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Growth and Pattern of Renewable Energy in India: A Way for Sustainable Development

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

The main objective of the present study is to analyse the growth and pattern of renewable energy in India. Renewable energy is generated from natural sources, which are replenished more quickly than consumed. Renewable energy has a significantly positive impact on protecting the environment from the problem of carbon emissions, which is most required in India, as India is the fourth largest nation producing the highest carbon emission. As being a developing nation, the energy requirement has continuously increased in India, and it is expected India will become third larger country that requires energy sourced after China and US up to 2040. The study observed that the energy deficit in the normal and peak periods has declined, and the share of renewable energy reached 20.3 per cent in 2021-22. Moreover, the majority of renewable energy is owned by the private sector, and the western coastal states of India have the highest density of renewable energy. The study suggested optimum policy recommendations to enhance renewable energy and promote sustainable development in India.

Keywords: Energy consumption; renewable energy; RECAI.

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1. INTRODUCTION

Deteriorating the global environment due to increasing carbon emission is a predominant concern in front of global policymakers as well as the whole of human existence [1,2]. Emission from global greenhouse gases (GHG) significantly contributes to environmental deterioration [3], which was also addressed in the Paris agreement and targeted that 25 per cent of existing emissions must be reduced by 2030 [4]. Moreover, the production of energy through conventional sources, such as oil, coal, and natural gas, produces adverse environmental pollutants and contributes to about one-third of emissions of global greenhouse gases [5,6]. It is essential for policymakers to enhance the standard of living of people by providing renewable energy such as energy by biofuels, hydro, geothermal, tidal, solar, waste, and wind [7,8]. Production of required energy by the nation through renewable ways over conventional ways of energy help to protect the environment and also encourage green environment [6]. On the contrary, non-conventional energy methods significantly contribute to carbon emissions, a severe issue in front of the global environment. United Nations (UN) in 2015 also introduced the 2030 agenda for Sustainable Development to attain a sustainable future. Moreover, the 7^{th} goal of SDGs is also focused on "ensure reliable, affordable, sustainable and modern energy for all" [9]. It focused on providing sustainable energy widely.

According to Global Energy Review [10], the carbon emission related to energy substantially increased from 21.5 Gigatons (Gt) in 1991 to 36.3 Gt in 2021. Moreover, in overall emissions by energy, the emission from coal has been higher over the period. In the case of country-wise carbon emission, the highest emission was produced by China, i.e., 27 per cent of global emissions, followed by the US (15 per cent), EU (9.8 per cent), and India (6.8 per cent). Therefore, increasing renewable energy is urgently needed to diminish carbon emissions.

In India, as being a developing nation with an increasing population, the requirement for energy has increased drastically over the period, which is a pre-requirement for economic growth [11]. World energy council predicted that in 2030, the electricity demand in India would reach its peak, and in the same period, India will become the biggest coal consumer in the world. It is pertinent here to mention that the Ministry of Power, India enacted a 10-year action plan under National Electricity Plan to ensure the supply of electricity to citizens at affordable or reasonable prices with focusing the efficiency in production. Therefore, the present study aims to investigate the energy requirement in India and analyse the growth and pattern of renewable energy in India.

2. PROJECTED ENERGY CONSUMPTION IN THE WORLD AS WELL AS IN INDIA

Fig. 1 depicts the projected energy consumption required by the different nations. In 1991-92 among the selected major nations, the highest energy was demanded by the United States (US), i.e., 1966 million tone oil equivalent (Mtoe) energy, which increased to 2334 Mtoe in 2020, and it is also expected to be reached about 2299 Mtoe in 2040. Further, in 1991-92, European Union (EU) demanded the second highest energy sources at 1672 Mtoe, which marginally declined to 1667 Mtoe in 2020. It is expected that the energy requirement will decrease in the EU. China consumed 195 Mtoe energy sources in 1990, which increased to 3387 in 2020, and it is expected to reach 4207 Mtoe in 2040. In the case of the Indian economy, there was merely 195 Mtoe energy demand in 1990, which increased to 880 Mtoe in 2020, and it is expected to be 1921 Mtoe in 2040. In 2020, China consumed the highest energy, which increased with a CAGR of 5.48 per cent (from 1990 to 2020), whereas the Indian requirement increased with a CAGR of 5.15 per cent. As per projections, it is expected that the highest energy consumption would be increased with an anticipated CAGR of 3.98 per cent (from 2020 to 2040) in India, followed by Africa with a CAGR of 3.44 per cent, Brazil with 1.86 per cent, the Middle East with 1.73 per cent and China with 1.22 per cent.

