A Statistical Review of Energy in India

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Abstract. The usage of renewable energy resources has increased significantly in India because of the country's growing energy needs and environmental issues brought on by traditional fossil fuels. Global technological developments accelerated this transition. This article highlights the advantages and disadvantages of the form of energy generation as well as the difficulties in scaling up the energy units. It also provides a broad overview of the rise in renewable energy units in India during the past 10 years. A thorough statistical analysis of India's renewable energy market in 2024 is also included in the article, which looks at the industry's present capabilities, growth patterns, and contributions to the country's energy mix. It includes the anticipated increase in renewable energy consumption in India. The data came from a variety of sources, including the National Solar Mission, the Indian Solar Power Corporation, the International Renewable Energy Agency, the Ministry of New and Renewable Energy, the National Institute of Wind Energy, and the IBFA.

Keywords: Solar PV, Wind, Hydel, Renewable Energy

1 Introduction

1.1 World energy scenario

India has emerged as the world's third-largest energy user in the process of becoming fifth India has become the third largest energy consumer in the world as it is moving towards becoming the fifth largest economy in the world. Renewable energy has now been declared as the national priority as energy consumption has increased because of industrialization and population growth [1]. In order to reduce carbon emission from the burning of fossil fuels and to maintain the ecology, the Government of India has initiated various projects to promote wind, solar and biomass energy. Research supported by the International Renewable Energy Agency (IRENA) shows that the world's total renewable energy capacity was 1698 Giga Watts in 2014, and is expected to grow to 3870 GW by the end of 2023 [3].

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As per the statistics of IRENA, India has jumped to the 6th position in the world in terms of renewable energy production, which has increased by 473 GW. For the FY 2014-15, India's total renewable energy capacity has been 275.9 GW, according to the data of the Ministry of New and Renewable Energy. Renewable energy capacity of the country rose by 190.57 GW during 2023-2024, which is 134.63% increased in just 9 years. According to MNRE, the country will have a total of 473.1 GW of renewable energy by the end of 2023. Furthermore, in 2023-2024, the country's total non-renewable installations will be followed by installing a renewable capacity of 18.5 GW. This made it the fourth largest renewable energy producer and user in the world for the sixth time in a row [3].

India has dramatically increased its installed capacity from 81.22 GW in March 2015 to 190.57 GW by March 2024, making it a global leader in the growth of renewable energy. The percentage of installed capacity based on non-fossil fuels has increased significantly over this period, rising from 31.53% to 44.97%. Furthermore, renewable energy sources including solar, wind, biomass, and small hydropower have become increasingly important in the production of energy, increasing their share from 5.58% in 2014–15 to 13.02% in 2023–24. The previous nine years have seen a 260% increase in Renewable Energy capacity, excluding major hydro plants. The nation achieves its lofty goal of installing 500 GW of renewable energy capacity in the year [4].

2 Review of literature

2.1 Energy patterns

With 507 GW added in 2023 alone, the number of new RE installations worldwide has increased significantly. It is almost 50% increase over 2022, demonstrating the market's acceleration towards renewable energy. Due to lower generating costs and policies implemented by most nations to encourage them, it is predicted that solar and wind power will account for 96% of its capacity. By 2028, renewable energy output is predicted to reach 14,400 TWh, or 42% of global power generation. Advances in renewable energy capacity in relation to technological advances are shown in Figure 1 and 2. [3].

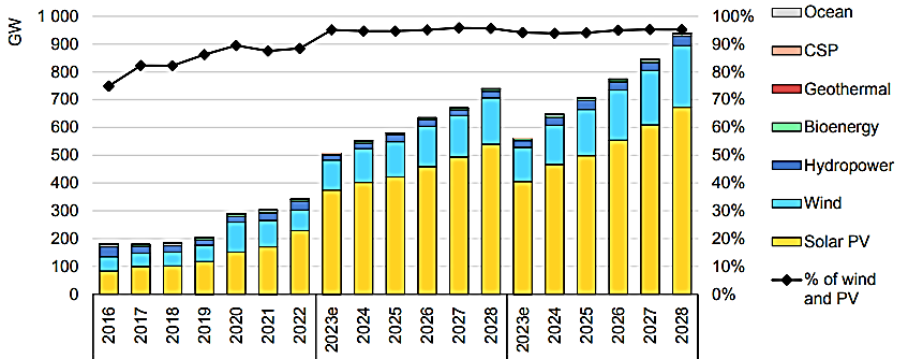

Fig. 1. RE capacity additions by technology trends.

