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Socio- Economic Impact of Green Energy in India

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ABSTRACT

This study examines the latest advancements in green energy within India and their socioeconomic implications, taking into account both environmental sustainability and economic progress. India's dedication to transitioning to clean energy is motivated by its ambitious renewable energy targets, efforts to combat climate change, and the aim of generating socio-economic advantages for its large population. This research analyzes the effects of India's transition to green energy on job creation, economic growth, rural development, and environmental sustainability. It consolidates current statistics on India's renewable energy output and evaluates the socio-economic results arising from this transition. Green energy is swiftly becoming more significant as India works to satisfy its increasing energy needs while minimizing its carbon emissions. India has positioned itself as a global frontrunner in the deployment of renewable energy, particularly in solar, wind, and biogas sectors.

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INTRODUCTION

India stands as one of the rapidly advancing economies globally, characterized by a significant demand for energy to support its industrial and urban development. With a burgeoning economy and a vast population, the country faces the critical task of reconciling its energy requirements with sustainable growth. Historically dependent on coal and other fossil fuels, India has made notable progress in incorporating renewable energy into its energy portfolio. By the conclusion of 2023, India secured the fourth position worldwide in terms of installed renewable energy capacity, a feat propelled by governmental initiatives and investments from the private sector. The country has established ambitious objectives for enhancing green energy production, in line with its obligations under the Paris Agreement and the goal of achieving net-zero carbon emissions by 2070. Renewable energy sources, including solar, wind, hydro, and biomass, are essential not only for environmental sustainability but also for fulfilling socio-economic objectives such as poverty alleviation, rural electrification, and job creation.

Literature Review

Renewable Energy Growth in India

Research indicates that India holds the third position worldwide in renewable energy capacity, primarily due to its emphasis on solar and wind energy. As reported by Statista, India's total installed renewable energy capacity reached approximately 176 gigawatts (GW) in 2023, reflecting an increase from about 134.8 GW in 2020.

Here are some other renewable energy highlights for 2023:

- Solar energy: The largest source of renewable capacity, accounting for 36.7% or 1,418 GW
- Hydropower: The second largest source of renewable capacity, accounting for 32.7% or 1,265 GW
- Wind energy: The third largest source of renewable capacity, accounting for 26.3% or 1,017 GW
- Bioenergy: Accounting for 3.9% or 149 GW
- Variable renewables: Wind and solar accounted for 63.0% of renewable capacity.

The International Renewable Energy Agency (IRENA) collaborates with nations to assist them in formulating and executing policies and strategies related to renewable energy. Additionally, IRENA disseminates statistics on renewable energy, encompassing data on installed capacity gathered from diverse sources.

Socio-Economic Impacts of Green Energy

Studies indicate that India's green energy programs are driving socio-economic changes, particularly in rural regions. The growth of job prospects in renewable energy fields such as manufacturing, installation, and maintenance is promoting rural advancement.

Environmental and Health Benefits

Transitioning to renewable energy sources significantly decreases air pollution and greenhouse gas emissions. This shift offers considerable health advantages, especially for urban areas plagued by elevated pollution levels. Data from the Ministry of Health indicates that India experiences more than 1 million fatalities each year as a result of air pollution, a situation that could be alleviated through the adoption of cleaner energy alternatives.

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Methodology

The study utilizes a qualitative analysis of secondary data obtained from government reports, international energy organizations, and scholarly sources. Furthermore, it examines quantitative data regarding renewable energy capacity, job creation, and environmental indicators to assess the socioeconomic effects.

Growth of Renewable Energy in India

India's renewable energy sector has seen exponential growth over the past decade. Current data from the Ministry of New and Renewable Energy (MNRE) in 2023 indicate as on 31st March 2024, India's add up to introduced power capacity came to 441.97 GW, an increment from 275.90 GW of 2014- 15, reflecting a development of 60.19% over the past nine years. Add up to introduced capacity beneath the Renewable Energy sector, counting huge Hydro was expanded from 81.22 GW of 2014-15 to 190.57 GW by 2023-24 with a development of 134.63% amid the period. Installed capacity beneath Solar, Wind, Bio Power and Small Hydro Power was 143.64 GW as on 31st March 2024 which was upgraded from 39.95 GW of 2014-15, having a momentous development of 259.55%.

