

# Review of Sustainable Development through Renewable Energy: A Comprehensive Analysis

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## Abstract:

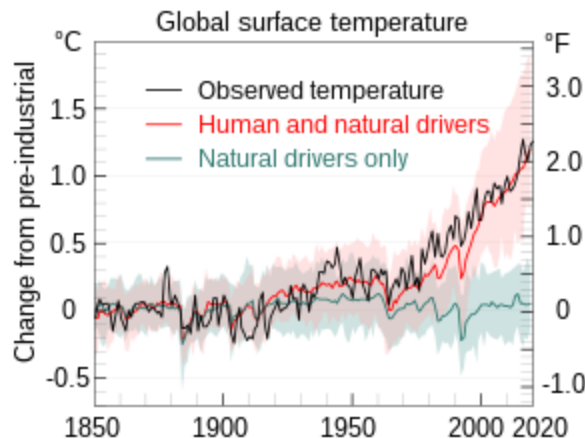
This study delves into the multifaceted realm of renewable energy, examining its pivotal role in achieving sustainable development. With a focus on technological advancements, policy implications, and socioeconomic impacts, the research aims to provide a holistic understanding of how renewable energy can drive global sustainability efforts. By shedding light on its environmental benefits, economic potential, and contributions to energy equity, this comprehensive outlook underscores the transformative power of renewable energy in shaping a more sustainable future for our planet and its inhabitants.

**Keywords:** Renewable energy, Sustainable development, Socio-economic impacts, Environmental implications, Policy implications, Sustainable Development Goals (SDGs), Energy security, Job creation, Climate change mitigation, Economic growth.

## I INTRODUCTION:

### Background & history:

India has long embraced renewable energy in its energy planning since the 1970s via MNRE (Ministry of New & Renewable Energy) programs. The contemporary world faces climate change and fossil fuel-related crises, highlighting the urgency of transitioning to renewables. Renewable energy, including solar and wind power, is growing globally, offering economic opportunities and addressing energy poverty.



Graph 1.1 - Change in average surface air temperature since the Industrial Revolution, plus drivers for that change. Human activity has caused increased temperatures

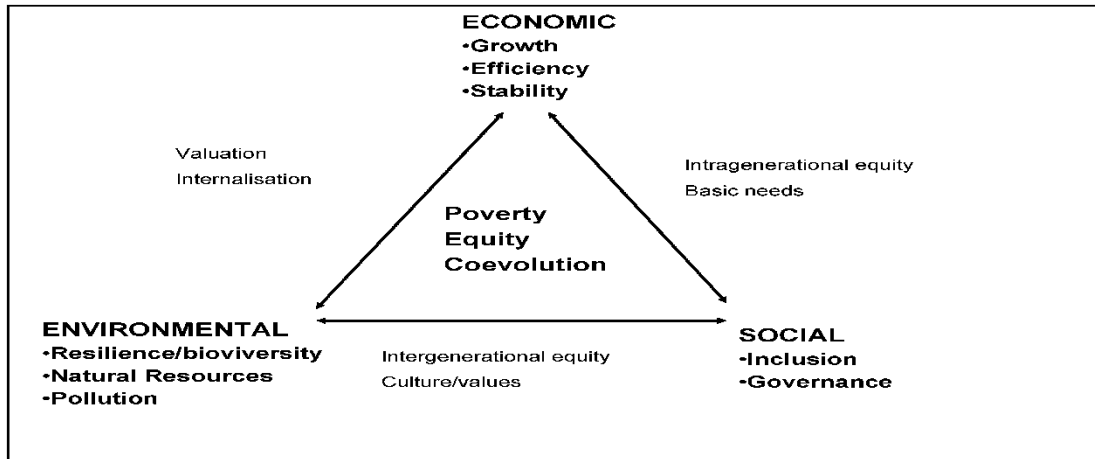
### **1.1 Sustainable Development: understanding its Vital Significance:**

Renewable energy is vital for sustainable development, addressing climate change, and improving air and water quality. It fosters resource conservation, enhances energy security, and spurs economic growth through job creation. Additionally, renewables promote access to electricity in remote areas, stimulate technological innovation, and reduce environmental degradation, aligning with intergenerational equity principles.

