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Review

Renewable Energy: A Sustainable Future

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Abstract

Renewable energy sources such as solar, wind, hydro, geothermal, and biomass are critical to achieving sustainable development and reducing greenhouse gas emissions. This paper explores the different types of renewable energy, their global potential, current usage statistics, advantages, challenges, and future prospects. Data from international energy agencies and research studies are included to highlight trends and opportunities. The paper concludes that renewable energy is essential for combating climate change and ensuring long-term energy security.

Keywords: Renewable energy, solar, wind, hydropower, geothermal, biomass, sustainability, climate change.

1. INTRODUCTION

Energy is one of the most important resources for human development. However, traditional energy sources such as coal, oil, and natural gas are finite and contribute significantly to environmental degradation. Renewable energy provides a sustainable alternative by harnessing natural processes that are constantly replenished.

According to the International Energy Agency (IEA, 2023), renewable energy accounted for nearly 30% of global electricity generation in 2022, with solar and wind showing the fastest growth. Transitioning to renewable energy is not only environmentally necessary but also economically beneficial.

2. Types of Renewable Energy

2.1 Solar Energy

- Derived from sunlight using photovoltaic (PV) cells or solar thermal systems.
- Global solar capacity reached *1,185 GW in 2023* (IRENA, 2024).
- India, China, and the U.S. are leading in solar installations.

2.2 Wind Energy

- Generated using wind turbines on land (onshore) or sea (offshore).
- Global wind power capacity was 906 GW in 2023 (GWEC, 2024).
- Offshore wind farms are expanding rapidly in Europe and China.

2.3 Hydropower

Oldest and largest renewable source, producing 15% of global electricity (World Bank, 2023).

Large dams and small-scale hydro projects contribute to energy security.

S/N	Energy Source	2020 Capacity (GW)	2023 Capacity (GW)	% Growth
1	Solar	714	1185	66
2	Wind	743	906	22
3	Hydro	1330	1360	2
4	Geothermal	14	16	14
5	Biomass	140	160	14

2.4 Geothermal Energy

- Uses heat from beneath the Earth's surface.
- Countries like Iceland, Indonesia, and the Philippines lead in geothermal production.
- Global geothermal capacity: 16 GW in 2023 (IRENA, 2024).

2.5 Biomass Energy

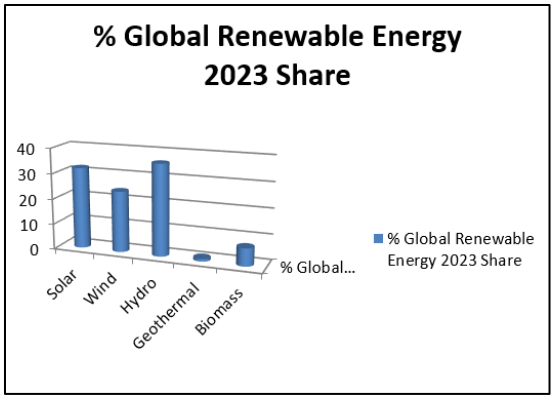
- Derived from organic materials such as agricultural waste, wood, and animal manure.
- Contributes to both electricity and heat generation.
- Global biomass energy use: 10% of total primary energy supply (IEA, 2023).

3. Global Data and Trends

Table 1: Global Renewable Energy Capacity (2020–2023)

Source: IRENA (2024), GWEC (2024), World Bank (2023)

Types of Energy	% Global Renewable Energy 2023
Solar	32
Wind	24
Hydro	36
Geothermal	1
Biomass	7

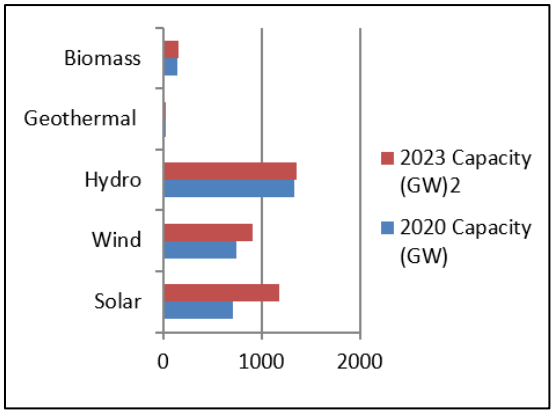


Bar Graph Description

X-axis: Years (2020, 2021, 2022, 2023)

Y-axis: Capacity (GW)

Bars: Solar shows a steep rise from 714 GW to 1,185 GW; Wind rises from 743 GW to 906 GW.

