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A Review of the Current Status of Renewable Energy in India and Government Initiatives

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Abstract

The rapid economic growth in India has resulted in a significant increase in energy demand. The country's reliance on fossil fuels highlights the urgent need for alternative energy sources to address environmental concerns, energy security, and sustainability. Renewable energy plays a vital role in India's energy transition. This research paper reviews the current status of renewable energy in India and explores the government's initiatives aimed at advancing the energy sector. The study focuses on two key objectives: (1) examining the current status of renewable energy in India, particularly its installed capacity and energy generation, and (2) analysing the government's efforts to foster the development of the renewable energy sector. India's energy strategy is framed under the climate action plan, based on the five principles of 'Panchamrit'. The strategy aims to achieve 500 GW of non-fossil energy capacity by 2030 and source 50% of its energy needs from renewable sources by the same year. With rapid population growth contributing to rising energy demands, renewable energy, alongside coal, has become critical in meeting this demand. While energy consumption continues to grow, significant progress in the renewable energy sector has been observed, particularly between 2014-15 and 2023-24. During this period, energy generation from Solar, Wind, Bio, and Small Hydro Power sources increased by 265.89%, with the share of renewable energy in total installed capacity rising from 1.04% in 1998-99 to 32.5% in 2023-24. Rajasthan, Gujarat, Tamil Nadu, Karnataka, and Maharashtra contribute 61% of India's total renewable energy capacity. The private sector, alongside central and state governments, plays a critical role in this growth. Key government initiatives, including the National Solar Mission, PM-KUSUM Scheme, National Green Hydrogen Mission, and others, are essential to ensuring the sustainability and expansion of the renewable energy sector, contributing to India's long-term energy security and energy independence.

Keywords: *Climate Change, Fossil fuel, Renewable energy, solar energy, Sustainability, Panchamrit*

Introduction

India's economy has experienced strong growth, leading to a significant rise in energy demand. Currently, the country relies heavily on coal and oil for its energy needs. This dependence on fossil fuels highlights the need for alternative energy sources to ensure energy security, sustainability, and reduce environmental impact. Renewable energy is a key alternative in this transition. India's goal to shift to renewable energy and achieve net-zero emissions by 2070 is crucial, particularly as it is the world's third-largest emitter of greenhouse gases and home to some of the most air-polluted cities. This shift will help combat climate change, improve air quality, and contribute to a more sustainable future. In the context of environmental concern Sustainable Development Goal 7 seeks to ensure access to affordable, reliable, sustainable, and modern energy for all, directly linking renewable energy development to broader sustainable growth. On this background, this research paper provides a comprehensive review of the current status and government initiatives for the development and growth of renewable energy in India. The study is based on the following objectives:

Objectives and Research Methodology:

- To examine the current status of renewable energy in India, focusing on installed capacity and energy generation.
- To analyse the government initiatives for the development of the renewable energy sector in India.

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- To gain a deeper understanding of India's progress in renewable energy and the role of government efforts in shaping its future energy landscape this study is important.

The present study is entirely based on secondary data collected from authentic sources, including CMIE, Economic Outlook, the Ministry of New and Renewable Energy, the Central Electricity Authority, the Ministry of Power, and others.

Panchamrit and climate strategy of India:

India with the aim of energy independence and energy security adopted ambitious climate strategy based on 'Panchamrit. Energy security ensures the consistent availability of affordable, reliable energy, through diversification and strong infrastructure. 'Energy independence' in India aims to achieve self-sufficiency in energy production by meeting energy needs primarily through domestic resources, reducing reliance on fossil fuel imports. India is working towards energy independence by 2047, focusing on expanding renewable sources like solar and wind power to reduce foreign dependence and address climate change. This goal will help India overcome trade deficits and support Carbon reduction with the government supported greener energy solutions for a sustainable future. In this context, at the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26), India announced its ambitious climate action plan, with five key elements, collectively referred to as the 'Panchamrit,' which form the foundation of the country's climate strategy. The plan includes:

- Reaching 500 GW of non-fossil energy capacity by 2030.
- Sourcing 50% of its energy needs from renewable sources by 2030.
- Reducing total projected carbon emissions by one billion tonnes by 2030.
- Cutting the carbon intensity of the economy by 45% by 2030, compared to 2005 levels.
- Achieving net-zero emissions by 2070

These ambitious commitments reflect India's determination to accelerate its transition to cleaner energy sources, mitigate climate change, and contribute to global climate goals while fostering sustainable growth. Today, the growing consumption of energy in both the domestic and commercial sectors emphasizes the need for a comprehensive analysis of current energy usage, installed generation capacity, actual energy production, and future demand. Accurate forecasting is crucial for shaping effective economic and environmental policies, as well as guiding investments into renewable energy. Therefore, the following section of this research paper examines these key aspects.

Current status of energy consumption and renewable energy in India:

Renewable energy, often referred to as clean energy, is sourced from natural resources that are continuously recharged. As the global population grows, the demand for energy in the household sector, businesses, and other industries continues to rise. Innovation and the expansion of renewable energy sources are key to maintaining a stable energy supply, preventing climate change, and protecting the Earth and other natural resources for future generations.

Projection of primary energy consumption in India: India's energy consumption has grown significantly due to rapid population growth. In 1970-71, there were 1.02 crore domestic consumers and 30.2 lakh commercial consumers. By 2022-23, domestic consumers increased to 27.3 crore, while commercial consumers grew to 3.2 crore. With a projected population of 1.658 billion by 2050, India's energy consumption is expected to grow at the fastest rate among major economies by 2040. Renewable energy, along with coal, has become crucial in meeting this demand. By 2020, renewable energy surpassed gas and oil to become the second-largest source of domestic power.

In terms of global energy consumption, India's consumption rose from 195 Mtoe in 1990 to 880 Mtoe in 2016, with projections reaching 1,921 Mtoe by 2040. In comparison, the US and China consumed 2,334 Mtoe and 3,387 Mtoe, respectively, in 2016. From 1990 to 2016, India's energy consumption grew by 5.2%, compared to 0.6% for the US and 5.9% for China. From 2016 to 2040, India's consumption is projected to increase by 4.2%, while China's will grow by 1.5%, and the US will see no increase. This highlights India's rapid energy demand growth, with renewable energy playing a key role in meeting future needs.

The energy requirement and availability of power (electrical energy) in India:

India's energy requirements and availability have changed significantly over time. In 1999-2000, energy demand was 4,80,430 Mkwh, with a shortfall of 6.21%. By 2023-24, energy demand increased to 16,26,132 Mkwh, a 3.38-fold rise, with a reduced deficit of just 0.25%. Peak demand in 2023-24 was 2,43,271 MW, with a deficit of only 1.37%. Factors responsible for this increase include urbanization, rising incomes, industrial growth, agricultural mechanization, and the adoption of electric vehicles and appliances. In 2012, electricity demand across sectors was: industrial – 336 TWh, residential – 175 TWh, commercial – 86 TWh, and agriculture – 136 TWh. Projections for 2047 show significant increases across all sectors, with industrial demand reaching 1,366 TWh, residential demand 1,840 TWh, commercial demand 771 TWh, and agriculture 501 TWh,. The population growth is the cause of rising residential demand of energy in India. India has made significant progress in reducing energy deficits, yet electricity demand continues to be more compare to supply due to rapid economic growth. In 2023, electricity consumption per capita reached 985 kWh, with total energy consumption growing at an average annual rate of 6.5% since 2020.

The Contribution of Renewable Energy Sources to Energy Demand in India:

Table 1 shows the electricity produced from renewable energy sources in India for the year 2014-15 was 61.72 billion units. The contributions from various sources in 2014-15 were as follows: wind power at 54.71%, solar power at 7.45%, bagasse at 18.95%, small hydro power at 13.06%, and biomass at 5.11%. By the present year, electricity generation from these renewable sources has increased to 225.83 billion units. While in 2023-24 the contribution of wind power has decreased by 18%, bagasse by 14%, small hydro power by 9%, and biomass by approximately 3%, the contribution from solar power has seen a significant increase of 43%.