Table 1.1: Cumulative Installed Capacity since 2014-15 (in GW)

Year	Mode- Wise Breakup (GW)					Grand Total	Growth (%)	Share of RE (%)
	Non- RE		Renewable (RE)					
	Thermal	Nuclear	Hydro	RES*	Total RE			
2014- 15	188.90	5.78	41.27	39.95	81.22	275.90	10.62	29.44
2015- 16	210.68	5.78	42.78	47.09	89.87	306.33	11.03	29.34
2016- 17	218.33	6.78	44.48	58.56	103.04	328.15	7.12	31.40
2017- 18	222.91	6.78	45.29	70.65	115.94	345.63	5.33	33.54
2018- 19	226.28	6.78	45.40	79.41	124.81	357.87	3.54	34.88
2019- 20	230.60	6.78	45.70	88.26	133.96	371.34	3.76	36.07
2020- 21	234.73	6.78	46.21	95.80	142.01	383.52	3.28	37.03
2021- 22	236.11	6.78	46.72	109.89	156.61	399.5	4.17	39.20
2022- 23	237.27	6.78	46.85	125.16	172.01	416.06	4.15	41.34
2023- 24	243.22	8.18	46.93	143.64	190.57	441.97	6.23	43.12
Gr (2014-15 to 2023- 24)	28.76%	41.52%	13.71%	259.55%	134.63%	60.19%		
CAGR (2014-15 to 2023- 24)	2.85%	3.93%	1.44%	15.28%	9.94%	5.38%		

Source: Ministry of New and Renewable Energy (MNRE)and Central Electricity Authority(CEA)

RES*- Comprising of Solar, Wind, Bio- Power and Small Hydro Power Gr= Growth (%)
CAGR= Compound Annual Growth Rate

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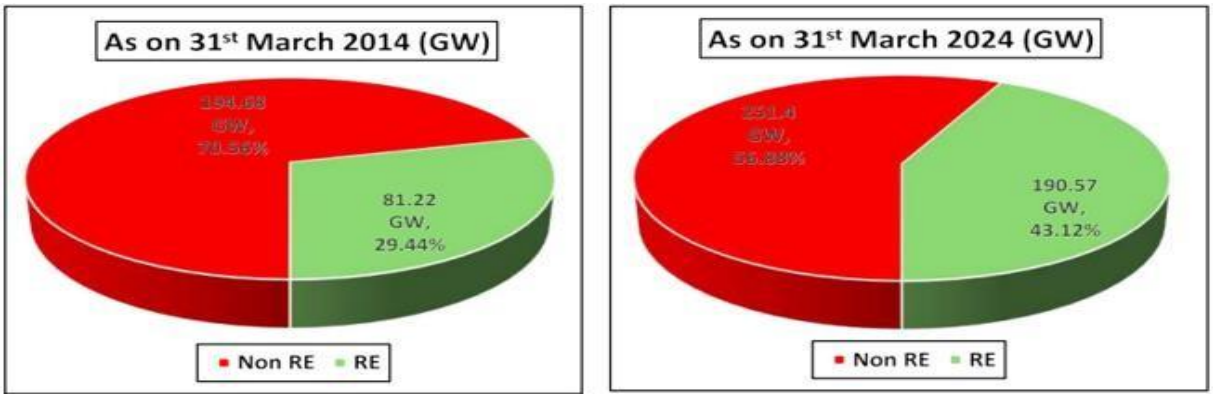


Figure 1.1: Share of Renewable Energy

Source: Ministry of New and Renewable Energy(MNRE) and Central Electricity Authority(CEA)

During the last 9 years, the Renewable Energy sector has made a remarkable contribution in the total installed capacity with a significant share of 43.12% in 2023-24 from 29.44% of 2014-15. Fig 1.2 Trend in Cumulative Capacity installation.



Figure 1.2: Trend in Cumulative Capacity Installation

Source: Ministry of New and Renewable Energy (MNRE) and Central Electricity Authority (CEA)

The chart reveals that the trend of year wise capacity establishment of renewable energy division was reliably outpacing that of the non-renewable vitality segment, narrowing the gap between the two altogether. This reflects the expanding move towards the use of renewable energy sources, with a compound yearly development rate (CAGR) of 9.94 % from 2014-15 to 2023-24.

