



# Availability Of Green Energy Sources In India: State-Wise

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## Abstract

One of the most important ways of tackling climate change is investing in green energy and technologies, which hold the promise to boost sustainability, with this being a key step in the transition to a green economy. In order to accelerate the shift away from thermal power plants towards renewable energy sources, it is imperative that green energy continues to receive its due attention. Fossil fuel burning is the major factor in climate change with an average holding of 75% of total greenhouse gas (GHG) emissions and about 90% of Carbon Dioxide (CO<sub>2</sub>) emissions. The burning of coal and oil pollutes the air and their extraction contaminates groundwater and affects marine life. The planet's fossil fuel reserves are about to last the next 100 years.<sup>35</sup> Their acute shortage may result in power blackouts in the liveliest cities in the next few decades.

The purpose of this study is to identify the most relevant renewable energy sources in India and their contribution in generation of green energy. Out of various components of a particular source which is most popular in the country. In our study we found that solar energy source is domination and its ground mounted project is most popular components. The state of Rajasthan was on first rank all over the country in green energy generation up to September, 2023.

**Key Words:** *Renewable Energy, Sustainable Development, Solar energy, sources of energy, components*

## Introduction

India has reached some significant economic milestones in recent years. In 2022, the country became the fifth largest economy in the world. And in 2023, India has surpassed China in terms of population, an economically significant milestone given the relatively young population – an average age of around 28 years compared to the average (and ageing) Chinese population of 39 years. In advanced economies, in contrast, populations are ageing, which will likely lead to slower growth of the labour force and economy and rising budgetary pressures. India's economic growth is projected to average around 6% per year this decade, according to the International Monetary Fund.

Despite the economic and geopolitical turbulence of recent years, the government continues to recognise climate change as critical to India's growth and development aspirations. India's economy is one of the most vulnerable in the world to the physical effects of climate change. While climate impacts alone are not likely to stop the relatively rapid rates of economic growth this decade, it is likely to mean that longer-term output and income convergence with richer economies will be slower. Thus, addressing climate change – reducing emissions and increasing resilience to climate impacts – is fundamental for India to deliver economic development and prosperity to its citizens.

Climate change also offers new growth opportunities for India in the manufacture and supply of low-carbon goods and services, as the world transitions to low-carbon energy. India is already taking steps to seize these opportunities and create new jobs, economic growth and a more sustainable natural environment. For example, the government has set ambitious targets for deploying renewable energy and improving energy efficiency, which creates domestic demand for these products. It is also investing in research and development in sustainable manufacturing.

## Review of literature

**Tomar Arun Kumar Singh and Gautam K.K. (2018)** observed that production of rice and wheat would be decrease by 28 % and 68% due to increase in temperature of 4°C. Up to 2100 this will make many countries dilapidated. In this situation, renewable energy is the most elegant choice to make for meeting our energy demand, ensuring sustainable development and help human race to continue, at least not make an end from energy crisis.

**Singhal Shalabh, Kumar Ajay and Kumar Sanjiv (2020)** found that renewable source of energy are cost effective, easily beat the fossil fuels and friendly user. It has capacity to become the foundation for fulfilling future requirement of energy in the country. It will remove the dependency of using the natural resources like coal, oil, gas etc.

**Shetty Tushar, Shetty Chirag and Shah Ishaan (2021)** inferred that there is an urgent need for decrease dependency on fossil fuels and for this purpose there is need of transition from fossil fuel energy systems to renewable resource energy systems. The expansion of renewable energy can reduce global warming emissions, create new jobs and industries, improve air quality and help India move towards move cleaner and safer place where energy is affordable and in abundance.

**Salunke Nachiket and M D Dhiware (2022)** conclude in their paper that India has plenty of renewable energy to bridge the gap between demand and supply. So we must assiduously put in efforts to harness sundry forms of renewable energy sources with the utilization of more incipient technologies to compose an unsullied and safe place for our coming generations.

**Pahariya Yogesh and Devidas Nimbalkar Vaishali (2023)** in their paper conclude that conventional energy required for buildings can be reduce through various sources of renewable energy. In new buildings on the basis of site, orientation of building and local climatic conditions combination of various solar passive design aspects can easily be integrated. Hence, integration of solar passive features into the building leads to reduction in energy consumption of building which ultimately reduces the CO2 emissions and helps in sustainable development.