Table 1 Electricity generation from Renewable energy sources 2014-2015 to 2023-24

Year	Total (Billion Units)	Wind power (%)	Solar power (%)	Bagasse-based electricity (%)	Small hydro power (%)	Biomass based electricity (%)	Other renewable energy sources (%)
2014-15	61.72	54.71	7.45	18.95	13.06	5.11	0.72
2015-16	65.78	50	11.32	19.68	12.71	5.67	0.4
2016-17	81.55	56	16.56	12.19	9.38	5.13	0.3
2017-18	101.84	52	25.40	11.63	7.55	3.34	0.35
2018-19	126.76	49	30.98	10.70	6.87	2.18	0.33
2019-20	138.34	47	36.24	2.91	7.92	2.12	0.26
2020-21	147.25	41	41.02	7.68	6.97	2.39	1.1
2021-22	170.91	40	43.00	7.36	6.12	2.04	1.3
2022-23	203.55	35	50.12	6.32	5.49	1.55	1.24
2023-24	225.83	37	51.35	4.79	4.20	1.51	1.21

Source: Calculations based on CMIE, Economic outlook data

In 2023-24, renewable energy sources contributed 20.75% to India's total energy generation. Since the year 2014-15, generation of energy from Solar, Wind, Bio and Small Hydro Power has increased by 265.89%, reflecting significant growth in the country's renewable energy sector. According to the Renewable Energy Statistics 2024, India ranks 5th globally in total renewable energy generation and 4th in solar power generation.

In 2023-24, the top five states—Rajasthan, Gujarat, Karnataka, Himachal Pradesh, and Tamil Nadu—produced 56% of India's total renewable energy. Rajasthan, Karnataka, Gujarat, Tamil Nadu, and Andhra Pradesh generated over 75% of the country's solar power, while Gujarat, Tamil Nadu, Karnataka, Andhra Pradesh, Rajasthan, and Maharashtra contributed 93% of wind energy. Maharashtra, Uttar Pradesh, Karnataka, West Bengal, and Chhattisgarh together accounted for 74% of bioenergy production, and Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Karnataka, and Sikkim contributed 62.47% of large hydro power generation.

Installed Capacity of Renewable Energy in India and States:

The installed capacity of renewable and conventional (non-renewable) energy refers to 'the total maximum power generation potential of all power plants in a system, derived from all energy sources'. This includes both renewable and non-renewable sources, or conventional and non-conventional sources of energy. The table 2 below provides the installed(generating) capacity from conventional and renewable sources of energy in India:

Table no. 2 Installed Capacity in Renewable Energy and Conventional (NRE) Sector (in GW)

Year	Conventional Energy (Non-RE)		Total Conventional (Non-RE)	Renewable energy sources		Total RE	Grand Total (RE+NRE)
	Thermal	Nuclear		Hydro	Other Renewables*		
1994-95	57.25	1.94	59.19	20.50	0.00	20.50	79.69
2000-01	72.91	2.70	75.61	25.22	1.27	26.49	102.10
2005-06	82.41	3.36	85.77	32.32	6.19	38.51	124.28
2010-11	112.84	4.78	117.62	37.57	18.46	56.03	173.65
2014-15	188.90	5.78	194.68	41.27	31.69	72.96	267.64
2015-16	210.67	5.78	216.45	42.78	38.83	81.61	298.06
2016-17	218.33	6.78	225.11	44.48	57.26	101.74	326.85
2017-18	222.90	6.78	229.68	45.30	69.02	114.32	344.00
2018-19	226.30	6.78	233.08	45.40	77.64	123.04	356.12
2019-20	230.80	6.78	237.58	45.70	86.76	132.46	370.04
2020-21	234.73	6.78	241.51	46.21	94.44	140.65	382.16
2021-22	236.10	6.78	242.88	46.72	109.89	156.61	399.49
2022-23	237.27	6.79	244.06	46.85	125.16	172.01	416.07
2023-24	243.22	8.18	251.40	46.93	143.64	190.57	441.97

Source: CMIE, Economic Outlook

(Other Renewables*Comprising of Solar, Wind, Bio-Power and Small Hydro Power etc.)