Fig. 2 demonstrates the projected energy consumption in India from 1990 to 2040. As mentioned above, in 1990, there was 195 Mtoe energy consumed by India, which may increase to about 1921 Mtoe in 2040. Moreover, from 1990 to 1995, there was nominal consumption of renewable energy, which started to increase in 2000 with a consumption of 1 Mtoe. After that,

the consumption of renewable energy steadily increased in India, which reached 41 Mtoe in 2020, and it is expected that it would be increased to 256 Mtoe in 2040. In India, the consumption of renewable energy increased with a CAGR of 20.40 per cent from 2000 to 2020; however, after 2020, the estimated consumption of renewable energy is expected to grow with a CAGR of 9.59 per cent.

3. ENERGY/POWER REQUIREMENT AND AVAILABILITY IN INDIA

The Central Electric Authority (CEA) issued the data regarding power supply on a monthly basis in the context of Energy requirement and Energy availability in Million Units (Mus), as well as Peak demand and Peak met in Mega Watt (MW). Table 1 depicts the requirement, availability, and deficit of power in the normal period and peak period from 2007-08 to 2021-22. The total energy requirement in India was 739343 MUs in 2007-08, which has increased continuously over the period and reached 1379812 MUs in 2021-22. Whereas, in terms of availability of energy as per requirement, there was merely 89 per cent of requirements met in 2007-08, which increased to 99.5 per cent in 2021-22. Moreover, the deficit of energy requirement has declined from 73336 MUs (11.01 per cent) in 2007-08 to 5788 MUs (0.42 per cent) in 2021-22. As compared to the previous year in 2021-22, the energy requirement increased by 8.2 per cent, and energy supplied increased by 8.1 per cent. Moreover, during the period, the energy requirement increased with a CAGR of 4.56 per cent, which is minimal less than increased energy availability, i.e., 5.31 per cent.

On the other hand, in terms of Peak demand, in 2007-08, there was 108866 MW of energy demanded by the Indian economy, which increased to 203014 MW in 2021-22. Whereas, the energy availability in the Peak period also increased in India from 90793 MW in 2007-08 to 200539 MW in 2021-22. In 2007-08, the energy deficit in the Peak period was about 19.91 per cent of the requirement, which declined over the period and reached around 1.23 per cent in 2021-22. As compared to the previous year in 2021-22, the energy demand in the Peak period has increased by 6.7 per cent, whereas Peak Met increased by merely 5.9 per cent. Moreover, during the Peak period, the energy demand increased with a CAGR of 4.55 per cent, which is minimal less than increased energy availability, i.e., 5.82 per cent.

It may be observed from Table 1 that the availability of energy deficit was higher in the Peak period as compared to the Normal period. However, it may be concluded here that there is adequate availability of energy in India. The energy deficit between requirement and availability is not only due to inadequacy of power availability but also affected by other factors such as disruption in the distribution channels, forced outage of generating units, commercial reasons, financial constraints etc.