**Bala Anju (2023)** in her article, “Environmental Sustainability through Renewable Energy” observed that the use of conventional sources of energy causes problems of environmental pollutions. To reduce carbon emissions, clean the air and put our civilization on a more sustainable footing use of renewable energy is essential. In a small area renewable energy source provide energy in decentralized manner while at large scale use it tends to reduce burden from non-conventional energy systems. The Indian efforts in utilization of renewable energy sources have been focused on utilization of solar thermal energy, conversion of solar energy into electricity, wind energy and bio mass energy.

**Wadhwa Manjula (2023)** in his paper titled Renewable Energy Making India Self- Sufficient found that world cannot achieve its climate target without India’s support and contribution. India must therefore be ready to seize this leadership opportunity.

**Singh Jagriti and Dutt Maani (2023)** found that intergenerational equity, which recognizes the long and short-term inferences of sustainability in order to address the requirements of both present as well as forthcoming generations, is implied in the universal viewpoints about the concept of sustainability, despite the abundance of definitions and interpretations of the term in the literature.

## Objectives

The main objectives of the study are: -

1. To judge the dominating source of the Renewable Energy generation among the various sources and which state/UT is dominating in aggregate Renewable Energy generation.
2. To judge the dominating component of dominating source of Renewable Energy and which state is dominating in that component.

## Research Methodology and collection of data

We have taken all the 28 states and 8 UTs of India as population and top ten states as sample for the study. Our study is based on secondary data and period regarding generation of renewable energy is September,2023. Data were collected from the website of Ministry of New and Renewable Energy. Necessary statistical tools like percentage and rank were used for inference.

## Results and analysis

Table -1 Renewable Energy Projects as on September, 2023 in top ten states/UTs : Source-wise

S. No.	STATES / Uts	Small Hydro Power (MW)	Wind Power (MW)	Bio Power Total (MW)	Solar Power	Total Capacity (MW)
1	Andhra Pradesh	163.31 (3.28) 7	4096.65 (9.27) 6	566.39 (5.23) 5	4555.20 (6.35) 7	9381.55 (7.12) 6
2	Arunachal Pradesh	133.11 (2.67) 9				
3	Chhattisgarh			275.00 (2.54) 8		
4	Gujarat		11094.02 (25.11) 1		10417.56 (14.51) 2	21715.45 (16.48) 2
5	Haryana			263.95 (2.44) 9		
6	Himachal Pradesh	969.71 (19.46) 2				
7	Jammu & Kashmir	161.43 (3.24) 8				
8	Karnataka	1280.73 (25.70) 1	5313.55 (12.03) 3	1907.28 (17.60) 3	9347.18 (13.02) 3	17848.74 (13.54) 4
9	Kerala	266.52 (5.35) 4	62.50 (0.14) 9			
10	Madhya Pradesh	123.71 (2.48) 10	2844.29 (6.44) 7		3167.92 (4.41) 8	6270.86 (4.76) 7
11	Maharashtra	382.28 (7.67) 3	5147.18 (11.65) 5	2641.94 (24.38) 1	4988.33 (6.95) 5	13159.73 (9.99) 5
12	Punjab	176.10 (3.53) 6		527.85 (4.87) 6	1266.55 (1.76) 10	1970.50 (1.50) 10
13	Rajasthan		5193.42 (11.75) 4		18089.21 (25.20) 1	23431.56 (17.78) 1

14	Tamil Nadu		10300.62 (23.31) 2	1043.70 (9.63) 4	7082.49 (9.87) 4	18549.86 (14.08) 3
15	Telangana		128.10 (0.29) 8	220.37 (2.03) 10	4712.98 (6.57) 6	5152.32 (3.91) 8
16	Uttar Pradesh			2219.56 (20.48) 2	2620.43 (3.65) 9	4889.09 (3.71) 9
17	Uttarakhand	218.82 (4.39) 5				
18	West Bengal			343.46 (3.17) 7		
	<b>Tota l (MW) Agg regate Percentage</b>	<b>4982.75</b>	<b>44184.63</b>	<b>10835.27</b>	<b>71780.74</b>	<b>131783.39</b>
		3.78	33.53	8.22	54.47	100