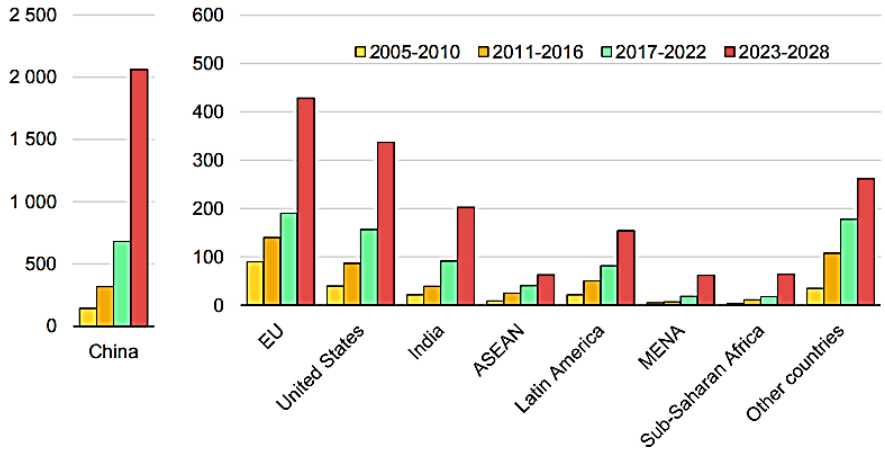

Fig. 2. Country-wise renewable capacity growth.

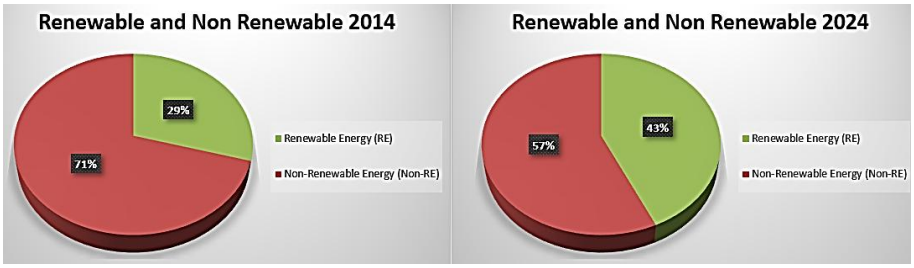

Fig. 3. Renewable and non-renewable energy share in India during 2014–2024.

Based on the MNRE-generated report displayed in Figure 3, it shows that 29% of energy comes from renewable sources, whereas 71% of fossil fuels were used in 2014. In 2024, there will be a more significant change, with 43% of the share coming from renewables and 57% from fossil fuels [5].

2.2 Review of different renewable energy resources

2.2.1 Solar photovoltaic

In the worldwide market for renewable energy, solar photovoltaics have the largest proportion. Because of controlled electricity pricing and ongoing PV (Photovoltaic) module cost reductions, China has long been the world's top manufacturer of solar PV. By the end of 2024, China should have achieved its cumulative solar PV and wind energy capacity target of 1,200 GW, which was once set for 2030. This would represent a significant advancement in the development of renewable energy. India's solar capacity increased from 1171 MW in 2014 to 15 GW, with a total rise of 94.16 GW until November 2024[11]. Due to several government programs, rising energy demand, and more understanding of solar technology, India's usage of solar power is expanding daily.

According to the 2023 MNRE and IRENA projections, India is now the fifth-largest country in terms of solar PV energy generation. With 18.7 GW of solar power capacity, Rajasthan state leads India, while Haryana has 1.02 GW. With a capacity of 4.66 GW, Telangana state ranks fifth nationwide. By 2030, India wants to have 280 GW of solar electricity installed as shown in figure 4 and 5.