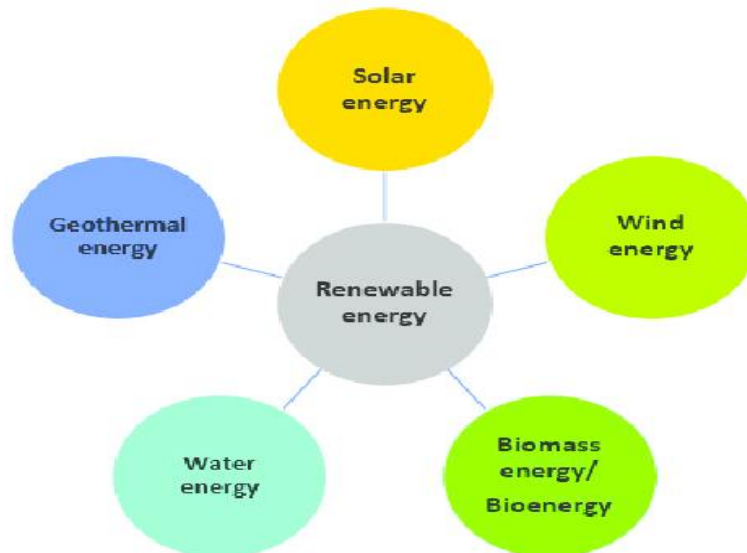
### **1.2 Sustainable Development Goals & Renewable Energy:**

The Sustainable Development Goals (SDGs) were established by the United Nations in September 2015 as part of the 2030 Agenda for Sustainable Development. This global initiative comprises 17 SDGs and 169 targets, addressing a wide range of global challenges such as poverty, inequality, climate change, environmental degradation, and peace. The development of these goals involved extensive international negotiations and consultations among governments, civil society organizations, businesses, and various stakeholders. The United Nations played a central role in facilitating these discussions and reaching a consensus on the goals and targets. Each of the 17 SDGs serves as a critical component of a shared global framework designed to tackle pressing global issues and guide collective efforts toward creating a more sustainable and equitable world by the year 2030. While member states of the United Nations bear the responsibility for implementing and monitoring progress toward these goals within their own countries, a diverse array of international organizations, non-governmental organizations (NGOs), and other actors work collaboratively to support and advance the SDGs on a global scale. The SDGs encompass a wide spectrum of objectives, including eradicating poverty, ensuring access to clean water and sanitation, promoting gender equality, addressing climate change, and fostering peace and justice. This comprehensive framework provides a roadmap for governments, organizations, and individuals to work together in pursuit of a better future for all, grounded in sustainability and inclusivity

**Renewable energy plays a pivotal role in achieving sustainable development goals:** - Renewable energy is a key driver of sustainable development goals (SDGs). It addresses environmental sustainability by reducing greenhouse gas emissions and supporting cleaner air and water (SDGs 13 and 14). It promotes economic growth and job creation (SDG 8) while improving energy access, thereby alleviating poverty, enhancing healthcare, and education (SDGs 1, 3, and 4). Renewable energy also reduces inequality (SDG 10) by providing affordable energy to marginalized communities and enhances energy security (SDG 7) by diversifying energy sources. Overall, renewable energy contributes significantly to achieving multiple SDGs.



### 1.4 Renewable Energy Sources



**II Scope of Work:** - The scope of work in sustainable development through renewable energy is expansive and dynamic, offering a multitude of avenues to address pressing Socio-economical & environmental challenges. At its core, this field aims to transition society towards cleaner and more sustainable energy sources while fostering economic growth. Key areas of focus include the development and optimization of renewable technologies, such as advanced solar panels and wind turbines etc.

### III Literature Review :

The study by Mirjanić and Pavlovic (2019) emphasizes the importance of educating communities on solar energy installation to promote renewable energy adoption, which fosters environmental awareness and reduces reliance on imports, leading to a cleaner and more sustainable society by mitigating harmful emissions from fossil fuels.

