Empirical Analyses of Renewable Energy in India: Effects on Current Trends

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K. M. Sri Gururaghavendra
Research Scholar, Department of Economics
Jnana Bharathi Campus, Bangalore University, Bangalore, Karnataka, India
https://orcid.org/0009-0008-6153-8548

T. Rajendra Prasad
Senior Professor, Department of Economics
Jnana Bharathi Campus, Bangalore University, Bangalore, Karnataka, India

Abstract
The study highlights renewable energy's crucial role in India's sustainable growth. Renewable energy is derived from natural resources that are replenished more than consumed. India is the third-largest consumer of energy in the world and fourth globally in installed renewable energy capacity, with 163 giga watts. The southern region is a major contributor to renewable energy with 50282.92 megawatts than other regions. Wind source is the highest energy generator than other renewable sources,and India is currently facing a significant energy challenge. With a population of over 1.3 billion, energy demand is continually increasing. Finally, the percentage of renewable energy in total power generation climbed significantly increased from 15.38 percent in 2015 to 20.49 percent in 2022. Therefore, renewable energy has a big impact on India's sustainable development.

Keywords: Corban Emission, Fossil Energy, Renewable Energy, Hydrozoan Sustainable Development, Biomass, Power Generation

Introduction

Renewable energy is derived from natural resources that are replenished at a higher rate than consumed, for example, sunlight and wind, which are constantly replenished. India is the third-largest consumer of energy in the world. According to the REN21 Renewables 2022 Global Status Report, India ranks fourth globally for installed renewable energy capacity after China, the USA, and Brazil, with wind and solar power capacity (Figure 1). The nation established a new goal of 500 giga watts of non-fossil fuel-based energy by 2030 during COP26. Under the Panchamrit, this has been a crucial promise. This is the greatest expansion strategy for renewable energy in the world. India has set goals to reach net-zero carbon emissions by 2070, achieve cumulative renewable energy installations of 50% by 2030, and lower the carbon intensity of the country's economy by less than 45% by the end of the decade. By 2030, India wants to produce 5 million tonnes of green hydrogen. Therefore, 125 giga watts of renewable energy capacity will be used to promote this programme. India's key sustainable energy practices are promoting solar power. India has abundant sunlight throughout the year, making it an ideal location for solar energy generation. The government has set ambitious targets for solar power capacity and has implemented various policies and incentives to encourage its adoption. This includes establishing solar parks rooftop solar installations, and promoting solar power in rural areas. Another important

sustainable energy practice in India is the development of wind power. India has a vast coastline and several windy regions, which makes it suitable for wind energy generation. India is also exploring offshore wind energy projects to harness its wind power potential further. In addition to solar and wind power, India also focuses on other renewable energy sources such as biomass, hydropower, and geothermal energy. The government has implemented policies to promote the use of biomass for power generation, including providing subsidies and incentives. Hydropower projects are being developed in various parts of the country, and efforts are being made to tap into the geothermal energy potential in certain regions. India also invests in developing smart grids and energy storage technologies to support adopting sustainable energy practices. Smart grids enable efficient management and distribution of electricity, while energy storage technologies help address the intermittent nature of renewable energy sources (Table 1). This study aims to explain the role of Renewable energy in total power generation in India. And Contribution to renewable energy for sustainable development in India.

Methodology

To achieve the study's goals, we mainly employed secondary data sources gathered from yearly reports of several union and state government ministries, including the Ministry of Renewable Energy, National Rooftop Solar, Ministry of Power, etc. Most data were gathered from the CMIE, Indiast at, and Statista databases. Based on the nature of the study, conducted over eight years from 2015 to 2022, we used simple analytical tools, including tabulations, charts, and quantitative procedures.

Result and Discussion

In this section, we discussed India's renewable energy generation performance, the share of renewable energy to fossil energy, and regional generation in India. Details are followed below.

India has the fourth largest renewable energy installed capacity, actively increasing its renewable energy capacity with 163 gigawatts globally, fourth in wind power capacity, and fourth in solar power capacity. The government has implemented various policies and incentives to promote solar energy, such as the Jawaharlal Nehru National Solar Mission and the Solar Park Scheme, which reflects India's commitment to clean energy and sustainably addressing its growing energy needs. China leads the world in renewable energy capacity, with a massive 1,161 GW. It reflects China's strategic investments in renewable energy sources like wind, solar, and hydro. The United States has a substantial renewable energy capacity of 352 giga watts. Wind and solar power have been major contributors to this capacity. Brazil's 175 giga watts of renewable energy capacity primarily stems from its extensive use of hydroelectric power. We can see the other countries' performance also in the figure. These capacities reflect each country's specific energy policies, available resources, and commitment to a more sustainable and eco-friendly energy future.

