

Sustainable energy for future needs: An imperative for a greener tomorrow

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Abstract

According to Worldometer, around 8.1 billion inhabitants survive on mother earth, and earth provides the most essential resources like oxygen and water for survival. However, humanity has taken advantage of available resources on earth and has started exploring them with the available technology and machinery. As a result, the rapid consumption of exhaustible energy sources like fossil fuels, the purposeful clearing of forested lands, water pollution, industrialization, and waste disposal into the environment are increasing faster. Due to these activities, the earth's ecosystem is in great danger and requires an immediate remedy to safeguard it. Therefore, relying on renewable energy sources and promoting sustainable energy for future needs is one of the possible solutions to prevent environmental damage.

Keywords: Climate change; Renewable energy; Energy policy

1. Population Vs. Availability

The world's current population is around 8.1 billion and is estimated to reach 9 billion by 2037 and 10 billion by 2058 [1]. With this increase in population growth globally, a question will arise: Do we have the resources to survive and lead a healthy and comfortable life on this planet? In addition, out of 29.2% of the Earth's surface (i.e., land), only 12.56% is suitable for human living, and the rest will be covered with deserts, mountains, and other unsuitable areas. In contrast, in the current scenario, industrialization, global environmental pollution, such as air pollution, biodiversity loss, climate change, deforestation, food waste, noise pollution, ocean acidification, ozone depletion, plastic pollution, water pollution, and water shortage, is increasing gradually [2]. Due to these impacts, the survival of humans has become more challenging. However, different preventive steps, also called global initiatives [3], as shown in Table 1, have been implemented by various nations to safeguard the earth's ecosystem, and some of them are the Paris Agreement, United Nations Sustainable Development Goals (UN-SDGs), and Montreal Protocol.

2. Influence of Climatic Change

Climate change is no longer a distant menace but a present reality. The increasing frequency of extreme weather events, melting polar ice sheets, and rising global temperatures emphasize the necessity for immediate action. The Intergovernmental Panel on Climate Change (IPCC) has consistently emphasised the correlation between the accelerating tempo of climate change and human activities, notably the burning of fossil fuels [4]. According to the most recent worldwide statistics on climate change, the average temperature of the entire planet has risen by 1.2°C during the 19th century, with the most recent decade (2010-2019) being the decade with the highest average for global temperature. At the same time, the year 2023 is one of the warmest years ever recorded, and significant temperature anomalies have been noted globally. Carbon dioxide levels in the atmosphere hit a record high of 419 ppm in the year 2021, the highest level in over three million years. Additionally, the sea levels had grown by nearly 20 centimetres since the year 1880. In order to mitigate these effects, it is absolutely necessary for us to develop renewable energy sources and dramatically limit the amount of carbon imprint that we leave behind. Research on renewable energy in recent years has also shown progress, both fully dedicated [5]–[7] and blended applications with fossil fuels [8]–[11].



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Table 1.
Strategies followed by
different nations to
regulate environmental
pollution

United States	Clean Air Act	Clean Water Act	Environmental Protection Agency (EPA)
	To control toxic pollutants like SO ₂ and PM and establish air control standards.	To control the discharge of pollutants into water and to establish quality standards for surface waters.	To implement environmental regulations and to conduct research on environmental issues.
European Union	European Green Deal	REACH Regulation	Air Quality Directives
	To make Europe climate neutral by 2050 by regulating emissions, energy, industry, and biodiversity.	To regulate the use of chemicals to protect humans and the environment	To set a limit for air pollutants and improve air quality.
China	Air Pollution Action Plan	Water Pollution Prevention and Control Action Plan	Renewable Energy Expansion
	To control PM 2.5 levels, especially in major urban areas	To improve the quality of water resources	To invest in solar, wind, and hydropower to reduce reliance on coal.
India	National Clean Air Program	Swachh Bharat Mission	Renewable Energy Targets
	Aims to reduce PM 2.5 and PM 10 concentrations in major cities	To focus on cleaning streets, roads, and infrastructure to manage solid waste	To promote solar and wind energy to reduce the reliance on fossil fuels
Australia	National Clean Air Agreement	Renewable Energy Target	Water Management Strategies
	To control air pollution and improve air quality standards	To increase the share of renewable energy in the national energy mix with policies	To manage and protect water resources, particularly in drought-prone regions.
Germany	Energiewende	Circular Economy Package	NOx Reduction Program
	Transition to renewable energy sources and reduce carbon emissions	To implement policies that promote recycling and reduce waste	Measures to control NOx from transportation and industry

3. Promising Energy VS. Challenges

Sustainable alternatives to fossil fuels, such as biofuels, solar, wind, hydro, and geothermal power, are promising renewable energy sources that substantially contribute to reducing greenhouse gas emissions and mitigating climate change [12]. In particular, solar and wind power have experienced significant cost reduction and efficiency improvements, rendering them more feasible for widespread implementation. These technologies generate electricity by utilising natural processes, thereby ensuring a more sustainable and cleaner energy supply. Nevertheless, the integration of these intermittent energy sources into existing power grids continues to pose a challenge, necessitating the development of energy storage technologies and grid management. Furthermore, the initial capital investment for renewable energy infrastructure can be substantial, and there are apprehensions regarding the environmental impact of the fabrication and disposal of renewable energy components, including solar panels and wind turbines. The long-term advantages of renewable energy are compelling despite these obstacles. By diversifying the energy supply, renewable energy sources can substantially reduce greenhouse gas emissions, improve air quality, and provide energy security. The extant challenges can be addressed through innovations in technology and policy support. Investments in research and development are indispensable for the advancement of storage solutions, the enhancement of grid integration, and the reduction of production costs.

