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# From Coal to Clean: The Socio-Economic Benefits of India's Renewable Energy Trajectory


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## ABSTRACT

As one of the fastest-growing economies globally, India faces the dual challenge of meeting its increasing energy demands while minimizing carbon emissions. The study highlights the country's significant strides in renewable energy adoption, particularly in solar, wind, and biogas sectors, and evaluates their implications for job creation, rural electrification, public health, and energy security. Drawing on secondary data from government reports, international agencies, and academic sources, the research underscores the transformative potential of green energy in fostering rural empowerment, reducing air pollution, and promoting decentralized energy access. With a renewable energy capacity exceeding 190 GW by 2024, India has emerged as a global leader in clean energy deployment. The study also discusses key challenges such as intermittency, land use constraints, and policy gaps that hinder further progress. Through case studies of solar irrigation in Uttar Pradesh, wind power in Gujarat, and biogas in Rajasthan, the study illustrates real-world benefits and calls for strengthened policy support and public-private collaboration. The research affirms green energy as a strategic driver of sustainable socio-economic transformation in India.

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## INTRODUCTION

India, as one of the fastest-growing economies in the world, finds itself at the crossroads of development and sustainability. With a population exceeding 1.4 billion and a growing demand for industrial expansion, urbanization, and improved standards of living, the country faces a formidable challenge in ensuring sufficient, affordable, and reliable energy for all. Historically dependent on fossil fuels such as coal and petroleum, India has experienced a corresponding rise in carbon emissions, air pollution, and environmental degradation. This fossil-fuel-centric growth model, while aiding rapid industrial progress, has simultaneously undermined ecological integrity and public health. In response, the country has embarked on a major transition toward green energy, recognizing it as an essential component not only of environmental policy but also of its broader socio-economic agenda. The significance of this shift is underscored by India's commitment to the Paris Agreement and its pledge to achieve net-zero carbon emissions by 2070. Against this backdrop, the research article titled *"Socio-Economic Impact of Green Energy in India"* by Shabir Ahmad Malik and Ishfaq Ahmad Bhat offers a timely and critical exploration of how renewable energy is transforming the nation's socio-economic landscape.

India's green energy revolution is not merely an environmental initiative; it is a strategic reorientation of the country's developmental trajectory. Renewable energy—encompassing solar, wind, hydropower, biomass, and biogas—has become the cornerstone of India's energy planning. Government initiatives, private sector investments, and international cooperation have propelled India into the global spotlight as a leader in renewable energy deployment. By 2024, India had achieved an installed renewable energy capacity of over 190 GW, a remarkable increase from 81.22 GW in 2014–15, reflecting a growth rate exceeding 130%. These gains include significant advancements in solar energy, which alone accounts for a large share of the green energy mix, followed by wind, hydro, and bioenergy sources. This exponential growth is not only a testament to India's technical capacity and policy vision but also a demonstration of its resolve to achieve energy security, reduce its carbon footprint, and promote sustainable development. The article under review goes beyond numerical assessments and delves into how these green energy developments impact the lives and livelihoods of millions of Indians.

One of the most transformative socio-economic outcomes of India's green energy expansion has been employment generation. The renewable energy sector has emerged as a significant employment driver, particularly in rural and semi-urban areas. The construction, installation, operation, and maintenance of solar panels, wind turbines, and bio-digesters have created diverse opportunities for both skilled and semi-skilled labor. According to the Council on Energy, Environment, and Water (CEEW), more than one million green jobs were generated in India by 2023 across solar, wind, and biomass sectors. Such employment is not only reducing rural underemployment but also empowering marginalized communities. In areas like Uttar Pradesh, the introduction of solar-powered irrigation pumps has improved agricultural productivity while simultaneously creating installation and maintenance jobs for rural youth. These developments, as highlighted in the article, represent more than economic growth—they signify a model of inclusive development where the green energy transition directly contributes to poverty alleviation and livelihood security.

Another compelling aspect of the article is its focus on rural electrification and energy access. In a country where a significant portion of the population resides in villages, access to reliable electricity has historically been a barrier to development. Conventional grid connectivity has often been infeasible or inefficient in remote regions. However, decentralized renewable energy systems—particularly solar photovoltaic (PV) installations—have revolutionized rural energy access. These systems have enabled households, farms, and small businesses to function with increased productivity and reduced dependency on diesel generators or firewood. As Mishra (2024) notes, the deployment of solar PV in dairy farms has not only stabilized energy supply but also enhanced overall agricultural sustainability. The article thus emphasizes that green energy is not merely about climate mitigation; it is fundamentally about empowering communities, improving livelihoods, and fostering local entrepreneurship.