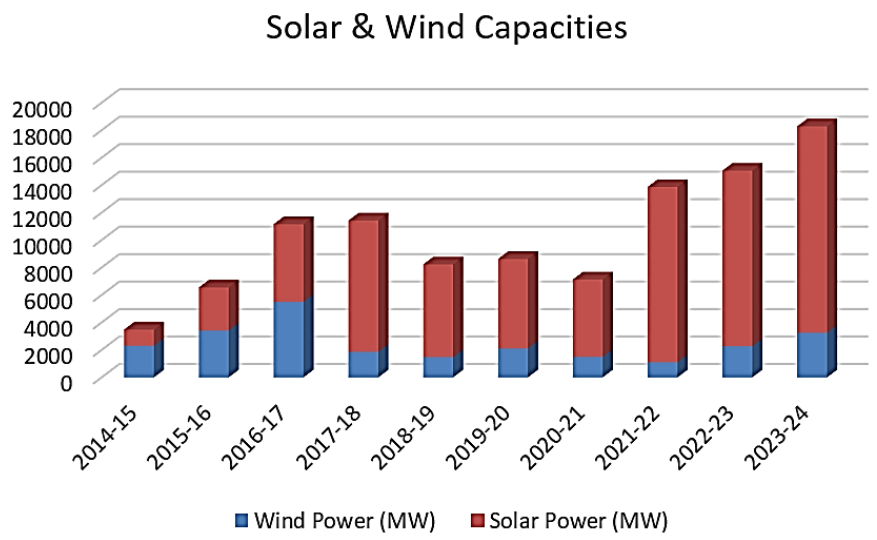

Fig. 4. Solar and wind capacities in India.

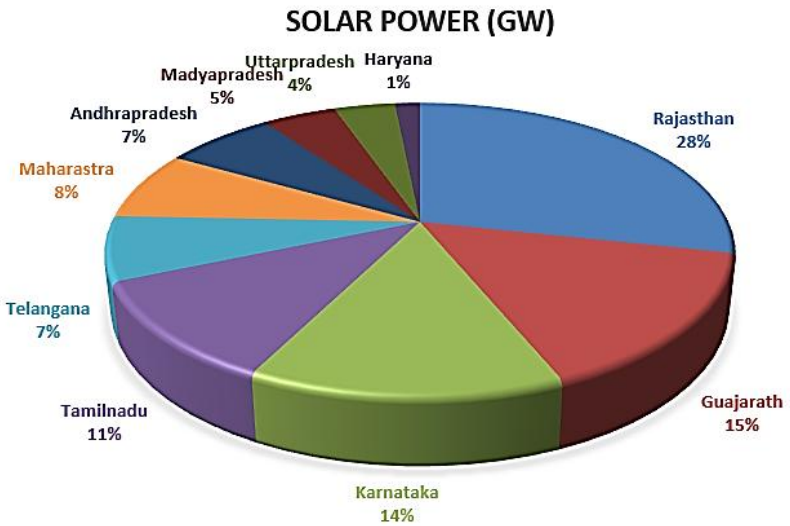

Fig. 5. State-wise solar power generation in India.

2.2.2 Wind power

Selecting potential sites necessitates a comprehensive Wind Resource Assessment because wind is a site-specific and intermittent energy source. Through the National Institute of Wind Energy (NIWE), the government has installed over 900 wind-monitoring stations around the country and published wind potential maps at heights of 50, 80, 100, 120, and 150 meters. The latest assessment indicates a total wind power potential of 1163.9 GW at 150 meters above ground level and 695.50 GW at 120 meters. Gujarat led in wind power production at a height of 120 meters with an installed capacity of 142.5 GW, while Rajasthan topped the chart at 150 meters with 284.2 GW of installed capacity as shown in figure 6.

