



Renewable energy in India: Current status

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Abstract

India, a global trailblazer in sustainable energy solutions, strategically adopts renewables to address surging energy demands. As of December 31, 2022, the nation showcases significant achievements across solar (63.3 GW), wind (41.93 GW), bioenergy (10.73 GW), and small hydro (4.94 GW). Innovative projects contribute 11.06 GW, forming a robust pipeline of 218.1 GW. Large hydro adds 46.85 GW, resulting in a total renewable capacity of 167.75 GW. Diverse solar potential is evident across states like Jammu & Kashmir and Rajasthan. Wind power installations in Gujarat and Tamil Nadu underscore regional commitments. The consistent growth in wind energy generation, reaching 59,532 MU in 2022-23, emphasizes the efficacy of wind projects. With over 5 million small biogas plants installed nationwide, the New National Biogas and Organic Manure Programme reflects India's commitment to sustainable waste management, positioning the country as a key global player in the renewable energy transition.

Keywords: Sustainable renewable wind solar hybrid energy

Introduction

India, with its burgeoning population and growing economy, has become a trailblazer in the global pursuit of sustainable energy solutions. The country has strategically embraced renewable energy sources to meet its increasing energy demands while addressing environmental concerns and advancing its commitment to combat climate change. As of December 31, 2022, India's renewable energy landscape is marked by significant achievements across various sectors, including solar, wind, bioenergy, and small hydro. These milestones not only underscore India's dedication to clean and green energy but also highlight the nation's pivotal role in the global renewable energy transition.

India's solar prowess shines with an installed capacity of 63.3 GW, complemented by 51.13 GW in progress and 20.34 GW tendered, achieving a cumulative 134.77 GW. Wind energy thrives with 41.93 GW installed, 12.93 GW ongoing, and 1.2 GW tendered, reaching 56.06 GW. Bioenergy hits 10.73 GW, small hydro marks 4.94 GW installed, and 0.54 GW underway, totaling 5.48 GW. Innovative hybrid projects contribute 11.06 GW. Large hydro impresses with 46.85 GW installed and 14.15 GW underway, summing up to 61 GW. India's overall renewable

capacity stands at an exceptional 167.75 GW, projecting growth to 279.1 GW. This data-centric overview underscores India's dedication to a sustainable future, not only meeting domestic energy needs but significantly contributing to a cleaner, greener global landscape.

Renewable Energy in India

India's renewable energy evolution involves ambitious goals, substantial investments, and technological strides. Driven by environmental, security, and economic factors, the nation pivots from fossil fuels. Solar prowess defines India's global standing, propelled by abundant sunlight and cost-effective solar panels. The Jawaharlal Nehru National Solar Mission initiated a solar capacity surge. Wind energy thrives in favorable conditions, supported by policies. Bioenergy taps into organic sources, with biogas gaining momentum. Small hydro projects harness river energy, contributing eco-friendly power to the renewable grid.

Global impact

India's renewable energy commitment resonates globally, aiding the collective effort to combat climate change. Aligned with international agreements like the Paris

Agreement, India's transition echoes the broader goal of temperature control. With evolving technology and supportive policies, India emerges as a pivotal player, spearheading the global renewable energy transformation.

Objectives

- To review the renewable energy policy in India.
- Examine the renewable energy in India: Current status

Data and methodology

The study used secondary data, collect data from the Ministry of New and Renewable Energy (MNRE), Annual Report 2022-23. And also gathered from both published and unpublished sources, including book reviews, journal articles, working papers, books, magazines, newspapers, reports, Extract relevant information on installed capacities, implementation progress, tendered projects, solar potential, wind power installations, electricity generation, and biogas plant achievements.

Literature reviews

Abu Rayhan (2023) ^[2]: The research analyzes sustainable energy's future, addressing climate change, exploring technologies, policy frameworks, and international agreements. It assesses economic, social, and environmental impacts, including job creation and energy access.

Charles Rajesh Kumar and MA Majid (2020) ^[5]: This study explores the potential of renewable energy to drive sustainable development in India by ensuring widespread access to affordable and clean energy. They examine India's progress in renewable energy, including achievements, challenges, and future prospects. The study focuses on electricity generation, investment opportunities, job creation, and the identification of key obstacles hindering the sector's growth. The findings and recommendations of this research aim to inform policymakers, industry stakeholders, investors, and researchers in their efforts to advance India's renewable energy landscape.