Furthermore, the article critically examines the public health benefits stemming from the adoption of cleaner energy technologies. The link between energy consumption patterns and health

outcomes is particularly evident in India, where urban pollution and rural biomass usage have created severe respiratory and cardiovascular health crises. Fossil fuel combustion, especially coal, has contributed significantly to air pollution, resulting in over one million deaths annually due to air-quality-related illnesses, as reported by the Ministry of Health and the World Health Organization. Transitioning to green energy, particularly clean cooking technologies and electrification, has helped mitigate these adverse health effects. For example, replacing traditional biomass stoves with biogas systems, such as the Deenbandhu model in Rajasthan, has reduced indoor air pollution and associated respiratory illnesses, particularly among women and children. This health dividend, coupled with environmental benefits, strengthens the case for accelerating the adoption of renewable energy across India.

Energy independence is another dimension explored with depth and nuance in the article. India, as the world's third-largest oil importer, remains vulnerable to global energy price shocks and geopolitical disruptions. The transition to domestic renewable energy sources significantly enhances national energy security by reducing dependency on imported fuels. Wind farms in Gujarat and solar parks in Rajasthan are examples of how local energy generation is becoming a reality. Moreover, emerging technologies like green hydrogen are being explored to decarbonize hard-to-abate sectors such as steel and transport. As noted by Madheswaran et al. (2024), India's focus on hydrogen production aligns with its broader strategy to diversify its energy portfolio and promote self-reliance. This strategic orientation not only serves environmental and economic goals but also strengthens national sovereignty in the energy domain.

Despite its promising trajectory, the green energy transition in India is not without its challenges, a reality the article acknowledges and addresses. Intermittency remains a significant technical obstacle, particularly with solar and wind energy that depend on weather conditions. Energy storage technologies are advancing but remain costly and under-deployed. Land acquisition and ecological disruption pose another set of concerns, especially for large-scale projects. Solar and wind farms, while clean in output, require significant land area, sometimes leading to the displacement of communities or disruption of natural habitats. Moreover, the policy landscape, though ambitious, suffers from inconsistencies, financial bottlenecks, and bureaucratic hurdles. These barriers limit the scale and speed at which renewable energy can be deployed. The article calls for a concerted and coherent policy approach that includes stronger incentives, robust regulatory mechanisms, and effective public-private partnerships to overcome these systemic constraints.

India's renewable energy expansion has also catalyzed substantial economic investment, both domestic and international. Programs like the Production-Linked Incentive (PLI) scheme have spurred local manufacturing of solar modules and created a competitive ecosystem for clean technology. Foreign direct investment in the green energy sector has increased steadily, reflecting global confidence in India's market potential and policy direction. These economic dynamics not only contribute to GDP growth but also position India as a green manufacturing hub capable of exporting renewable technologies to other developing nations. The resulting market expansion, innovation, and cost reductions further fuel the country's transition to a sustainable energy future.

Case studies referenced in the article provide a grounded understanding of how green energy is affecting local realities. In Gujarat, the state's wind energy dominance—bolstered by a 1,600 km-long coastline—has turned it into a national leader in wind power generation. With over 12 GW of installed capacity, Gujarat accounts for nearly 26% of India's total wind capacity, proving how geography and policy alignment can produce scalable energy solutions. Similarly, biogas programs in rural Rajasthan, as explored by Panwar and Samar (2024), have demonstrated the socio-economic benefits of integrated renewable energy systems that enhance health, reduce emissions, and support agricultural productivity through bio-fertilizer applications.

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**

The rise of green energy in India represents a paradigmatic shift in the country's development trajectory, one that intertwines environmental stewardship with socio-economic progress. As the country endeavours to meet its expanding energy demands while simultaneously reducing carbon emissions and ensuring equitable growth, renewable energy has emerged as a pivotal force in shaping India's future. The literature on this subject spans various dimensions—from environmental sustainability and rural development to energy access and public health—reflecting the multi-sectoral impact of India's renewable energy transition. This review synthesizes key findings from prominent academic and institutional sources to map the current understanding of the socio-economic implications of green energy in India, identify recurring themes, and highlight existing research gaps.