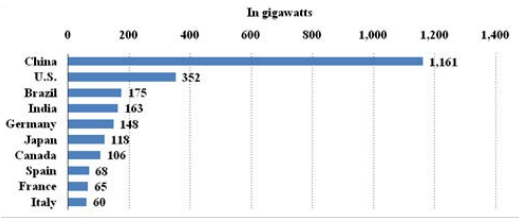

Figure 1 Leading Countries in Installed Renewable Energy Capacity Globally in 2022

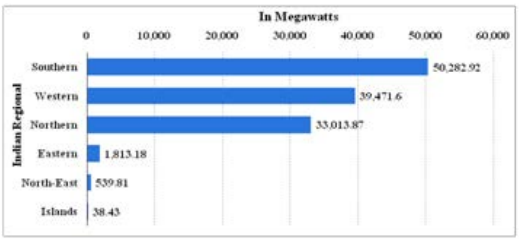

Figure 2 Installed Renewable Energy Capacity in India as of March 2023 by Region

The table provides data on the regional-wise installed renewable energy capacity as of 2023 in India. The Southern region of India has the highest installed renewable energy capacity among all the regions, with 50,283 megawatts. This region likely has significant investments in renewable energy sources such as solar, wind, and possibly hydropower, contributing to its high capacity. The Western region of India has the second-highest installed capacity, with around 39,472 megawatts. This region likely has a considerable presence of renewable energy

projects, possibly due to favorable geographic and climatic conditions for solar and wind energy sources. The Northern region ranks third in installed renewable energy capacity, with about 33,014 megawatts. This region might also have substantial investments in renewable energy infrastructure. The Eastern region has a relatively lower installed renewable energy capacity than the Southern, Western, and Northern regions, with around 1,813 megawatts. This could be due to various factors, such as fewer natural resources for renewable energy or lower investments. The North-Eastern region of India has the second-lowest capacity among all the regions, with approximately 540 megawatts. This region might face challenges related to its geography and terrain, making it less conducive for large-scale renewable energy projects. The Islands have India's lowest installed renewable energy capacity, with just 38.43 megawatts. Given their remote and isolated nature, establishing renewable energy projects on these islands might be more challenging and costly.

Table 1 Power Generation from Various Renewable Energy Sources in India during the Period 2014 to 2022

(in Million Units)

Years	Wind	Solar	Biomass	Bagasse	Small Hydro	Others	Total
2015-16	33029.39 (50.2)	7447.92 (11.3)	3727.21 (5.7)	12953.29 (19.7)	8354.51 (12.7)	268.53 (04)	65780.85 (100)
2016-17	46004.34 (5.2)	13498.87 (16.5)	4198.33 (5.1)	9950.15 (12.2)	7924.62 (9.7)	292.38 (0.4)	81868.69 (100)
2017-18	52666.09 (51.7)	25871.07 (25.4)	3404.95 (3.3)	11847.35 (11.6)	7691.58 (7.6)	358.45 (0.4)	101839.49 (100)
2018-19	62036.38 (48.9)	39268.2 (31)	2763.82 (2.2)	13562.67 (10.7)	8702.75 (6.9)	425.28 (0.3)	126759.1 (100)
2019-20	64646.37 (46.7)	50131.1 (36.2)	2937.96 (2.1)	10804.46 (7.8)	9451.22 (6.8)	365.9 (0.3)	138337.02 (100)
2020-21	60149.95 (40.8)	60402.25 (41.0)	3512.98 (2.4)	11302.85 (7.7)	10258.41 (7)	1621.06 (1.1)	147247.51 (100)
2021-22	68640.07 (16)	73483.94 (43.0)	3482.7 (2.0)	12573.88 (7.4)	10463.54 (6.1)	2268.17 (1.3)	170912.3 (100)
2022-23	71814.16 (35.3)	102014.24 (50.1)	3161.32 (1.6)	12863.16 (6.3)	11170.11 (5.5)	2529.18 (1.2)	203552.17 (100)
Total	492755.06 (44.9)	376716.6 (34.3)	30349.12 (2.8)	107642.45 (9.7)	82076.24 (7.5)	8542.55 (0.8)	1098082.04 (100)

Source: Ministry of Power, Govt. of India; **Note:** (Brackets) denotes the shares of renewable energies in percentage

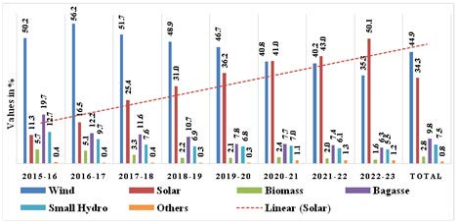

Figure 3 Power Generation from Various Renewable Energy Sources in India, from 2014 to 2023