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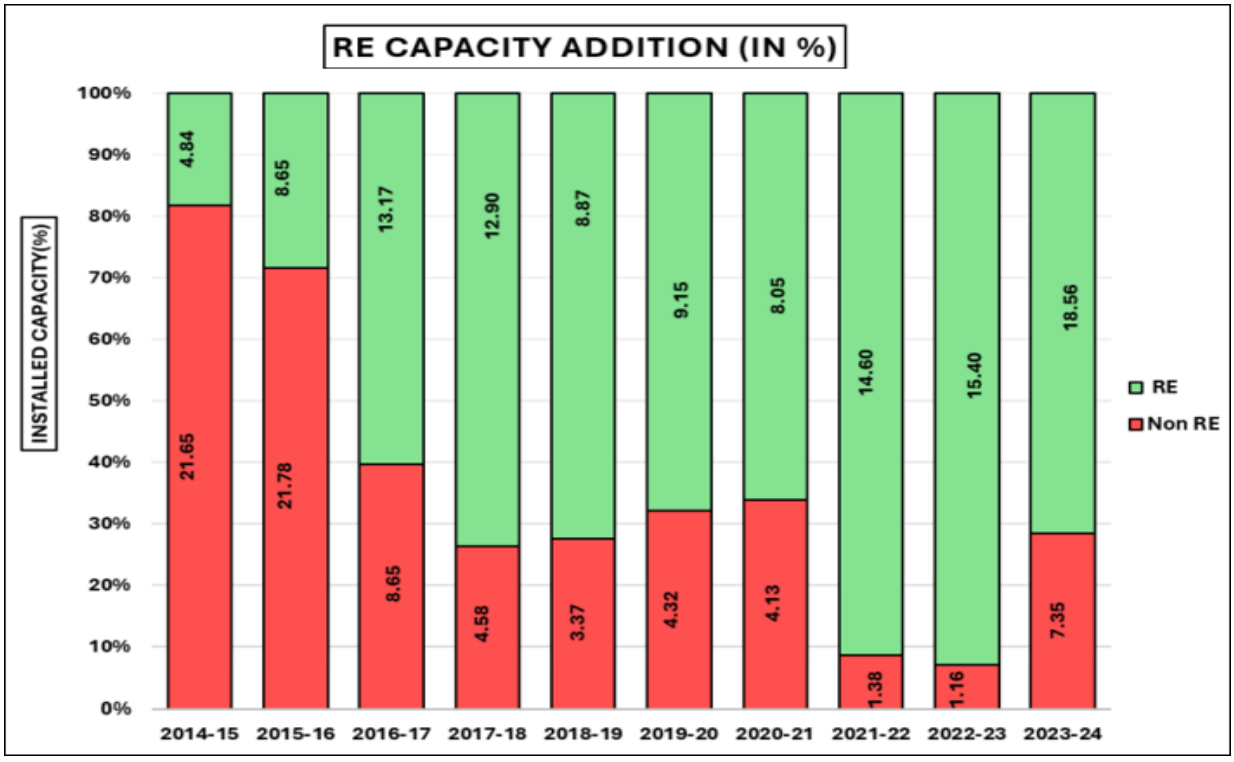


Figure 1.3: Year wise capacity addition (in %)

Data shown inside the bar diagram represents the installed capacity in GW. In terms of year-on-year capacity addition, the RE sector has shown remarkable capacity expansion compared to non-RE sector. This reveals India's dedication towards its utilization of Renewable Energy potential.