The foundational literature on India's renewable energy development is anchored in analyses of the country's installed energy capacity and technological progress. According to IRENA (2022), India ranks among the top five countries globally in terms of renewable energy deployment, with a significant share in solar, wind, hydro, and bioenergy. The Ministry of New and Renewable Energy (MNRE) has documented a continuous rise in installed renewable capacity, from approximately 39.95 GW in 2014–15 to over 143.64 GW by 2023–24, excluding large hydropower. Scholars like Vyas (2023) attribute this rapid growth to aggressive policy incentives, improved financing frameworks, and declining costs of technology. These factors have enabled a robust expansion of renewable energy infrastructure across both urban and rural landscapes. However, the quantitative success of installed capacity has been critically examined by researchers such as Panwar and Samar (2024), who caution that the real value of green energy lies in its ability to generate inclusive, socio-economic dividends.

A substantial body of literature focuses on the employment-generating potential of India's renewable energy sector. The Council on Energy, Environment, and Water (CEEW, 2022) notes that the sector created over 1 million green jobs by 2023 in areas like solar panel installation, wind turbine maintenance, and bioenergy production. Chatterjee and Kanitkar (2024) conducted a case study in Uttar Pradesh demonstrating how solar-powered irrigation pumps have not only increased agricultural productivity but also created jobs across socio-economic strata. They argue that employment in renewable energy tends to be more geographically inclusive compared to conventional energy sectors, with particular benefits in underdeveloped rural areas. This view is supported by the International Labour Organization, which emphasizes the importance of a "just transition" where renewable energy expansion leads to decent work opportunities and supports the reskilling of fossil fuel-based labor forces.

Equally significant is the literature on rural electrification and decentralized energy access. Historically, millions of households in rural India have lacked reliable electricity, relying instead on polluting and expensive alternatives like diesel generators. Renewable energy, particularly solar photovoltaic (PV) systems and mini-grids, has proven instrumental in bridging this gap. Mishra (2024) explores the contribution of solar PV in enhancing energy access in India's dairy farming sector, arguing that stable electricity improves storage, production, and income for farmers. The Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya Scheme), supported by renewable sources, has helped achieve near-universal household electrification. These findings are corroborated by IEA (2023), which identifies India as a global leader in rural electrification via renewables. Scholars argue that electrification catalyzes broader development outcomes in health, education, and entrepreneurship.

The health benefits of green energy have received considerable scholarly attention, especially concerning the reduction of air pollution and indoor smoke exposure. According to WHO (2023), over one million premature deaths occur annually in India due to air pollution, much of it stemming from fossil fuel combustion. The transition to renewable energy mitigates these health hazards by reducing

greenhouse gas emissions and improving air quality. Mishra and Patel (2024) explore the health implications of clean cooking technologies and show that biogas adoption significantly reduces respiratory ailments among rural women. Their research indicates that energy transitions driven by renewable sources are not only environmentally beneficial but also yield substantial public health savings. However, the literature also identifies implementation challenges, including poor awareness, affordability, and limited distribution infrastructure for clean cooking technologies in remote areas.

Energy security is another recurring theme in the literature, with scholars arguing that renewable energy enhances India's strategic autonomy. Madheswaran et al. (2024) emphasize the importance of green hydrogen in reducing India's reliance on imported oil and gas. India's energy landscape has long been vulnerable to geopolitical tensions and global market volatility, as it imports nearly 85% of its crude oil. The growing domestic capacity for solar, wind, and bioenergy reduces this dependence, thus reinforcing national energy sovereignty. This aligns with broader governmental narratives such as the "Atmanirbhar Bharat" (self-reliant India) initiative, which positions renewable energy as a key pillar of economic and strategic independence.

A subset of the literature evaluates the market dynamics and investment trends in India's green energy sector. The Production-Linked Incentive (PLI) scheme launched by the Indian government has catalyzed domestic manufacturing of solar modules and fostered public-private partnerships. Studies by IEA (2023) and IRENA (2022) suggest that India is poised to become a global hub for renewable technology production and export. These developments are expected to generate significant economic spillovers, such as job creation in ancillary sectors and technological innovation. However, researchers also caution about structural barriers such as policy inconsistencies, land acquisition hurdles, and financing bottlenecks, particularly for small and medium enterprises. These issues, if unresolved, could limit the scalability and inclusivity of India's green energy revolution.