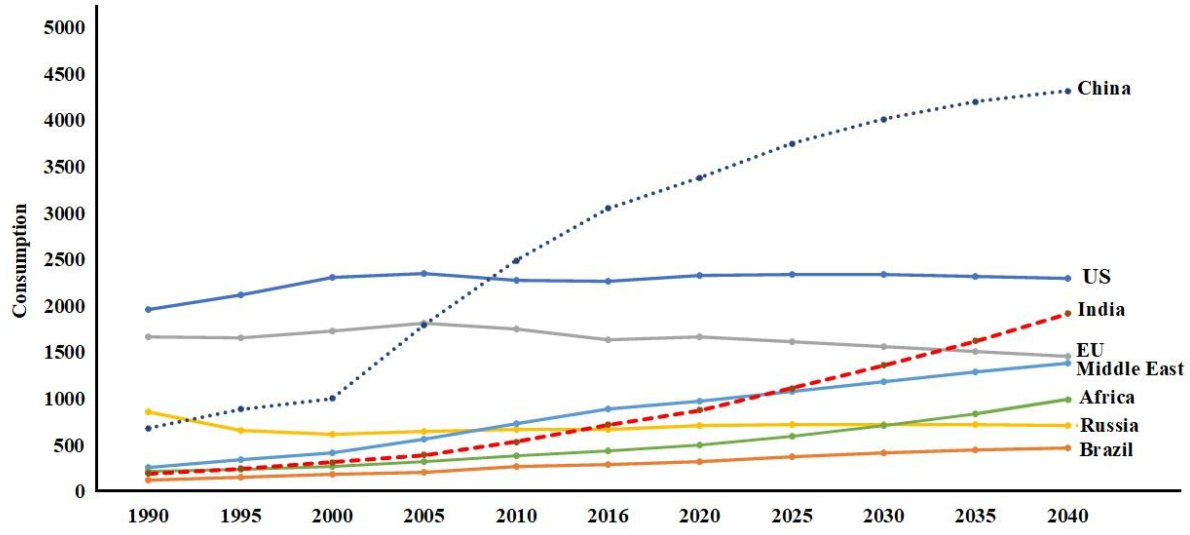

Fig. 1. Projected energy consumption/requirement in the world from 1990 to 2040
Source: BP Energy Outlook country and regional insights-India [12]

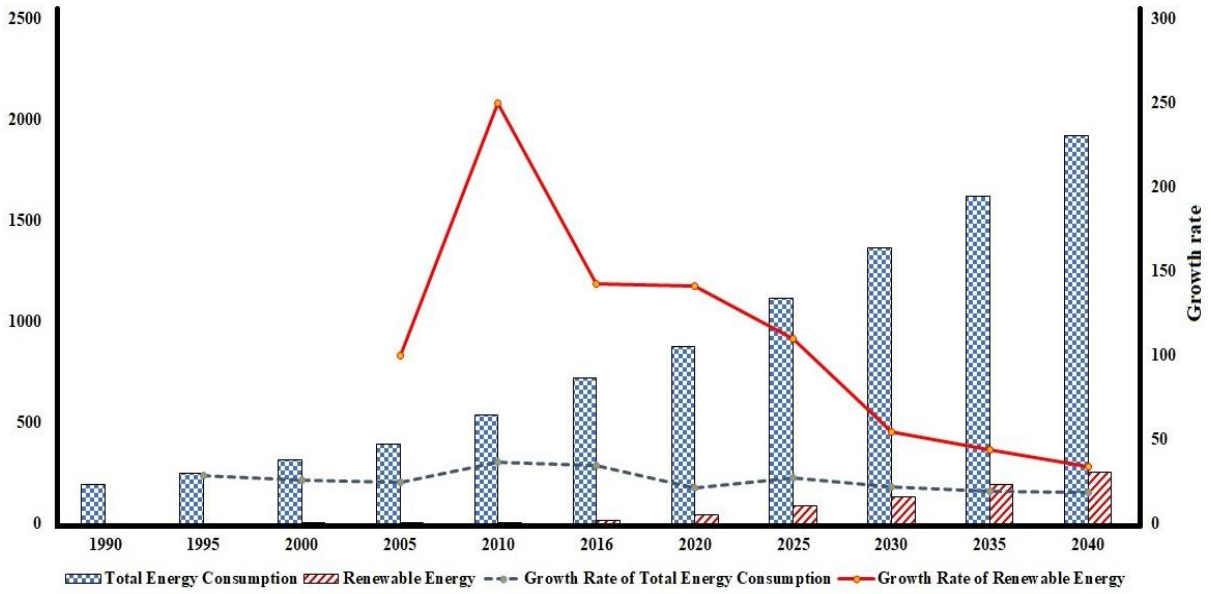

Fig. 2. Projected Energy Consumption in India from 1990 to 2040
Source: BP Energy Outlook country and regional insights-India [12]

Table 1. Status of power supply in India from 2007-08 to 2021-22

Year	Energy Requirement (MU)	Availability (MU)	Deficits		Peak Demand (MW)	Peak Met (MW)	Deficits	
			(MU)	in %			(MW)	in %
2007-08	739343	666007	-73336	-11.01	108866	90793	-18073	-19.91
2008-09	777039	691038	-86001	-12.45	109809	96785	-13024	-13.46
2009-10	830594	746644	-83950	-11.24	119166	104009	-15157	-14.57
2010-11	861591	788355	-73236	-9.29	122287	110256	-12031	-10.91
2011-12	937199	857886	-79313	-9.25	130006	116191	-13815	-11.89
2012-13	998114	911209	-86905	-9.54	135453	123294	-12159	-9.86
2013-14	1002257	959829	-42428	-4.42	135918	129815	-6103	-4.70
2014-15	1067085	1028955	-38130	-3.71	148166	141160	-7006	-4.96
2015-16	1114408	1090850	-23558	-2.16	153366	148463	-4903	-3.30
2016-17	1142928	1135332	-7596	-0.67	159542	156934	-2608	-1.66
2017-18	1213326	1204697	-8629	-0.72	164066	160752	-3314	-2.06
2018-19	1274595	1267526	-7069	-0.56	177022	175528	-1494	-0.85
2019-20	1291010	1284444	-6566	-0.51	183804	182533	-1271	-0.70
2020-21	1275534	1270663	-4871	-0.38	190198	189395	-803	-0.42
2021-22	1379812	1374024	-5788	-0.42	203014	200539	-2475	-1.23
CAGR	4.56	5.31			4.55	5.82		