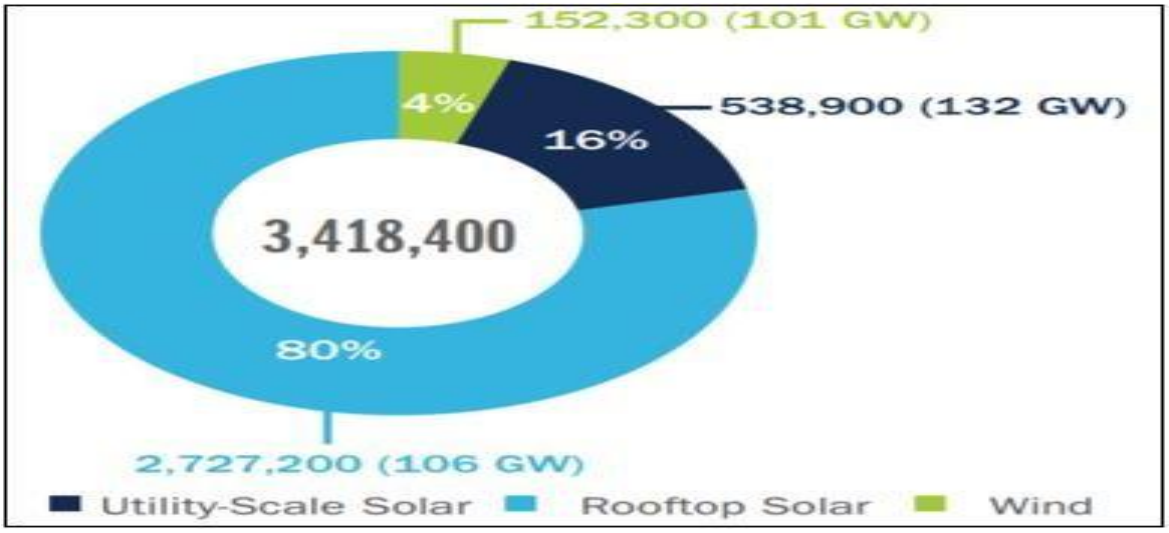
Socio-Economic Benefits of Green Energy in India

Job Creation and Economic Development Employment Generation:

Renewable energy has emerged as a key employment sector. In 2023, around 1 million jobs were created in solar, wind, and bioenergy sectors (CEEW, 2023). India's green energy transition has expanded job opportunities in rural areas, where solar panel installation and wind turbine maintenance have become common. This employment growth is pivotal in poverty reduction and rural empowerment. India's renewable energy division has ended up a critical driver of work, especially in rural ranges where solar and wind ranches have made various work openings. A study by Chatterjee and Kanitkar (2024) found that sun oriented water system pump sets in Uttar Pradesh not as it were moved forward rural efficiency but too created occupations over socio-economic classes, especially in upkeep and establishment administrations [Chatterjee & Kanitkar, 2024]. India can possibly make approximately 3.4 million occupations (brief and long term) by introducing 238 GW solar and 101 GW new wind capacity to accomplish the 500 GW non-fossil power era capacity by 2030 objective. These employments speak to those made in the wind and on-grid solar energy divisions. A workforce of approximately one million can be utilized to take up these green employment

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opportunities. Employments made are distinctive from the workforce required, as one laborer can perform more than one job. Sector wise work creation potential by accomplishing 101 GW Wind and 238 GW solar targets of non-fossil fuel capacity by 2030.



Rural Electrification and Energy Access

Rural India, home to a significant portion of the population, has historically struggled with access to reliable electricity. The deployment of decentralized renewable energy systems such as solar photovoltaic (PV) installations has provided rural communities with stable electricity, reducing their dependency on costly and unreliable diesel generators. The research by Mishra (2024) highlights the role of solar PV systems in enhancing energy access in rural dairy farms, thereby promoting sustainability and economic growth in India's agricultural sector [Mishra, 2024].

Rural Electrification and Economic Development:

Green energy projects have provided electricity to remote and underserved regions. The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya Scheme) aims to ensure last-mile electricity connectivity, significantly aided by renewable sources. Studies show that access to electricity facilitates education, healthcare, and small business growth, contributing to socio-economic up liftment.

Energy Security and Independence

Renewable energy plays a pivotal role in enhancing India's energy security by reducing its dependence on imported fossil fuels. As the world's third-largest oil importer, India's energy security is vulnerable to global oil price fluctuations. Expanding renewable energy sources reduces these risks while promoting energy independence. Studies such as those by Madheswaran et al. (2024) emphasize the potential of green hydrogen in India's decarburization efforts and its contribution to energy independence [Madheswaran et al.,

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2024].