Source: Authors' calculation from State-wise data from web site of Ministry of New and Renewable Energy

Table 1 exhibits installation of Renewal Energy Projects sources up to September, 2023 in top ten states & UTs in India in absolute terms in Megawatts (MW) as well as in relative terms. There are mainly four sources of renewable energy i.e. Small Hydro, Wind, Bio and Solar Power. In case of Small Hydro Power projects Karnataka stands on top with contributing 25.7 % of total capacity followed by Himachal Pradesh, Maharashtra, Kerala, Uttarakhand, Punjab, Andhra Pradesh, Jammu & Kashmir, Arunachal Pradesh and Madhya Pradesh. Here, it should also be noted that in four UTs and one state (Delhi) there is not any single small hydro projects. Gujarat occupied 1<sup>st</sup> position in installation of wind power within nine states with more than one fourth (25.11 %) contribution in aggregate followed by Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh, Telangana and Kerala. In remaining 19 states and 8 UTs no wind power projects were installed in the study period. In the matter of Bio Power Projects Maharashtra was on top with 24.38 % share in total bio-power generation up to September 2023 followed by Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Punjab, West Bengal, Chhattisgarh, Haryana and Telangana. In case of solar power projects Rajasthan was on top with more that one fourth contribution in total followed by Gujarat, Karnataka, Tamil Nadu, Maharashtra, Telangana, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh and Punjab. Rajasthan is dominating in aggregate power generation by all four components of renewable energy sources followed by Gujarat, Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh, Madhya Pradesh, Telangana, Uttar Pradesh and Punjab. It is also observed that in the list of top ten states only three states namely- Andhra Pradesh, Karnataka and Maharashtra contributes in all the four sources while Madhya Pradesh, Punjab, Tamil Nadu and Telangana in three sources, Gujarat, Kerala, Rajasthan and Uttar Pradesh in two, Arunachal Pradesh, Chhattisgarh, Haryana, Himachal Pradesh, J& K, Uttarakhand and West Bengal contributes only single source and these states not occupied anyplace in aggregate. Among the four sources Solar Power Projects are dominating (54.47 %) followed by wind power (33.53 %), Bio Power (8.22%) and small hydro power projects (3.78%). It can be inferred from the above table that in the matter of renewable energy generation by small hydro power projects state of Karnataka is on top while in wind

power generation Gujarat, bio power – Maharashtra and in solar power Rajasthan occupied first position in all over the India and contribution of solar power in total renewable energy generation is on top.

**Table -2 Installation of Solar Power Projects up to September, 2023 in top ten states: Component-wise**

Sr. No.	STATES / Uts	Solar Power				
		Ground Mounted Solar	Rooftop Solar	Hybrid Solar Comp.	Off-grid Solar/ KUSUM	Total
		(MW)	(MW)	(MW)	(MW)	(MW)
1	Andhra Pradesh	4286.87 (7.72) 6			88.34 (3.36) 7	4555.20 (6.35) 7
2	Chhattisgarh				386.73 (14.72) 3	
3	Gujarat	6896.36 (12.42) 3	2898.16 (26.16) 1	568.75 (22.31) 2	54.30 (2.07) 10	10417.56 (14.51) 2
4	Haryana		486.23 (4.39) 6		453.79 (17.27) 2	
5	Karnataka	7754.77 (13.97) 2	1562.11 (14.10) 3			9347.18 (13.02) 3
6	Kerala		512.67 (4.63) 5			
7	Madhya Pradesh	2779.00 (5.00) 8	296.02 (2.67) 10		92.90 (3.54) 6	3167.92 (4.41) 8
8	Maharashtra	3009.14 (5.42) 7	1716.30 (15.49) 2		262.89 (10.01) 4	4988.33 (6.95) 5
9	Punjab	886.27 (1.60) 10	298.92 (2.70) 9		81.36 (3.10) 8	1266.55 (1.76) 10
10	Rajasthan	14511.22 (26.13) 1	1002.44 (9.05) 4	1980.00 (77.69) 1	595.55 (22.67) 1	18089.21 (25.20) 1
11	Tamil Nadu	6567.41 (11.83) 4	449.22 (4.05) 7		65.86 (2.51) 9	7082.49 (9.87) 4
12	Telangana	4360.49 (7.85) 5	343.78 (3.10) 8			4712.98 (6.57) 6
13	Uttar Pradesh	2149.50 (3.87) 9			205.83 (7.83) 5	2620.43 (3.65) 9