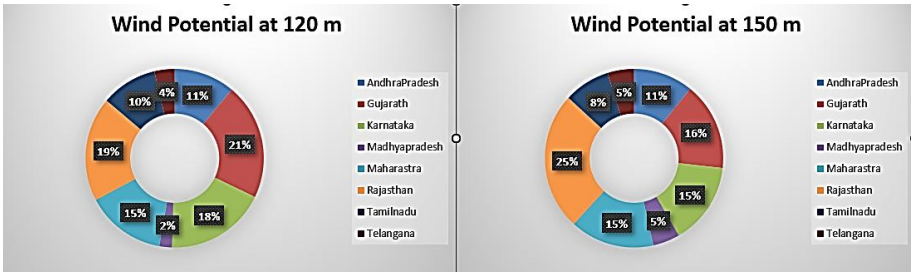

Fig. 6. State-wise wind potential at 120 meters and 150 meters.

2.2.3 Small hydro power

Under MNRE, small hydropower plants are considered while installing renewable energy. Figure 7 shows the installed capacity of small hydro power from 2014 to 2024, growing at a pace of 41.52% and a compound annual growth rate of 1.44%. Accordingly, it increased installed renewable capacity to 44.97% and 43.12%.

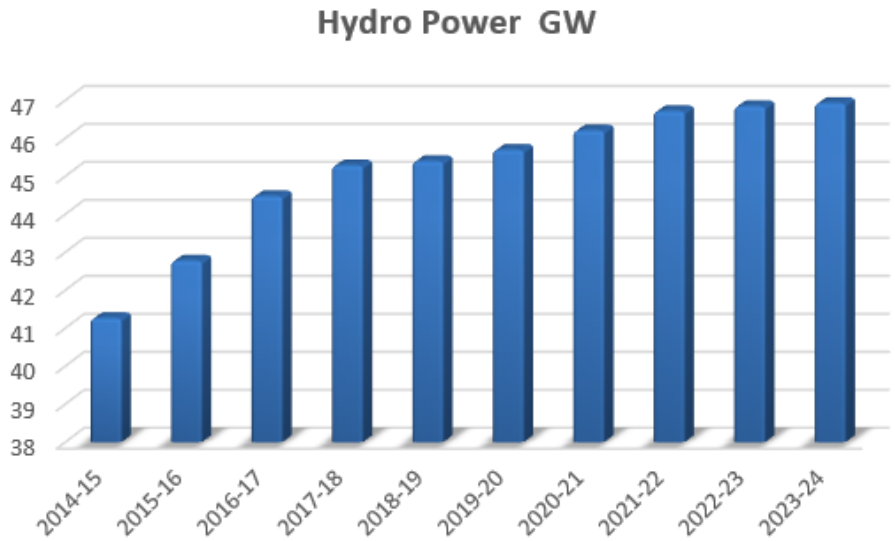

Fig. 7. Small hydro power during 2014–2024.

2.2.4 Bio power

Under MNRE, small hydropower plants are included in the renewable energy installation targets. Figure 7 illustrates the installed capacity of small hydropower from 2014 to 2024, which grew by 41.52% over the decade, with a compound annual growth rate (CAGR) of 1.44%. Consequently, the share of small hydropower in total installed renewable capacity increased to 44.97% and 43.12%, respectively.

The MNRE program provides financial support for large-scale projects and promotes the production of energy from urban, industrial, and agricultural waste through power plants, biogas, and bio CNG. By 2023, India's SATAT (Sustainable Alternative towards Affordable Transportation) initiative hopes to convert 5,000 plants into 15 MMT of CBG for use in industry, transportation, and cooking. Long-term price agreements are used by oil marketing companies to support this and guarantee the viability of the project. By 2024, biomass power

will have increased from 8.31 GW in 2014 to 10.36 GW. Additionally, waste's energy output increased from 0.24 GW to 0.59 GW [13].