The environmental sustainability of renewable energy deployment has been widely debated. While most scholars agree on the low-carbon advantage of renewables, concerns have been raised about land use, ecological disruption, and displacement. For instance, large-scale solar farms may require vast tracts of land, sometimes leading to habitat loss or the displacement of local communities. Similarly, wind farms in ecologically sensitive coastal or forested areas may affect bird migration patterns and biodiversity. These concerns are reflected in the research by Panwar and Samar (2024), who stress the need for environmental impact assessments and community consultation before project execution. This aspect of the literature urges a balanced approach, one that ensures environmental and social justice alongside energy goals.

Case studies from various Indian states provide contextual insights into how green energy is being localized and operationalized. Gujarat, for example, has become a national leader in wind energy, contributing over 25% of India's total wind capacity by 2024. According to reports from Elets Online (2024), Gujarat's success stems from its long coastline, robust policy incentives, and favorable wind conditions. In Rajasthan, the Deenbandhu biogas model has been effective in providing clean energy to rural households while also supplying organic fertilizer for agriculture. These state-specific experiences highlight the diversity of India's renewable energy landscape and the importance of tailoring interventions to local socio-economic and geographic conditions.

**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.

**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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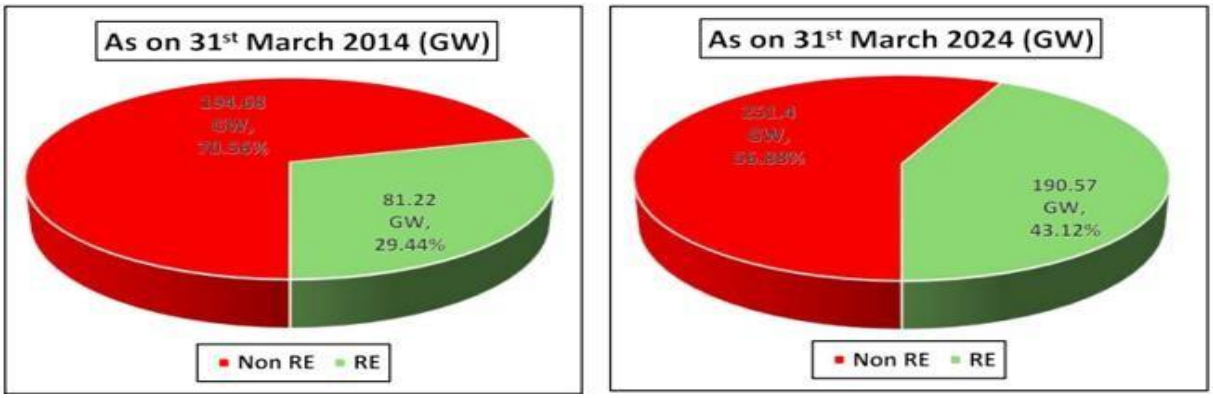