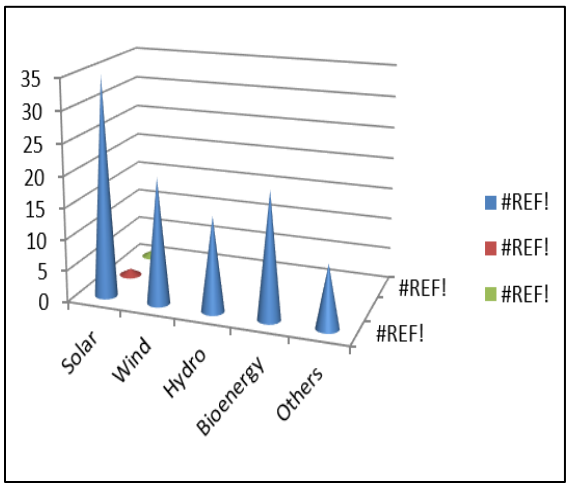


4. Benefits of Renewable Energy

- Environmental Benefits – Reduces CO_2 emissions and air pollution.
- Sustainability – Inexhaustible sources, unlike fossil fuels.
- Energy Security – Reduces dependence on imported fuels.
- Economic Growth – Creates millions of jobs globally (12.7 million in 2023, IRENA).
- Health Benefits – Cleaner air leads to fewer respiratory and cardiovascular diseases.

Employment in Renewable Energy Sector (2023)

Renewable Energy	Employment in Renewable Energy Sector (2023) %2
Solar	35
Wind	20
Hydro	15
Bioenergy	20
Others	10



5. Challenges of Renewable Energy

1. High Initial Costs: Solar panels, wind turbines, and storage systems require large upfront investments.
2. Intermittency: Solar and wind energy depend on weather and time of day.
3. Storage Limitations: Batteries and other storage technologies are still expensive.
4. Land and Resource Use: Large areas are needed for solar farms and wind turbines.
5. Policy and Infrastructure: Developing countries often lack supportive policies and grid infrastructure.

6. Case Studies

6.1 Germany's Energiewende

- Target: 80% renewable electricity by 2030.
- Achieved: 46% of electricity from renewable sources in 2023.

6.2 India's Solar Mission

- Target: 500 GW of renewable energy by 2030.
- Achieved: 125 GW solar capacities by 2023.

6.3 Iceland's Geothermal Success

- Over 85% of primary energy comes from geothermal and hydropower.

7. Future Prospects

Technology Innovation: Perovskite solar cells, floating wind farms, and advanced nuclear fusion.

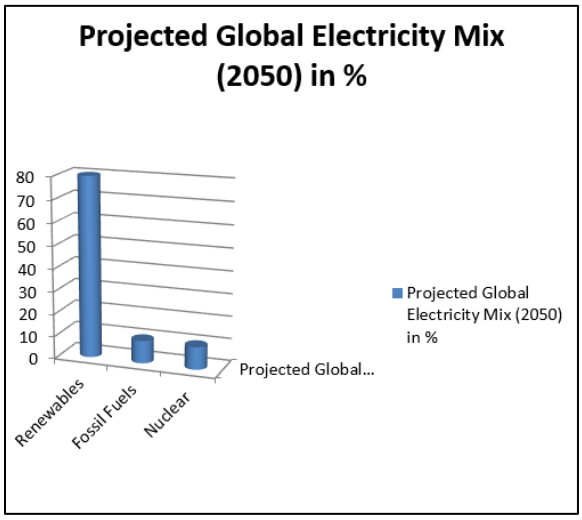
Energy Storage: Lithium-ion and solid-state batteries will improve reliability.

Green Hydrogen: Expected to play a major role in decarbonizing industries.

Global Cooperation: International agreements like the Paris Accord push renewable adoption.

Projected Global Electricity Mix (2050)

Energy	Projected Global Electricity Mix (2050) in %
Renewables	80
Fossil Fuels	10
Nuclear	10



By 2050, renewable could supply over 80% of global electricity, significantly limiting global warming (IPCC, 2023).

8. Conclusion

Renewable energy is no longer a niche alternative but a mainstream solution to the world's energy challenges. While obstacles such as cost, storage, and infrastructure remain, rapid technological advancements and strong policy support are driving global adoption. A transition to renewable energy is essential for environmental sustainability, economic growth, and energy security.

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