Subhashish Dey *et al.* (2022) ^[3]: This study examines the correlation between a nation's development level (measured by real GDP per capita) and the evolution of its energy mix. Recognizing India's position as the world's fourth most attractive renewable energy market, they explore the intricate relationship between renewable energy and sustainable development. The paper proposes that boosting investments in renewable energy generation, energy efficiency, and environmentally-focused technological innovation can significantly accelerate the transition to a sustainable future.

Major schemes on the renewable energy in India

- Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM): For decentralized solar power, Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) As of December 31, 2022, 88.45 MW of solar power plants had been installed under Component A of the scheme, 1.81 lakh standalone solar pumps had been installed under

Component B, and 1174 pumps had been reported solarized under Component C's individual pump solarization variant.

- Phase II of the Roof Top Solar (RTS) Program: Approximately 1.66 GW of capacity was reported installed as of December 31, 2022, falling short of the program's 4 GW RTS target in the residential sector. As of December 31, 2022, there were approximately 7.6 GW worth of grid-connected RTS plants installed nationwide. The Rooftop Solar Program's Phase II timeline has been extended until March 31, 2026.
- Grid-Connected Solar Photovoltaic (PV) Power Projects Under the Central Public Sector Undertaking (CPSU) Scheme: As of December 31, 2022, about 8.2 GW of projects had been awarded under this scheme; of those, about 1.5 GW had been put into service, and the remaining projects were still in the implementation stage.
- Creation of Solar Parks and Ultra Mega Solar Power Projects: As of December 31, 2022, 57 Solar Parks in 13 states, totaling 39.28 GW in capacity, had been approved under this program.
- "National Programme on High Efficiency Solar PV Modules" is the PLI Scheme. With an investment of Rs. 24,000 crore, the Indian government is putting the Production Linked Incentive (PLI) Scheme for the National Programme on High Efficiency Solar PV Modules into action in an effort to reach Giga Watt (GW) levels of manufacturing capacity for these modules. Approximately 8.7 GW of fully integrated solar PV module manufacturing capacity, valued at Rs 4,500 crore, were granted under PLI Tranche-I and are currently being implemented. On November 18, 2022, the Solar Energy Corporation of India (SECI) released the bid document for the selection of manufacturers under Tranche-II, which has an outlay of Rs 19,500 crore.
- Green Energy Corridor: As of December 31, 2022, 19868 MVA intrastate substations had been charged and 8759 ckm of intrastate transmission lines had been built. The seven states of Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu, and Uttar Pradesh are presently in the process of releasing tenders to carry out projects for the evacuation of 20 GW of renewable capacity under the terms of the second phase of the Intra-State Transmission System Green Energy Corridor Scheme (InSTS GEC-II), which was approved on January 6, 2022.
- Wind Energy: The Ministry of Finance has extended the concessional custom duty benefit (CCDC) for a number of wind turbine components until March 31, 2025, based on the recommendation of the MNRE (Notification No. 02/2023-Customs dated 01.02.2023).
- Bioenergy: As of December 31, 2022, there were approximately 10.2 GW of installed capacity in biomass power and cogeneration projects combined. As of December 31, 2022, the total installed capacity of waste to energy is 522.42 MWeq.

Data and interpretation**Table 1:** Sector-wise Cumulative Achievements (as of 31.12.2022) (in GW)

Sector	Installed capacity	Under Implementation	Tendered	Total Installed/Pipeline
Solar Power	63.3	51.13	20.34	134.77
Wind Power	41.93	12.93	1.2	56.06
Bio Energy	10.73			10.73
Small Hydro	4.94	0.54	0	5.48
Hybrid/ Round the Clock (RTC) / Peaking Power/ Thermal + RE Bundling			11.06	11.06
Sub-Total	120.9	64.6	32.6	218.1
Large Hydro	46.85	14.15		61
Total	167.75	78.75	32.6	279.1

Source: Ministry of new and renewable energy (Annual Report 2022-23).

Table 1 shows that India's renewable energy landscape exhibits substantial achievements. Solar power leads with an installed capacity of 63.3 GW, and a robust pipeline with 51.13 GW under implementation. Wind power contributes significantly with 41.93 GW installed, and 12.93 GW in progress. The bioenergy sector shows a cumulative installed capacity of 10.73 GW. Small hydro projects have added 4.94 GW, with 0.54 GW under implementation. Hybrid and

bundled power projects, totaling 11.06 GW, showcase a growing trend. The overall cumulative achievements, including large hydro, amount to 218.1 GW. The data underscores India's commitment to a diversified and sustainable energy portfolio, with a total installed and pipeline capacity of 279.1 GW across various renewable energy sectors.