Environmental and Health Benefits

The shift from fossil fuels to renewables is crucial for reducing air pollution and greenhouse gas emissions. Cleaner energy sources reduce the health burdens associated with fossil fuel combustion, particularly in urban areas with high levels of pollution. This transition also has substantial cost- saving implications for public health systems. The adoption of clean cooking technologies, as discussed by Mishra and Patel (2024), has the potential to alleviate health issues caused by traditional biomass use, such as respiratory diseases prevalent in rural India [Mishra & Patel, 2024]. According to the World Health Organization, India's reduction in coal consumption aligns with an anticipated drop in air pollution- related health problems by 20% over the next decade, improving quality of life.

Economic Impact and Market Expansion

India's investment in renewable energy is attracting foreign investment. With initiatives like the Production-Linked Incentive (PLI) scheme, the government has encouraged manufacturing of solar cells and modules within the country. The influx of capital into India's renewable energy market fosters technological innovation, increasing production efficiency and reducing costs.

Despite its progress, India's renewable energy sector faces challenges:

a) Intermittency and Storage:

Solar and wind energy are dependent on weather conditions, leading to energy intermittency. Effective

storage solutions are costly; though recent investments aim to improve battery technology.

b) Land Acquisition and Environmental Impact:

Large-scale renewable projects require significant land, often leading to displacement and environmental concerns. Wind and solar farms may disturb local wildlife and ecosystems, raising questions about sustainable development practices.

c) Policy and Financial Constraints:

The lack of consistent policies and financial support hinders the growth of renewable energy. Infrastructure and investment requirements remain high, and attracting consistent funding is challenging due to competing development priorities.

Case Studies: Green Energy Projects in India

1) Solar Irrigation Pump-Sets in Uttar Pradesh

The introduction of solar-powered irrigation systems has had a transformative impact on agriculture in Uttar Pradesh. According to Chatterjee and Kanitkar (2024), solar irrigation not

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only provides a sustainable water supply for crops but also reduces operational costs for farmers, improving their socio- economic conditions [Chatterjee & Kanitkar, 2024].

2) Wind Energy in Gujarat: A Wind Energy Powerhouse

Gujarat's noticeable quality in India's wind energy segment is developing quickly. The state boasts the longest coastline in the nation, extending around 1,600 kilometers. This broad coastline encounters high-speed winds, making perfect conditions for wind energy generation. This common advantage has situated Gujarat at the cutting edge of India's wind power sector.

Gujarat boasts India's highest introduced wind capacity, with roughly 12.1 GW as of July 2024 i.e. 25.7% of generally India's add up to wind power capacity. This amazing figure underscores Gujarat's critical commitment to India's worldwide standing as the fourth-largest coastal wind energy market.(https://egov.eletsonline.com/2024/10/gujarats- onshore-offshore-energy-powering-India's-energy-transition

3) Biogas in Rural Rajasthan

Panwar and Samar (2024) evaluated the socio-economic benefits of the Deenbandhu Biogas Model in Rajasthan, highlighting its role in providing clean energy to rural households while improving health outcomes and reducing dependence on firewood for cooking [Panwar & Samar, 2024]. Biogas technologies have also been linked to improving agricultural productivity through the use of bio- slurry as fertilizer.

Policy Recommendations

To fully realize the socio-economic benefits of green energy, India must:

- Strengthen policy frameworks that promote public-private partnerships for renewable energy infrastructure development.
- Enhance support for the reskilling of workers from traditional energy sectors.
- Promote decentralized renewable energy projects in rural areas to improve energy access and reduce poverty.
- Encourage investment in green hydrogen and other emerging technologies to diversify India's renewable energy portfolio.
- Expand research and development initiatives focused on innovative green energy technologies.

Conclusion

The shift towards green energy is revolutionizing India's energy sector, offering a sustainable approach to meet the nation's increasing energy needs. Its socio-economic benefits are reflected in job creation, rural advancement, better energy accessibility, and strengthened energy security. Nevertheless, this transition poses challenges that necessitate strong policies and

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investments to guarantee inclusive and fair growth. By encouraging public-private collaborations, investing in infrastructure, and advancing regulatory reforms, India can fully leverage its renewable energy resources. India's dedication to green energy serves as a significant catalyst for socio-economic change. The development of renewable energy in India not only fulfills climate objectives but also boosts employment, supports rural electrification, and alleviates health problems caused by pollution. However, it is essential to tackle the existing challenges of intermittency, land utilization, and financial viability to unlock the complete socio-economic benefits of renewable energy.

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