Sathaye and Rahman (2016) highlight that renewable energy technologies use non-depletable resources but face challenges like intermittency and variability. An approach is to classify small hydropower as renewable, receiving government support, while excluding large hydropower from incentives to address this controversy.

Patel and Parkins (2023) investigated municipal renewable energy development using a province-wide survey of 101 decision-makers, applying a framework combining the theory of planned behavior and transition theory. Their study identifies motivations and challenges specific to renewable energy projects within municipalities, shedding light on this understudied aspect of community energy.

Jensen and Thomsen (2020) address the challenge of handling massive time series data generated by modern renewable energy installations. They propose a next-generation time series management system capable of efficiently managing extensive data across edge, cloud, and client platforms, aiming to improve data handling for practitioners in the field.

**IV Research Gaps:** - Research in renewable energy faces several key challenges and research gaps: Intermittency and Reliability: Addressing the intermittency of renewable sources and ensuring reliable energy supply through energy storage and grid integration. Environmental Impact Assessment: Conducting thorough assessments to minimize adverse environmental effects, particularly in ecologically sensitive areas. Economic Viability: Research on reducing costs, enhancing efficiency, and improving financing options to make renewable energy economically competitive. Social Acceptance and Equity: Strategies for engaging communities and addressing concerns to enhance the social acceptance of renewable energy projects. Energy Storage, Integration, and Global Accessibility: Developing scalable energy storage solutions, optimizing grid infrastructure, and addressing global disparities in renewable energy access, particularly in developing nations.

**IV Aims & Objectives of the Study:** -

- To Examine the Long-Term Environmental Impacts of incorporating Renewable Energy.
- To Examine the Long-Term Socio-Economic Effects
- To Develop an Inclusive Sustainability Framework

**V Methodology of Study:** - This project combines literature review, government data analysis, and engineering expertise to enhance understanding of sustainable development through renewable energy. Its goal is to encourage socio-economic and environmental adoption of renewables, addressing the rising energy demand, reducing pollution, and promoting sustainability for future analyses.

**5.1 Analyzing the Projection of Global Primary Energy Source:-**

A global shift to sustainable energy sources is essential to limit global temperature increases below 2 degrees Celsius, as energy-related carbon emissions constitute a significant portion of greenhouse gases. The transition is driven by technological innovation, notably in renewables like solar and wind power, with a quarter of global electricity now coming from renewables. However, the transition is not progressing fast enough, as CO<sub>2</sub> emissions saw a 1.4% increase in 2022. Accurate predictions about the timing and extent of energy transitions are challenging, but historical examples show they typically take decades. Successful transitions hinge on well-designed government policies, as seen in Brazil's Proalcool program, Germany's Energiewende, and Denmark's climate objectives. Many countries, including the EU, India, and the United States, are raising renewable energy targets, while China leads the way with ambitious renewable and carbon reduction goals. Other nations like Russia and Turkey are also investing in renewables, emphasizing the global importance of the energy transition.

5.2 Employment opportunities for citizens in Renewable Energy in India: Renewable energy in India

Region	Consumption (million tones oil equivalent)											Change (percentage per annum)	
	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040	1990–2016	2016–2040
United States	1966	2119	2310	2349	2284	2273	2334	2344	2341	2325	2299	0.6%	0.0%
Brazil	126	158	188	211	268	298	330	378	419	451	477	3.4%	2.0%
EU	1672	1661	1732	1819	1754	1642	1667	1623	1570	1513	1460	-0.1%	-0.5%
Russia	865	662	620	647	673	674	711	720	723	722	716	-1.0%	0.3%
Middle East	264	351	423	565	734	895	980	1085	1189	1287	1382	4.8%	1.8%
Africa	222	244	274	327	389	440	509	603	710	840	1002	2.7%	3.5%
China	683	889	1008	1800	2491	3053	3387	3753	4017	4207	4319	5.9%	1.5%
India	195	251	316	394	537	724	880	1118	1365	1624	1921	5.2%	4.2%

has become a vital source of employment, offering a diverse range of jobs, but regional disparities persist. These jobs have positive socio-economic impacts but face challenges related to quality, stability, and gender diversity. The sector's growth is also influenced by policy and regulatory barriers. Innovations and international comparisons play a significant role in shaping India's renewable energy employment landscape.