Table 2: State-wise estimated Solar Energy Potential in the Country (GW)

Sl. No.	States/UTs	Solar Potential	Sl. No.	States/UTs	Solar Potential
1	Andhra Pradesh	38.44	17	Manipur	10.63
2	Arunachal Pradesh	8.65	18	Meghalaya	5.86
3	Assam	13.76	19	Mizoram	9.09
4	Bihar	11.2	20	Nagaland	7.29
5	Chhattisgarh	18.27	21	Odisha	25.78
6	Delhi	2.05	22	Punjab	2.81
7	Goa	0.88	23	Rajasthan	142.31
8	Gujarat	35.77	24	Sikkim	4.94
9	Haryana	4.56	25	Tamil Nadu	17.67
10	Himachal Pradesh	33.84	26	Telangana	20.41
11	Jammu & Kashmir	111.05	27	Tripura	2.08
12	Jharkhand	18.18	28	Uttar Pradesh	22.83
13	Karnataka	24.7	29	Uttarakhand	16.8
14	Kerala	6.11	30	West Bengal	6.26
15	Madhya Pradesh	61.66	31	UTs	0.79
16	Maharashtra	64.32		Total	748.98

Source: Ministry of new and renewable energy (Annual Report 2022-23).

Table 2 highlights India's state-wise solar potential, showcasing opportunities in states like Andhra Pradesh, Karnataka, and Tamil Nadu, each exceeding 15 GWp. Jammu & Kashmir and Rajasthan stand out with 111.05

GWp and 142.31 GWp, emphasizing untapped potential. Cumulatively, India's solar capacity reaches an impressive 748.98 GWp, guiding strategic planning for sustainable energy growth.

Table 3: State wise Wind Power installed capacity.

S. No.	State	Installed Capacity (MW)
1	Andhra Pradesh	4096.65
2	Gujarat	9866.62
3	Karnataka	5269.65
4	Kerala	62.5
5	Madhya Pradesh	2844.29
6	Maharashtra	5012.83
7	Rajasthan	4681.82
8	Tamil Nadu	9963.02
9	Telangana	128.1
10	Others	4.3
	Total (MW)	41929.8

Source: Ministry of new and renewable energy (Annual Report 2022-23).

Table 3 underscores the substantial contributions of Gujarat and Tamil Nadu, leading in wind power capacities at 9,866.62 MW and 9,963.02 MW, showcasing their commitment. Maharashtra, Andhra Pradesh, and Karnataka collectively contribute over 15,000 MW, indicating widespread adoption. Even smaller capacities in states like Kerala and Telangana highlight nationwide acceptance. With a total capacity of 41,929.8 MW, this data guides policymakers and investors towards effective wind energy utilization for sustainable power generation in India.

Table 4 The year-wise electricity generation from wind energy sources table illustrates a consistent and noteworthy growth in wind power production in India over the past nine years. The data reveals a steady upward trend, showcasing the effectiveness and increasing contribution of wind energy to the country's electricity grid. Starting from 33,768 million units (MU) in 2014-15, the generation has progressively risen, reaching 59,532 MU in 2022-23. This indicates a significant enhancement in the efficiency and capacity of wind power installations. The notable increase in the latest year, 2022-23, highlights the ongoing efforts and

advancements in harnessing wind energy for sustainable electricity generation. The data serves as a crucial indicator for policymakers and stakeholders, emphasizing the positive trajectory of wind energy's role in India's overall energy landscape.

Table 4: Year wise electricity generation from wind energy sources

S. No.	Year	Generation (MU)
1	2014-15	33768
2	2015-16	33029
3	2016-17	46004
4	2017-18	52666
5	2018-19	62036
6	2019-20	64639
7	2020-21	60149
8	2021-22	68640
9	2022-23	59532

Source: Ministry of new and renewable energy (Annual Report 2022-23).

Table 5: The State/UT- wise achievements for family type/small biogas plants, under the new national biogas and organic manure programme

S. No.	States/ UTs	Cumulative number of small biogas plants installed
1	Andhra Pradesh	268598
2	Arunachal Pradesh	3621
3	Assam	139414
4	Bihar	130072
5	Chhattisgarh	60250
6	Goa	4234
7	Gujarat	435638
8	Haryana	64013
9	Himachal Pradesh	47718
10	Jammu & Kashmir	3201
11	Jharkhand	7890
12	Karnataka	512755
13	Kerala	153666
14	Madhya Pradesh	379154
15	Maharashtra	931313
16	Manipur	2128
17	Meghalaya	11156
18	Mizoram	5857
19	Nagaland	7953
20	Odisha	271752
21	Punjab	187145
22	Rajasthan	72886
23	Sikkim	9044
24	Tamil Nadu	224037
25	Telangana	316727
26	Tripura	3744
27	Uttar Pradesh	441180
28	Uttarakhand	365188
29	West Bengal	1216
30	Andaman & Nicobar	97
31	Chandigarh	169
32	Dadar & Nagar Haveli	681
33	Daman & Diu	0
34	Delhi	578
35	Lakshadweep	0
36	Puducherry	17541
37	Total	5080616

Source: Ministry of new and renewable energy (Annual Report 2022-23).