The above table provides data on power generation from various renewable energy sources in India from 2015 to 2022. Wind energy generation started at 33,029.39 million units in 2015 and increased consistently, reaching 71,814.16 million units in 2022. Solar energy is the second largest generation source, starting at 7,447.92 million units in 2015 and experiencing significant growth, reaching 102,014.24 million units in 2022. Biomass and bagasse generation remained relatively stable, with some fluctuations. Small hydro generation grew steadily, reaching 11,170.11 million units in 2022. Other renewable energy sources, such as geothermal and tidal energy, remained relatively

small compared to wind and solar. Total renewable energy generation in India increased significantly, from 65,780.85 million units in 2015 to 203,552.17 million in 2022. In the trend line, solar energy overtakes wind energy. Because of the government's various policies and incentives to promote solar energy, such as the Jawaharlal Nehru National Solar Mission and the Solar Park Scheme, 57 solar parks in India with a combined capacity of 39.28 GW have been approved. With a total central financial support of Rs. 34,422 Crore, including service fees, the PMKUSUM program seeks to increase solar and other renewable capacity by 30,800 Megawatt by 2022.Wind Energy has an offshore target of 30 giga watts by 2030 and is also a major contributor to India's renewable energy portfolio, ranking fourth globally in installed wind capacity.

Table 2 Power Generation by Conventional and Renewable Energy with a Share in India from 2015 to 2022

		(Million Watt/Million Kilo watt)	
Years	**Conventional Energy (MKW)**	**Renewable Energy (MW)**	**Share of renewable Energy in %**
2015-16	1107822.2	65780.85	15.38
2016-17	1160140.9	81868.69	14.85
2017-18	1206306.2	101839.49	15.96
2018-19	1249336.7	126759.1	16.69
2019-20	1250783.9	138337.02	18.68
2020-21	1234607.6	147247.51	19.96
2021-22	1320947.1	170912.3	19.44
2022-23	1420912.9	203552.17	20.49
Total	9950857.5	1036297.13	

Source: Ministry of Power, Govt. of India

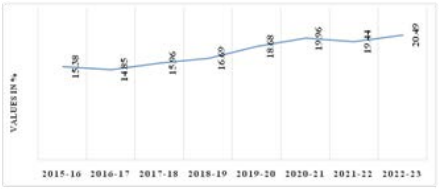

Figure 4 Share of Renewable Sources in Power Generation in India from 2015 to 2022

The table provides empirical data on the power generation capacity in a million watts for conventional energy sources and renewable energy sources in India from 2015-16 to 2022-23, and The total conventional energy capacity increased from 1,107,822.2 million watts in 2015-16 to 1,420,912.9 million watts in 2022-23.There has been a consistent upward trend in the capacity of conventional energy sources over the years. The total renewable energy capacity increased from 65,780.85 million watts in 2015-16 to 203,552.17 million watts in 2022-23. Renewable energy capacity has grown significantly more than tripled during this period. It demonstrates a clear shift towards a higher proportion of renewable energy sources in India's overall energy capacity mix. The total energy capacity, combining conventional and renewable sources, increased from 9,950,857.5 million watts in 2015-16 to 10,362,971.13 million watts in 2022-23.The above figure shows the share of renewable energy from 2015 to 2022, which increased from 15.38 to 20.49 percent. It shows the India's power shifting to sustainability.

India is currently facing a significant energy challenge. With a population of over 1.3 billion, energy demand is constantly increasing. However, India heavily relies on fossil fuels, particularly coal, for its energy needs. This over dependence on coal has led to several issues, including air pollution, greenhouse gas emissions, and climate change. Despite significant progress in recent years, a large portion of the population still does not have access to reliable and affordable electricity. This hampers economic development and quality of life for many people. India is heavily dependent on energy imports. The country imports a significant portion of its oil and gas, which strains its economy and energy security. India has been trying to diversify its energy mix and promote renewable energy sources to address these challenges. The government has developed a number of regulations and incentives to encourage investment in the industry and has set high goals for expanding renewable energy capacity.

Conclusion

India has immense potential for renewable energy because it transforms conventional power generation into renewable sources. The nation is blessed with abundant hydro, wind, and solar resources. India can solve its energy problems and

pave the road for a cleaner and more sustainable future by using these resources and implementing sustainable energy practices. Even while fossil fuels still make up most of India's energy mix, the nation is actively working to transition to a future based on sustainable and renewable energy. The rapid rise in the use of solar and wind power has been caused by the government's commitment to renewable energy objectives and the adoption of favourable policies and incentives. However, obstacles still need to be removed to effectively utilize India's potential for sustainable electricity.

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Author Details

K. M. Sri Gururaghavendra, *Research Scholar, Department of Economics, JnanaBharathi Campus, Bangalore University, Bangalore, Karnataka, India,* ***Email ID****: sgr.km177@gmail.com*

T. Rajendra Prasad, *Senior Professor, Department of Economics, JnanaBharathi Campus, Bangalore University, Bangalore, Karnataka, India*