India has made remarkable progress in increasing its renewable energy capacity. From 1994-95, when the total installed capacity was 79.69 GW, including 20.50 GW from renewables, the country's capacity grew to 267.64 GW by 2014-15, with 72.96 GW from renewables. By 2023-24, the total capacity reached 441.97 GW, with renewable energy contributing 190.57 GW. This represents a fivefold increase in total capacity, a fourfold increase in conventional energy, and a nine-fold increase in renewable

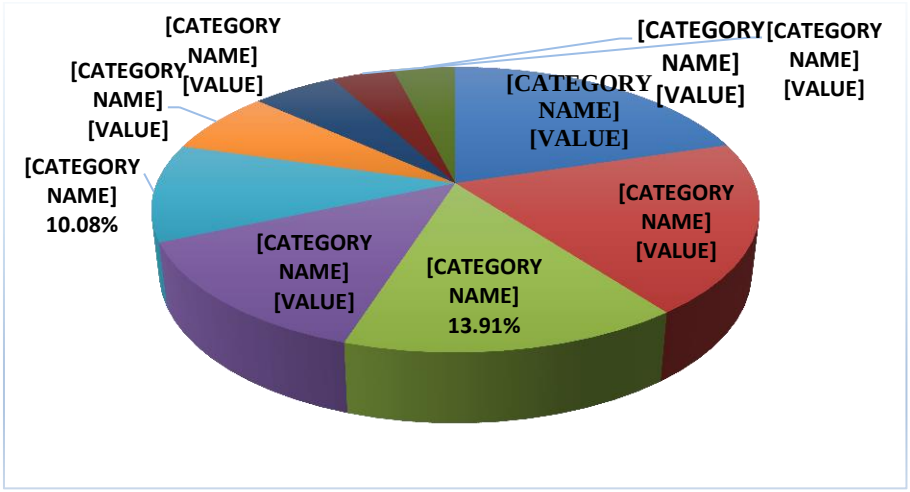
energy. The share of renewable energy in the total capacity rose from 1.04% in 1998-99 to 32.5% in 2023-24, highlighting India's significant advancements in its renewable energy sector over the past 26 years.

State wise installed capacity under Renewable Energy Sector:

Between 2017-18 and 2023-24, India experienced a significant rise in renewable energy capacity, with its share of total installed capacity growing from 33.55% to 43.12%, marking nearly a 10% increase. States like Gujarat, Rajasthan, Tamil Nadu, Karnataka, and Maharashtra have been at the forefront of this growth, significantly boosting their solar and wind energy production by Utilizing their geographic advantages. This growth highlights India's commitment to sustainable development and reducing reliance on fossil fuels. The chart 1 below illustrates the installed renewable energy capacity as on 31.03.2024 of key states.

As of March 31, 2024, Rajasthan, Gujarat, Tamil Nadu, Karnataka, and Maharashtra led India in renewable energy capacity, contributing about 61% of the total. Rajasthan had the highest share at 18.56%, followed by Gujarat (17.73%), Tamil Nadu (13.91%), Karnataka (12.35%), and Maharashtra (10.08%). Andhra Pradesh, Madhya Pradesh, and Telangana also made notable contributions. These states accounted for 70.76% of solar capacity and 93.37% of wind power. In bioenergy, Maharashtra, Uttar Pradesh, Karnataka, and Tamil Nadu contributed 71.49%, while for large hydro, Himachal Pradesh, Uttarakhand, Karnataka, Jammu and Kashmir, Maharashtra, and Telangana made up 57.15%.