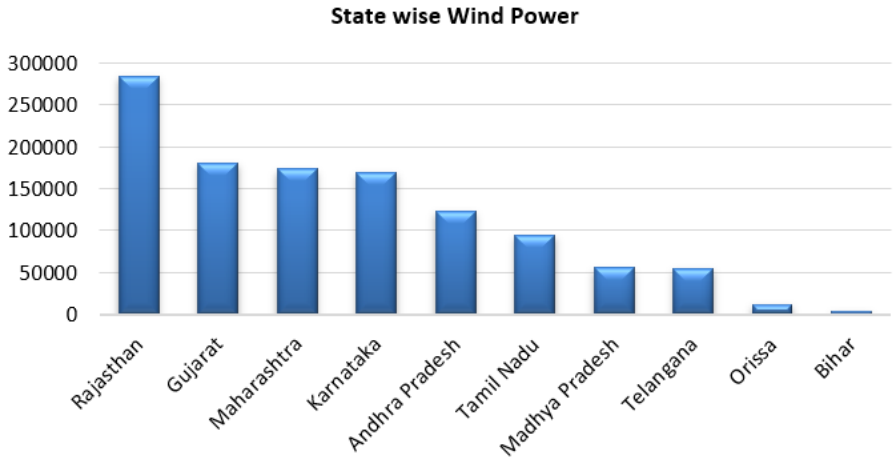

Fig. 8. State-wise wind and small hydro power. (a) Wind; (b) Small hydro.

2.2.5 Country-wise renewable energy

Rajasthan leads the list with a growth rate of 271%, followed by Gujarat with a growth rate of 194%, according to Table 1, which shows state-by-state RE capacity. According to research, Chandigarh produces the least amount of electricity from renewable sources. MNRE (Lok Sabha Secretariat, Ministry of New and Renewable Energy—Solar, 2024; Ministry of New and Renewable Energy—Wind, 2024; Ministry of New and Renewable Energy—Small Hydro, 2024; [13]) supports the information in Table 1 and figure 8 and 9.

Table 1. State-wise renewable energy.

State	Solar (MW)	Wind (MW)	Biopower (MW)	Small hydro (MW)
Rajasthan	24,553.1	5,195.8	~126.1	23.9
Gujarat	19,421.9	12,473.8	~112.5	91.6
Tamil Nadu	~10,309.8	11,409.0	~1,043.7	123.0
Karnataka	~9,690.1	6,731.3	~1,907.7	1,280.7
Maharashtra	~11,151.5	5,216.4	~2,643.2	382.3
Andhra Pradesh	~5,406.9	4,096.7	~566.4	163.3
Madhya Pradesh	~5,156.8	2,844.3	~134.9	123.7
Telangana	~4,842.1	128.1	~220.4	90.9
Uttar Pradesh	~3,368.9	—	~2,221.6	49.1
Kerala	~1,591.0	~63.5	~2.5	270.5

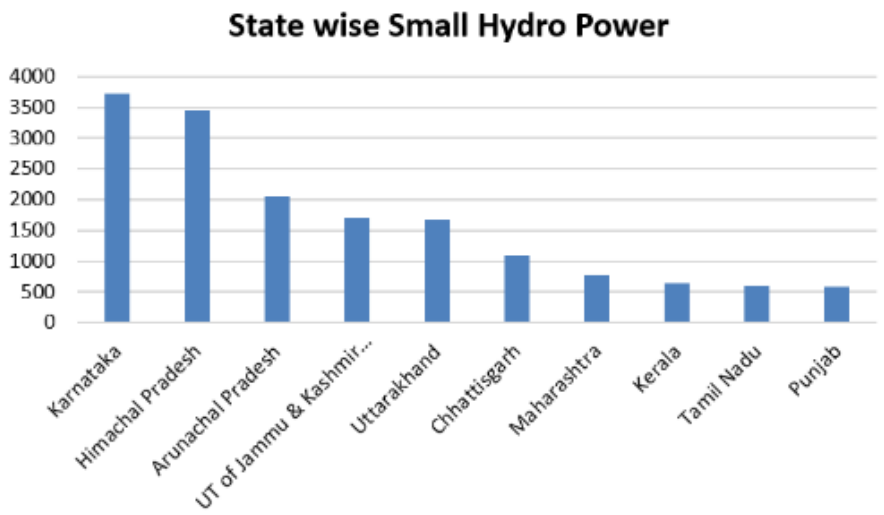

Fig. 9. Bio power during 2014–2024.