The table 5 State/UT-wise achievements for family-type/small biogas plants under the New National Biogas and Organic Manure Programme portrays a commendable nationwide adoption of biogas technology. Maharashtra leads with an impressive installation of 931,313 biogas plants, indicating a strong commitment to sustainable energy practices. Gujarat and Uttar Pradesh also stand out, contributing significantly with 435,638 and 441,180 installations, respectively. The widespread adoption is notable in smaller states and Union Territories like Sikkim, Andaman & Nicobar, and Puducherry, showcasing the program's reach across diverse regions. The cumulative installation of 5,080,616 biogas plants nationwide reflects the success and acceptance of this eco-friendly initiative. This data serves as a testament to the effectiveness of the New National Biogas and Organic Manure Programme in promoting clean energy and sustainable waste management practices across India.

Conclusion

India's renewable energy landscape, as of December 31, 2022, exemplifies the nation's remarkable progress towards sustainable energy solutions. Boasting an impressive total installed capacity of 167.75 GW across solar, wind, bioenergy, small hydro, and hybrid projects, India emerges as a global leader in renewable energy adoption. The solar sector leads with 63.3 GW, while wind power contributes 41.93 GW, and bioenergy showcases 10.73 GW. State-wise analysis reveals diverse solar potential, with states like Jammu & Kashmir and Rajasthan playing pivotal roles. Wind power installations in Gujarat and Tamil Nadu underline regional commitments. The consistent growth in wind energy generation, reaching 59,532 MU in 2022-23, indicates the efficacy of wind projects in meeting electricity demands. With over 5 million small biogas plants installed nationwide, the New National Biogas and Organic Manure Programme reflects India's dedication to sustainable waste management. These achievements, complemented by ongoing government initiatives, position India as a key player in the global renewable energy transition, contributing significantly to a cleaner and greener world.

References

1. Abolhosseini S, Heshmati A, Altmann J. A review of renewable energy supply and energy efficiency technologies. IZA Discussion Paper No. 8145. April 2014.
2. Abu Rayhan. The future of sustainable energy. ResearchGate. 2023;1(2):01-58. Available from: <https://doi.org/10.13140/RG.2.2.10562.96962/2>
3. Dey S, Sreenivasulu A, Veerendra GTN, Rao KV, Babu PSSA. Renewable energy present status and future potentials in India: An overview. Innovation and Green Development. 2022;1(1):100006. Available from: <https://doi.org/10.1016/j.igd.2022.100006>
4. Kumar A, Kumar K, Kaushik N, Sharma S, Mishra S. Renewable energy in India: Current status and future potentials. Renewable and Sustainable Energy Reviews. 2010;14(8):2434-2442. Available from: <https://doi.org/10.1016/j.rser.2010.04.003>
5. Kumar CR, Majid MA. Renewable energy for sustainable development in India: Current status, future

- prospects, challenges, employment, and investment opportunities. Energy, Sustainability and Society. 2020;10(1):1-36. Available from: <https://doi.org/10.1186/s13705-019-0232-1>
6. Ministry of New and Renewable Energy [Internet]. Available from: <https://mnre.gov.in>
7. National Portal for Rooftop Solar [Internet]. Available from: <https://solarrooftop.gov.in/>
8. Human Resource Development (HRD) Portal [Internet]. Available from: <https://hrd.mnre.gov.in>
9. Biourja Portal [Internet]. Available from: <https://biourja.mnre.gov.in/>
10. Research and Development (R&D) Portal [Internet]. Available from: <https://serviceonline.gov.in/dbt/>
11. PM KUSUM Portal [Internet]. Available from: <https://pmkusum.mnre.gov.in/landing.html>
12. Solar Street Light Portal [Internet]. Available from: <https://ssl.mnre.gov.in/>
13. AkshayUrja Portal [Internet]. Available from: <https://akshayurja.gov.in>
14. Indian Renewable Energy Idea Exchange portal (IRIX) [Internet]. Available from: <https://irix.gov.in>

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