Source: Central Electricity Authority, Ministry of Power, Government of India, Annual Report 2021-22 [13]

4. RENEWABLE ENERGY IN INDIA

Table 2 demonstrates the total energy requirement in India in 2021-22 and the energy produced by different renewable sources in India. It is evident that in 2021-22, there were 1611 billion units of energy required by the Indian economy, of which 337 billion units of energy comprising 20.3 per cent of total requirement produced through different renewable sources, in which the highest share of renewable energy produced by solar energy with 48.1 per cent of total renewable energy followed by wind (36.2 per cent), biomass (11.3 per cent), and small hydropower (4.5 per cent).

5. OWNERSHIP-WISE GROSS INSTALLED CAPACITY OF RENEWABLE ENERGY IN INDIA

Fig. 3 shows the ownership of gross installed capacity of renewable energy in India in 2021-22.

It may observe that the private sector leads the energy sector of India. In the case of thermal energy, 36.51 per cent of ownership is occupied by the private sector, 31.82 per cent by the state government, and 31.67 per cent by the central government. In terms of Nuclear energy, 100 per cent of the energy production is owned and produced by the central government. Whereas, in the case of renewable energy, 69.08 per cent of the energy is produced by the private sector, followed by state and central government with 19.51 and 11.41 per cent, respectively. The top private companies producing renewable energy in India are Tata Power Solar, Suzlon Energy, and ReNew Power. Tata Power Solar is the largest company in renewable energy with a capacity of 12.8 GW in India, which provides a specialised and customised solution for various sectors such as banking, telecom, healthcare, education, etc. Suzlon Energy is a leading company in the field of wind energy projects which have a capacity of renewable energy of 13.14 GW. ReNew Power produces renewable energy through solar and wind with a capacity of 13.4 GW.

6. STATE-WISE INSTALLED CAPACITY OF CUMULATIVE RENEWABLE ENERGY IN INDIA

Fig. 4 shows the state and UTs-wise installed capacity of renewable energy in India in 2021-22. Out of the total installed capacity of 120848.29 MW, Rajasthan state (21171.50 MW) situated at the first rank with the share of 17.5 per cent of total installed capacity, followed by Gujarat, Tamil Nadu, Karnataka, and Maharashtra with the share of 15.4, 14.5, 13.5, and 9.7 per cent, respectively. These five states have an installed capacity of 70.6 per cent of the total installed capacity in India. Moreover, Andhra Pradesh (7.7 per cent), Madhya Pradesh (4.9 per cent), Telangana (4.2 per cent), and Uttar Pradesh (3.9 per cent) are the other prominent states in India. These nine states have 91.3 per cent of the total installed renewable energy capacity.

Table 2. Estimated contribution of renewable energy sources to the total energy requirement in India

(in Billion Unit)

Year	2021-22
Total energy requirement	1611.0
Small hydropower	15.0
Biomass	38.0
Wind	122.0
Solar	162.0
Total renewable energy	337.0
Percentage contribution of renewable energy source	20.3 per cent

Source: Central Electricity Authority, Ministry of Power, Government of India, Annual Report 2021-22 [13]

7. CENTRAL GOVERNMENT EXPENDITURE ON RENEWABLE ENERGY

India has also committed to Paris Climate Agreement that forty per cent of energy production would be from non-fossil fuels by 2030 and net zero emissions by 2070. Moreover, in the short run, the Indian government also targets to increase the capacity of 500 GW of renewable energy by 2030. The government also focused on the fact that at least 50 per cent of energy requirements would be met by renewable sources up to 2030.