Chart No. 1 State wise installed capacity of Renewable Power as on 31.03.2024



Source: Ministry of New and Renewable Energy Resources, Govt. of India

Rajasthan led growth, adding 19,814.53 MW (271.83% increase), followed by Gujarat with 18,122.27 MW (194.04% growth). Tamil Nadu and Maharashtra saw growth rates of 64.75% and 52.18%, respectively, while Karnataka increased its capacity by over 5,200 MW (32.02% growth). Rajasthan also had the highest Compound Annual Growth Rate (CAGR) at 24.47%, with Gujarat, Tamil Nadu, Maharashtra, and Karnataka following at 19.69%, 8.68%, 7.25%, and 4.74%.

Gross Installed Capacity of Renewable Energy According to Ownership:

As per the Central Electricity Authority, India's total installed capacity of utilities in 1950 was 1,713 MW. As of March 31, 2023, India's total installed capacity reached 416,058.888 MW, with 125,159.805 MW coming from renewable energy, accounting for 30.08% of the country's total capacity. The installed capacity is divided across various sectors. Electricity Department/Government/Corporations/Joint Ventures hold 25.41% (105,726.43 MW), the Central Sector accounts for 24.05% (100,054.93 MW), and the Private sector holds the largest share with 50.54% (210,277.53 MW). In renewable energy, the private sector dominates, owning about 96.70% of the capacity, while the central and state governments hold 1.30% and 1.99%, respectively. Key private companies like Tata Power, Suzlon, and ReNew Power are driving the growth of India's renewable energy sector. India's renewable energy capacity has grown significantly, driven by solar, wind, and hydroelectric projects, reducing reliance on fossil fuels and enhancing energy security. With the addition of 8,180 MW of nuclear capacity, nearly half of the country's electricity generation now comes from non-fossil sources. The growth of renewable energy, especially solar power, is helping lower greenhouse gas emissions and diversify India's energy mixture. The above successful development in the energy sector is the outcome of government initiatives in the country for the development of renewable energy sector, discussed follows:

Government initiatives:

The government has introduced several initiatives to boost renewable energy, improve grid stability, and lower carbon emissions, aiming to ensure a reliable and sustainable energy future for the country. The Ministry of New and Renewable Energy implements many of the schemes explained below. The important initiatives are as follows:

1 **Centralized Data Collection and Coordination (CCDC) Wind Initiative:** The Centralized Data Collection and Coordination (CCDC) Wind Initiative, launched by the government in June 2020 with the objective to accelerate wind energy development in India. The initiative centralizes data collection, enhances wind resource mapping, and provides accurate assessments for optimal site selection, encouraging private sector investments and public-private partnerships. Over 800 wind-monitoring stations have been installed, and wind potential maps have been published. As of January 30, 2024, India's

wind power capacity reached 48.16 GW, a 30% increase since 2020. From 2004 to 2024, wind energy capacity grew from 1.86 GW to 48.16 GW. In 2024, the Union Cabinet approved Rs. 7,453 crores for India's first offshore wind projects, including funding for capacity development and port upgrades.

2 **National Green Hydrogen Mission:** National Green Hydrogen Mission launched by government in January 2023 with the aims of transition India to a hydrogen-based economy by advancing green hydrogen production and infrastructure. With over Rs. 8 lakh crore in investments, the mission targets a capacity of 5 million metric tons by 2030, creating 6 lakh jobs. The key achievements of mission include ₹19,744 crore allocated for infrastructure, establishment of 3 hydrogen production hubs, and tenders for 4.12 lakh tonnes of green hydrogen per year. Financial incentives, such as a 50% subsidy on electrolyser manufacturing, were also introduced by government. India hosted major global events, such as reinforcing its leadership in green hydrogen technology.