**Figure 1.1:** Share of Renewable Energy

*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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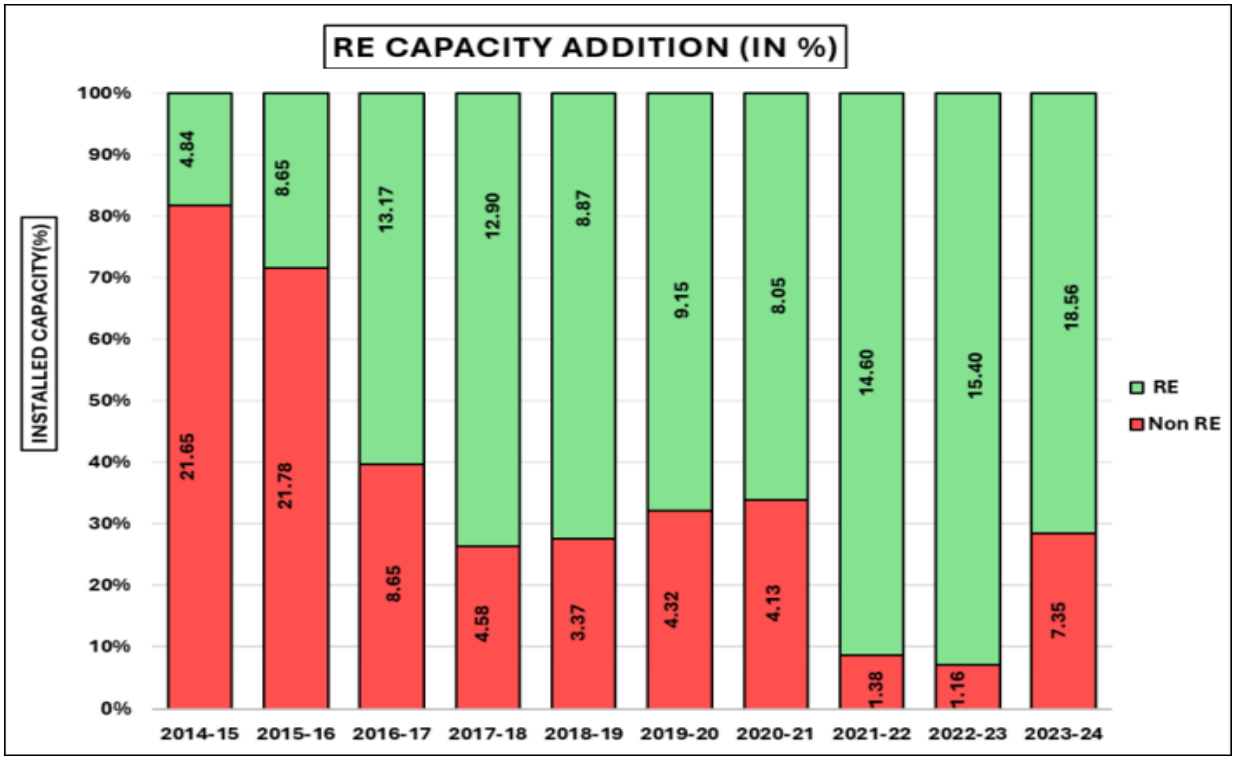


**Figure 1.3: Year wise capacity addition (in %)**

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 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.

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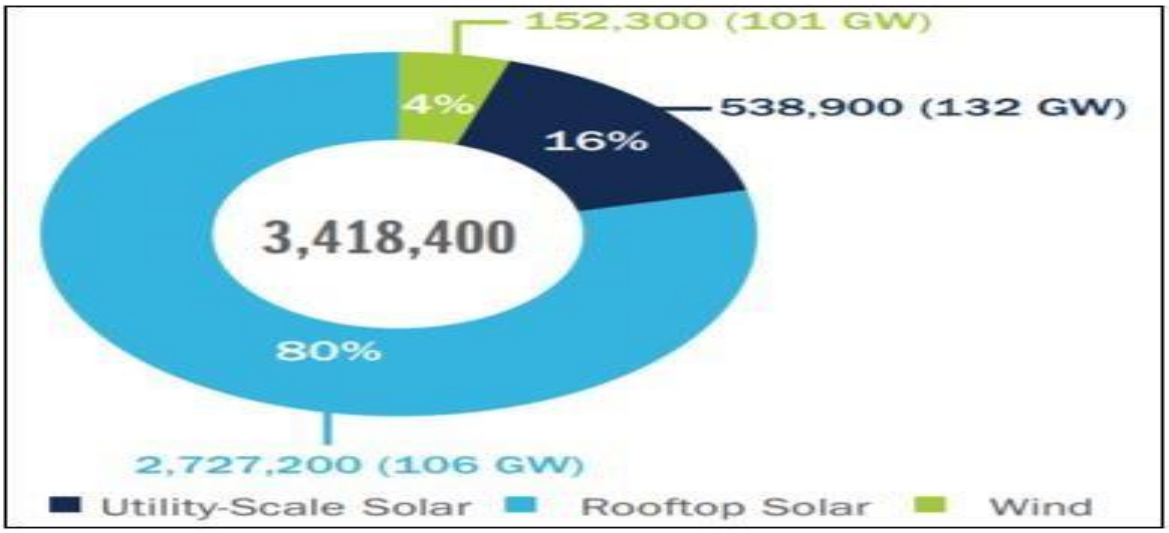


**Rural Electrification and Energy Access**

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., 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 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 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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