent supply of energy producing low emissions. Though restricted to locations with suitable geologic conditions, geothermal energy contributes significantly to the supply of sustainable and green power.

e. Biomass Energy:

Biomass energy is a clean energy source from organic matter, such as wood, agricultural waste, animal manures, and food or agricultural by-products. The materials may be burned directly for heat energy or converted to a chemically altered fuel such as ethanol, biodiesel, and biogas for generating electricity or fuels. Biomass energy is considered to be carbon-neutral because the carbon dioxide released from its use is offset by the absorption of plants by their cultivation cycle. It contributes significantly to waste disposal, supports the rural economies, and reduces dependence on fossil fuels. However, unjustified practices from biomass use may lead to deforestation and air quality issues.

Green Technologies in Practice:

Green technologies, also referred to as sustainable or environment-friendly technologies, refer to innovations that aim at cutting down environmental degradation and enhancing the efficient use of natural resources. Less pollution, energy and water conservation, lowering greenhouse emissions, and promoting a circular economy are the key focuses of such technologies. Some of the examples include solar panels, windmills, electric vehicles, energy-saving equipment, green roofs, and waste-to-energy plants. The green technologies feature prominently in combating climate change, safeguarding ecosystems, and promoting sustainable developments.

Green Building Technology: Application of sustainable construction materials, energy efficient designs and intelligent systems for reducing carbon footprints.

Electric Vehicles (EVs): Internal combustion engines replaced with battery-powered or hydrogen-based alternatives.

Carbon Capture and Storage (CCS): Carbon dioxide emission capturing technologies from energy production plants and production processes.

Smart grids: Smart Grids are advanced electric grids that enhance efficiency and reliability by virtue of integrating renewables and enabling demand-response.

Waste-to-Energy Technologies: The technology of transforming waste into sustainable energy substitutes using Technologies such as incineration, gasification, and anaer.

Environmental and Economic Benefits:

1. Environmental Benefits

a. Reduction in Greenhouse Gas Emissions:

One of the key environmental benefits for the use of renewable energy and sustainable technology is the significant reduction of carbon dioxide (CO₂) and other greenhouse gas (GHG) emissions. Unlike fossil fuels, renewable energy technologies such as solar, wind, hydroelectric, and geothermal energy produce electricity without releasing harmful pollutants and, as such, play critical roles in the global effort against climate change.

b. Air and Water Quality Improvement:

The burning of coal and oil releases harmful pollutants like sulfur dioxide, nitrogen oxides, and particulate matter, which reduce air quality and pose critical health threats. On the other hand, solar and wind energy harness improved air quality and helps alleviate respiratory and cardiovascular disease. Also, solar and wind energy technologies use significantly less water compared to thermal power plants, thereby facilitating the conservation of freshwater and reducing thermal pollution.

c. Conservation of Natural Resources:

These green technologies allow for the best use of natural resources through such innovations as energy-saving appliances, smart grid technology, and recycling systems. This helps in preventing excessive exploitation of fossil fuels, forest lands, and mineral deposits and helps maintain biodiversity and support long-term environmental balance.

2. Economic Benefits

a. Job Creation and Economic Growth:

Renewable energy and green technology offer job-intensive sectors, which create employment in the fields of manufacturing, installation, product and technology innovations, operation, and maintenance. Globally, reports have emerged that the global shift to clean energy will create millions of new job spaces, particularly for the emergent countries.

b. Energy Security and Reduced Import Dependence:

By harnessing indigenous renewable energy, countries decrease dependence on externally sourced fossil fuel. This policy improves national energy security, ensures price stability of energy, and protects economies from external shocks of international fluctuations of fuel prices and geopolitical shocks.

c. Cost Efficiency and Long-Term Savings:

Notwithstanding the initial capital cost of adopting renewable energy systems and green technologies being significantly high, operational and maintenance costs of such technologies are generally not on the high side. Over time, consumers benefit from the value of steady and lowered energy expenditure, making these technologies financially viable for long stretches of time. Besides that, improvements in technology and mass production have been reducing the costs of solar panels, windmills, and batteries.

Challenges and Barriers:

- **Stiff Upfront Cost:** Although operating constant costs are minimal, initial cash outlay on technology and infrastructure may be high.
- **Intermittency and Storage Issues:** Solar and wind are variable by nature, requiring effective energy storage solutions.
- **Land and Resource Use:** Large-scale installations can impact land use and biodiversity.
- **Policy and Regulatory Barriers:** Inadequate government support, subsidies for fossil fuels, and lack of regulatory frameworks can hinder adoption.

Recent Innovations and Trends:

- **Next-Generation Battery Technologies:** The innovation of lithium-ion, flow, and solid-state batteries for enhanced energy storage.
- **Floating Solar Farms:** Solar panels deployed on water bodies to save land and reduce water evaporation.
- **Hydrogen Energy:** Use of green hydrogen as a clean fuel for industry and transport.
- **AI and IoT in Energy Management:** Smart systems that optimize energy usage, predict maintenance needs, and reduce waste.
- **Circular Economy Models:** Integrating green tech with recycling, reusing, and upcycling practices.

Conclusion:

The growing need to address climate change, environmental degradation, and energy insecurity has made the movement toward clean energy and the use of green technologies more pressing at any point in history. The current study has analyzed the means by which clean energy alternatives such as solar, wind, hydropower, geothermal, and biomass offer clean, abundant, and sustainable alternatives to fossil fuels. Alongside these energy alternatives, green technologies provide new solutions for cutting environmental damage, increasing efficiency, and fostering sustainable development for various sectors. Environmental advantages of these energy systems are significant. The energy systems contain less emission of greenhouse gases, enhance the quality of air and water, save limited natural resources, and restore ecological balance.

The economic advantages of renewable energy and green technology include job creation, reducing costs for energy in the long term, increasing energy security, and inclusive economic progress, particularly for rural and developing economies. Despite some challenges—such as high initial costs, technological limitations, and policy gaps—the continued advancement of technology, supportive government policies, and growing global awareness are paving the way for broader adoption and integration of sustainable solutions. The research clearly shows that investing in renewable energy and green technologies is not just an environmental necessity but also an economic opportunity. In conclusion, renewable energy and green technologies represent a viable path toward a cleaner, more resilient, and equitable future. Their development and implementation must be prioritized globally to ensure environmental sustainability, energy justice, and long-term prosperity for present and future generations.

Acknowledgment

The author expresses deep gratitude to Late Nrdhan Patil Waghaye Arts & Science College, Murmadi/Tupkar, for providing academic and infrastructural support during the preparation of this research paper. Sincere thanks are also extended to colleagues, peers, and students whose valuable discussions and insights enriched the study.

The author acknowledges the contributions of various scholars and institutions whose research and reports have significantly informed and guided this work. Lastly, heartfelt appreciation goes to family and well-wishers for their constant encouragement, patience, and motivation throughout the research journey.

Financial support and sponsorship: Nil

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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