**5.3 Socio-economic implications, Environmental implications:-**

**Job Creation:** Renewable energy sector provides significant employment opportunities, particularly in rural areas, surpassing fossil fuel industries.

**Local Economic Development:** It boosts regional economies through local suppliers, taxes, and revenue for infrastructure.

**Energy Access and Security:** Renewable energy expands access to clean electricity, enhancing energy security and quality of life.

**Health and Environment:** It reduces air pollution, healthcare costs, and water consumption, benefiting public health.

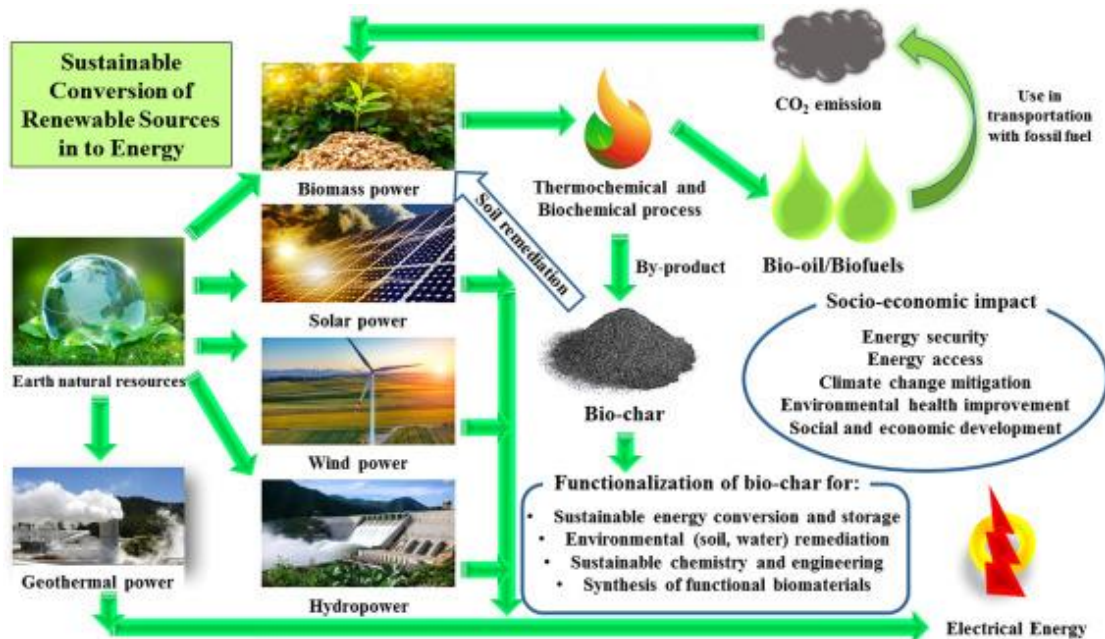
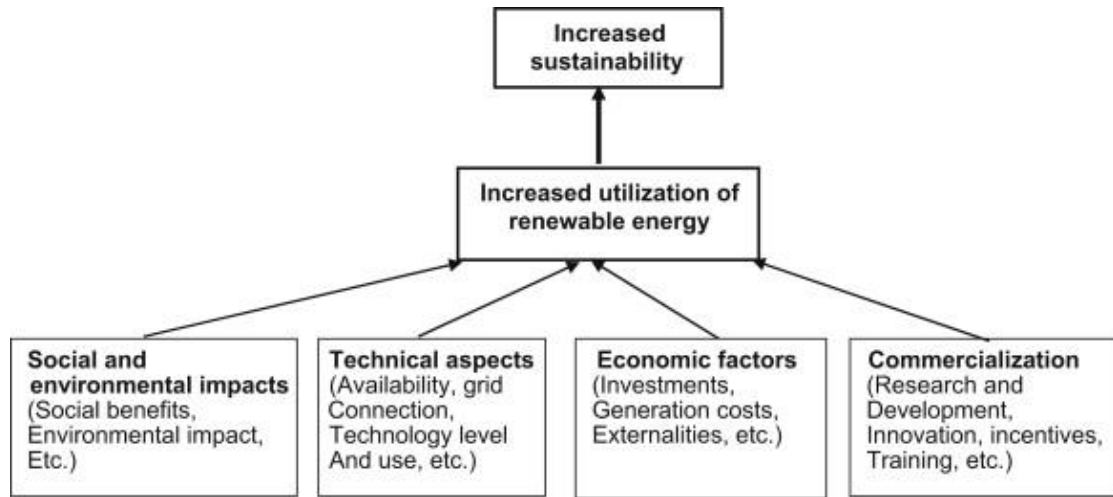
**Climate Change Mitigation:** Renewable energy reduces greenhouse gas emissions, aiding in climate change mitigation.