3 Conclusions

The remarkable growth of India's renewable energy sector during the last 10 years may be attributed to several factors, including the urgent need to satisfy energy demands, environmental concerns, and the global trend towards sustainable development. The statistical analysis of the study highlights the substantial contribution of renewable energy sources, such as solar, wind, biomass, and small hydro, to India's energy mix. Despite notable achievements, problems with finance, land acquisition, infrastructure limitations, and intermittency persist. To achieve its lofty goals for renewable energy, India must continue to place a strong focus on technological innovation, private sector engagement, and legislative improvements. Combining advanced energy storage technology, infrastructure modernization, and localized energy solutions will be necessary to scale up renewable energy projects. With consistent governmental support and well-thought-out implementation, India can become a global leader in renewable energy and pave the way for a cleaner, greener, and more sustainable future.

Conflict of interest: The authors declare no conflicts of interest.
Funding: Not applicable.

4 References

1. Central Electricity Authority, GCmap Dashboard, National Power Portal, https://npp.gov.in/dashBoard/gc-map-dashboard (accessed 20 Nov. 2024)
2. International Energy Agency, India, IEA, https://www.iea.org/countries/india (accessed 15 Nov. 2024)
3. International Renewable Energy Agency, Publications, IRENA, https://www.irena.org/Publications (accessed 1 Dec. 2024)
4. Lok Sabha Secretariat, Ministry of New and Renewable Energy, https://sansad.in/getFile/loksabhaquestions/annex/182/AS31_fzdQcL.pdf (accessed 20 Nov. 2024)

5. Ministry of New and Renewable Energy, Solar, Government of India (2024), https://mnre.gov.in/en/solar/ (accessed 3 Dec. 2024)
6. Ministry of New and Renewable Energy, Wind, Government of India (2024), https://mnre.gov.in/en/wind/ (accessed 3 Dec. 2024)
7. Ministry of New and Renewable Energy, Small Hydro, Government of India (2024), https://mnre.gov.in/en/small-hydro/ (accessed 3 Dec. 2024)
8. M. Waseem, M. Amir, G. Sree Lakshmi, S. Harivardhagini, M. Ahmad, Fuel cell-based hybrid electric vehicles: an integrated review of current status, key challenges, recommended policies, and future prospects, Green Energy Intell. Transp. **2**, 100121 (2023). https://doi.org/10.1016/j.geits.2023.100121
9. R.M. Elavarasan, G.M. Shafiullah, S. Padmanaban, N.M. Kumar, A. Annam, A.M. Vetrichelvan, J.B. Holm-Nielsen, A comprehensive review on renewable energy development, challenges, and policies of leading Indian states with an international perspective, IEEE Access **8**, 74432 (2020). https://doi.org/10.1109/ACCESS.2020.2988011
10. Ch. Lokeshwar Reddy, P. Satish Kumar, M. Sushama, Performance comparison of star connected cascaded STATCOM using different PWM techniques, Int. J. Power Electron. Drive Syst. **8**, 1303 (2017). https://doi.org/10.11591/ijpeds.v8.i3.pp1303-1319
11. V.K. Pandraka, R.A. Kumar, S.L. Gundebommu, S.T. Pottigari, Decentralized energy consumption monitoring RF communication-enabled modules for offline buildings connected to cloud, in 2024 IEEE Third International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES) (2024), 1161. https://doi.org/10.1109/ICPEICES62430.2024.10719152
12. V.K. Pandraka, R.R. Tinnavelli, R.A. Kumar, H.P. Bhupathi, S.L. Gundebommu, Effect of inverter voltage levels on torque ripples of PMSM drive, E3S Web Conf. **547**, 02016 (2024). https://doi.org/10.1051/e3sconf/202454702016
13. A. Lebsir, T. Benamimour, Renewable energies in the twenty-first century: a global view, in 2023 Second International Conference on Energy Transition and Security (ICETS) (2023), 1. https://doi.org/10.1109/ICETS60996.2023.10410757