4. Towards Policy-Making

There have been significant steps forward, and promises have been made around the world in recent policy-making on green energy. This is because of the need to act quickly on climate change and the push for sustainable energy systems. Some of the global initiatives are COP26 commitments and the International Solar Alliance (ISA). The COP26 summit in Glasgow reveal that many countries are in favour of renewable energy targets like global methane pledge. Similarly, ISA launched by India and France promote solar energy deployment globally, especially in developing nations. Table 2 highlights the recent policy-making by different nations, and this policy measures the global commitment to promoting renewable energy and driving significant progress towards a more sustainable energy future.

Table 2.
Key developments in
policy making by
different nations

USA	European Union	China	India
<p>Inflation Reduction Act (IRA)2022: The act provides tax exemptions and incentives for renewable energy. By 2030, greenhouse gas emissions should be minimised by 40%, green energy jobs created, and energy costs lowered.</p>	<p>European Green Deal: This Deal guides the EU to climate neutrality by 2050. Significant goals include lowering greenhouse gas emissions by 55% by 2030 and amending its Renewable Energy Directive to improve renewable energy utilisation to 40% by 2030.</p>	<p>14th Five-Year Plan (2021-2025): To reach 20% non-fossil fuel primary energy consumption by 2025, the five-year strategy promotes renewable energy.</p>	<p>National Solar Mission: Government subsidies and incentives are available for utility-scale and rooftop solar projects. Renewable energy project intends to reach 100 GW of solar power capacity by 2022, with more ambitious 2030 ambitions.</p>
<p>Clean Electricity Performance Program (CEPP): It intends to expedite the switch to 100% clean electricity by 2035.</p>	<p>Fit for 55 Package: It tries to connect EU policy with new climate targets by promoting renewable energy, energy efficiency, and carbon pricing.</p>	<p>Carbon Neutrality Goal: Committed to achieving carbon neutrality by 2060.</p>	<p>Renewable Energy Expansion: The policy framework promotes domestic renewable energy component production and grid infrastructure improvements.</p>

5. Conclusion and Important Notes

The analysis highlights the significant challenges posed by a rapidly growing global population, which is projected to reach 10 billion by 2058. With only 12.56% of Earth's land suitable for human habitation and increasing industrialization and environmental degradation, human survival is becoming increasingly precarious. Climate change exacerbates these issues, evidenced by rising global temperatures, record-high atmospheric CO₂ levels, and increasing sea levels. These changes necessitate urgent action to develop renewable energy sources and reduce carbon footprints. Promising renewable energy sources, such as biofuels, solar, wind, hydro, and geothermal power, offer substantial benefits in reducing greenhouse gas emissions and mitigating climate change. However, challenges such as integrating intermittent energy sources into power grids, high initial capital investments, and environmental concerns related to renewable energy infrastructure persist. Despite these obstacles, the long-term benefits of renewable energy, including reduced greenhouse gas emissions, improved air quality, and enhanced energy security, are compelling. Recent policy-making initiatives, such as COP26 commitments and the International Solar Alliance, underlined global efforts to promote renewable energy and achieve sustainability. These policies signify a global commitment to addressing climate change and advancing towards a sustainable energy future.

Governments and stakeholders should prioritize the development and deployment of renewable energy sources by accelerating renewable energy adoption. Investments in research and development are crucial to enhance energy storage solutions, improve grid integration, and reduce production costs. Additionally, it is essential to strengthen global initiatives such as the Paris Agreement, United Nations Sustainable Development Goals, and the Montreal Protocol to ensure coordinated efforts in combating climate change and promoting sustainability. Implementing policies that provide financial incentives for renewable energy projects, reducing initial capital investment barriers, and encouraging private sector participation are also vital. This includes tax credits, subsidies, and low-interest loans for renewable energy infrastructure. Supporting technological innovations that address the challenges of renewable energy is necessary for progress. This involves developing advanced energy storage systems, improving the efficiency of renewable energy technologies, and minimizing the environmental impact of their production and disposal. Increasing public awareness and education on the benefits of renewable energy and sustainable practices is another critical step. Engaging communities in local renewable energy projects and promoting sustainable living practices can help reduce the overall carbon footprint. Furthermore, fostering international cooperation and knowledge sharing is imperative to address common challenges in renewable energy adoption and climate change mitigation. Collaborative efforts can accelerate technological advancements and policy implementations on a global scale. By addressing these recommendations, we can pave the way for a sustainable and resilient energy future, ensuring that the growing global population can thrive in a healthier and more sustainable environment.

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