**Biodiversity and Ecosystem Preservation:** Proper planning can minimize harm to wildlife and habitats.

**Water Resource Management:** Renewable sources consume less water, easing water scarcity issues.

**Waste Management:** Renewable technologies produce minimal waste and are recyclable.

Challenges include land-use conflicts, intermittency, upfront costs, and the need for supportive policies and infrastructure. Collaboration among stakeholders is vital for a sustainable renewable energy transition.



**VI DISSCUSSIONS:** - In India's pursuit of sustainable development through renewable energy, critical policy and regulatory actions are needed. The Ministry of New and Renewable Energy (MNRE) should collaborate with State Electricity Regulatory Commissions (SERCs) to develop a cohesive strategy for sustainable renewable energy promotion, ensuring timely execution. Enforcing a "Must Run" policy at both central and state levels is essential to seamlessly integrate renewables into the national grid, reducing power costs and supporting sustainable economic growth. Granting SERCs authority to address regulatory uncertainties and expedite project approvals while emphasizing clear minimum performance standards is vital. Furthermore, establishing an efficient Renewable Energy Certificates (REC) policy and enhancing REC market development, along with improving Renewable Purchase Obligation (RPO) compliance through balanced regulatory mechanisms, will contribute to fostering sustainable renewable energy practices and employment opportunities.

**VI RECOMMENDATIONS:** - To promote sustainable development through renewable energy in India, addressing compliance issues and adhering to Renewable Purchase Obligation (RPO) targets is vital. Proactive measures should tackle DISCOM financial challenges, ensure must-run status for renewables, and resolve transmission constraints while guaranteeing timely payments to maintain project sustainability. Incentives should encourage utilities to surpass RPO mandates, tariff orders should ensure consistency, and transmission infrastructure development should align with sustainable power generation. Financial support and budget allocation, along with resolving Goods and Services Tax (GST) issues, are needed to secure financing for clean energy projects. Domestic manufacturing and R&D in sustainable technology should be promoted to reduce import dependency and foster sustainability. Awareness programs and educational institutions should spread knowledge about sustainable energy, while ongoing training and upskilling initiatives are crucial to address the skills gap in the renewable energy workforce. Prioritizing hybrid power projects and enforcing standards can optimize land use and ensure sustainable energy systems.

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10. World Resources Institute (WRI): WRI often publishes research on energy and climate issues, including renewable energy's role in addressing global challenges.
11. National Institute of Wind Energy (NIWE): NIWE is an autonomous research and development institution under the Ministry of New and Renewable Energy, focusing on wind energy research and development in India.

12. Solar Energy Corporation of India (SECI): SECI is a government company responsible for the promotion and development of solar energy in India. They often publish reports and updates on solar energy projects and initiatives.
13. Renewable Energy Policy Network for the 21st Century (REN21): REN21 provides global reports on the status and trends of renewable energy, which can include insights into India's progress.
14. Energy Transition Commission (ETC): ETC offers insights and recommendations on transitioning to a low-carbon energy system. Their reports may include information relevant to India's renewable energy goals.
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