3 **National Solar Mission (NSM):** Launched in January 2010, the National Solar Mission (NSM) aims to enhance India's energy security and contribute to global climate change efforts by promoting sustainable solar power growth. It supports initiatives like Solar Parks, Canal Bank & Canal Top, and Grid-Connected Solar Rooftops to boost solar energy generation. The mission's goals align with India's Nationally Determined Contributions (NDCs), including sourcing 50% of electric power from non-fossil fuels and reducing emission intensity by 45% by 2030. By 2023, India ranked 5th globally in solar power utilization, with capacity growing from 9.01 GW in 2016 to 97.86 GW in 2025. The country's solar potential was estimated at 748.98 GW in 2024, and the number of solar parks increased from 34 in 2016 to 58 by 2024. Off-grid solar projects, including home lights, lamps, and street lights, also grew significantly from 2016 to 2024.

4 **PM-KUSUM Scheme:** The **Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana (PM-KUSUM Scheme),** launched in March 2019, provides financial support to farmers for the installation of solar-powered irrigation systems, such as solar pumps and grid-connected solar power plants. The scheme aims to promote solar energy, reduce dependency on diesel pumps, lower fuel costs, and enhance energy access in rural areas. Additionally, farmers can sell surplus solar energy back to the grid, boosting their income. With subsidies ranging from 30% to 50%, PM-KUSUM makes clean energy more accessible and helps reduce carbon emissions. By December 2024, the scheme plans to install over 6.1 lakh solar pumps, up from 3.3 lakh in 2021, and solarize 35 lakh grid-connected agricultural pumps. As of June 2024, more than 4 lakh farmers have benefited from the scheme, with Components B and C offering capital subsidies for standalone and grid-connected pumps. Furthermore, 11.34 GW of solar capacity was installed between January and November 2024.

5 **PM Surya Ghar Muft Bijli Yojana:** The yojana is launched in February 2024. This is the world's largest domestic rooftop solar initiative, aiming to supply solar power to one crore households by March 2027. It offers financial incentives to help households install solar panels, reducing reliance on the national grid and lowering electricity bills. In its first year, over 1 lakh homes installed rooftop panels, and within 10 months, 7 lakh installations were completed, averaging 70,000 per month. States like Gujarat, Maharashtra, Kerala, and Uttar Pradesh have made significant progress. The scheme also includes the 'Model Solar Village' program, with an ₹800 crore budget, encouraging villages to adopt solar energy, with winning villages receiving ₹1 crore for further renewable energy development.

6 **BioUrja and Akshay Urja:** The BioUrja Initiative, running from April 2021 to March 2026, promotes Waste to Energy projects that convert urban, industrial, and agricultural waste into biogas, bio-CNG, power, or producer/syngas. It provides Central Financial Assistance (CFA) to project developers and service charges to implementing agencies. The initiative also supports the establishment of biomass briquette/pellet manufacturing plants and non-bagasse biomass-based cogeneration projects in industries. The Akshay Urja Program, launched by the Government of India, encourages the use of renewable energy across the country through various schemes, events, and Akshay Urja Shops. It promotes clean energy solutions like solar, wind, and biomass, playing a key role in advancing India's sustainable energy future.

7 **Other initiatives:** The **FAME Scheme** promotes the adoption of electric vehicles (EVs) and the development of EV charging infrastructure to support cleaner transportation. The Ujjwala Yojana provides LPG connections to households, reducing reliance on biomass fuels, cutting carbon emissions, and improving health. Incentive Programs for Renewable Energy **Storage** aim to boost energy storage technologies, enhancing the stability of solar and wind power grids. The **Perform,** Achieve, and Trade (PAT) Scheme **incentivizes industries to improve energy efficiency and adopt cleaner technologies. Lastly, the** Atmanirbhar Bharat Abhiyan focuses on boosting domestic renewable energy manufacturing to reduce reliance on imports.

Conclusions:

The government's climate strategy, valued at US$ 109.50 billion (Rs. 9,22,866 crore), aims to expand India's power infrastructure to meet a demand of 456 GW by 2032. The Ministry of New and Renewable Energy targets 500 GW of non-fossil-based electricity generation by 2030. The success in the targets is based on the key initiatives of the government that focus strengthening transmission networks, integrating renewable energy, and enhancing energy security. These efforts contribute to the country's energy sector sustainability, as reflected in its growing installed and generation capacity.

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