	<b>Total (MW)</b>	<b>55525.60</b>	<b>11078.95</b>	<b>2548.75</b>	<b>2627.49</b>	<b>71780.74</b>
	<b>Percentage in Aggregate</b>	<b>77.35</b>	<b>15.43</b>	<b>3.55</b>	<b>3.66</b>	<b>100.00</b>

Source: Authors' calculation from State-wise data from web site of Ministry New and Renewable Energy

Table -2 shows solar power projects up to September, 2023 in top ten states component-wise and state-wise in absolute terms as well as relative terms. There are mainly four components of solar energy namely - Ground Mounted solar, Rooftop solar, Hybrid solar and Off-grid Solar/ Kisan Urja Suraksha evam Utthan Mahabhiyan (KUSUM). Rajasthan is dominating in ground mounted solar energy generation projects by contributing 26.13 % in aggregate followed by Karnataka, Gujrat, Tamil Nadu, Telangana, Andhra Pradesh, Maharashtra, Madhya Pradesh, Uttar Pradesh and Punjab. In roof-top solar energy generation Gujarat is on top followed by Maharashtra, Karnataka, Rajasthan, Kerala, Haryana, Tamil Nadu, Telangana, Punjab and Madhya Pradesh. Hybrid solar projects were installed only Rajasthan and Gujrat. Their contribution in solar energy generation is 77.69 and 22.31 % respectively. In the matter of solar energy generation by Off-grid Solar/ Kisan Urja Suraksha evam Utthan Mahabhiyan (KUSUM) projects again Rajasthan is dominating followed by Haryana, Chhattisgarh, Maharashtra, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Punjab, Tamil Nadu and Gujarat. In aggregate solar energy generation Rajasthan state is dominating and its share is more than one fourth (25.2) followed by Gujarat (14.51), Karnataka (13), Tamil Nadu (9.87), Maharashtra (6.95), Telangana (6.57), Andhra Pradesh (6.35), Madhya Pradesh (4.41), Uttar Pradesh (3.65) and Punjab (1.76). Here, it should be noted that in the list of top ten states component-wise Chhattisgarh and Kerala are contributing only in a single component, Andhra Pradesh, Haryana, Karnataka, Telangana and Uttar Pradesh in two, Madhya Pradesh, Maharashtra, Punjab and Tamil Nadu in three while Gujarat and Rajasthan are contributing in all the four components of the solar energy generation. Among the four components of solar energy generation projects Ground Mounted is on top followed by roof-top, Hybrid solar and Off-grid Solar/ Kisan Urja Suraksha evam Utthan Mahabhiyan (KUSUM). So, it can be concluded that Rajasthan state is dominating in all the four components except roof-top as well as in aggregate renewable energy generation by the solar source and ground mounted projects are main component of solar energy source.

## Conclusion

Among the various source of renewable energy generation solar power projects are dominating and their contribution in aggregate renewal energy generation is 54.47 %. Renewable energy generation source-wise, Karnataka is dominating in small hydro projects, in wind power Gujarat, in bio power – Maharashtra and in case of solar power Rajasthan occupied top position. In aggregate renewal energy generation by all the source Rajasthan again dominating among all over the country. Among the four components of solar energy source namely- Ground Mounted solar, Rooftop solar, Hybrid solar and Off-grid Solar/ Kisan Urja Suraksha evam Utthan Mahabhiyan (KUSUM), Ground Mounted projects are dominating with more than two-third (77.35%) share in aggregate solar energy generation. Except roof- top solar energy Rajasthan rank 1<sup>st</sup> in remaining three components as well as in aggregate at all India Level.

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