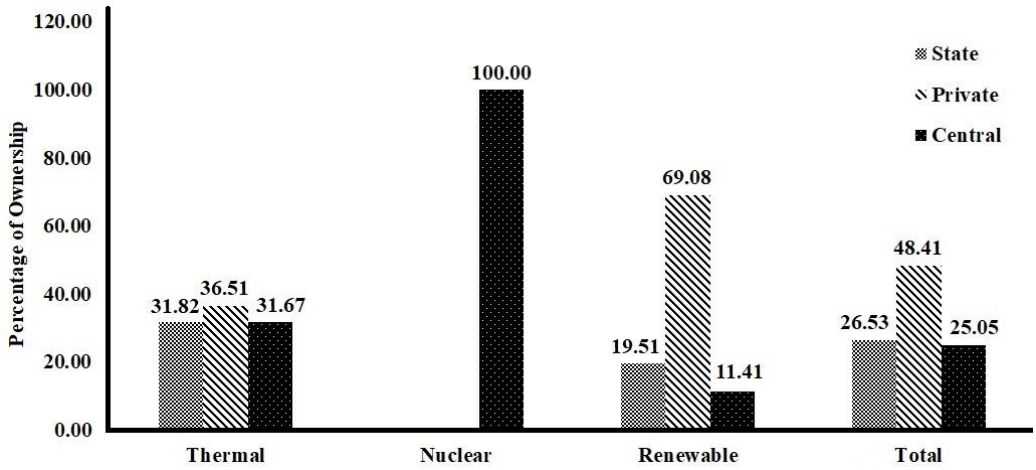

Fig. 3. Ownership of the energy sources in India (2021-22)

Source: Central Electricity Authority, Ministry of Power, Government of India, Annual Report 2021-22 [13]

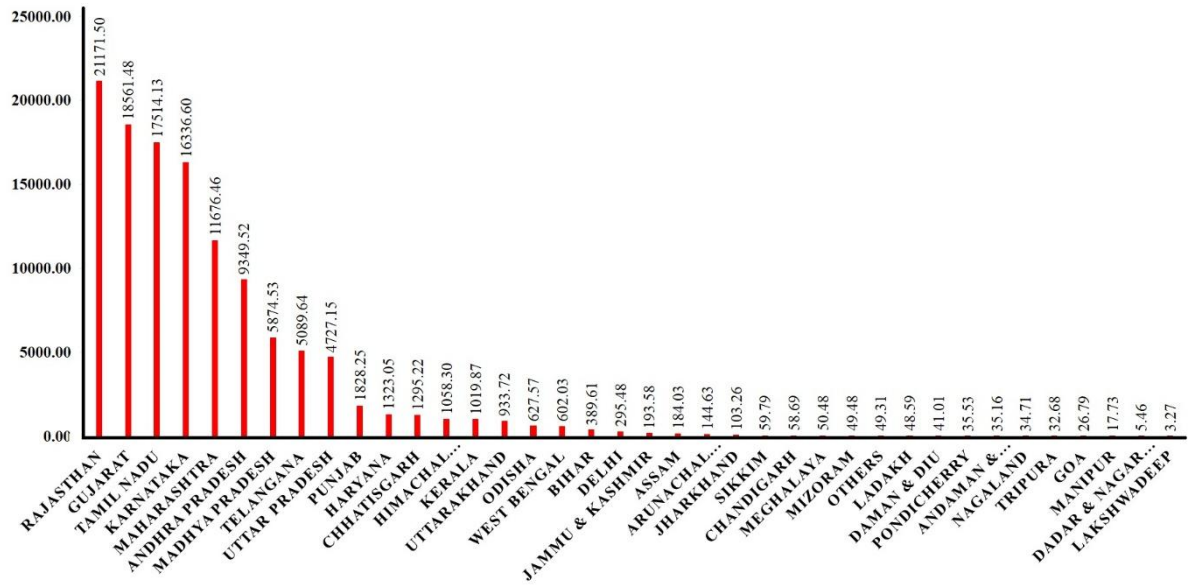

Fig. 4. State wise capacity of cumulative renewable energy (2021-22)

Source: Central Electricity Authority, Ministry of Power, Government of India, Annual Report 2021-22 [13]

Table 3 shows the government spending to encourage renewable energy sources in India. The government has emphasised awareness programs, workshops, surveys, research and development, etc. In 2020-21, the central government spent 2643.3 crore rupees to encourage renewable energy in India, which increased to 7681.8 crores in 2021-22 (revised) and 6900.7 crores in 2022-23 (budget estimate).

8. RENEWABLE ENERGY COUNTRY ATTRACTIVENESS INDEX (RECAI)

This index ranks the world's top 40 countries based on the attractiveness of investment in renewable energy and deployment opportunities. Ranking of this index measures the effectiveness of the market and trends of investment in a particular country. Table 4 shows the ranking of this index. The United States (US) ranked first with an index value of 72.8 in 2021 and 2020, followed by China and India with an index value of 70.7 and 70.2, respectively [16,17].

Table 3. Budget allocation for renewable energy by the government of India

(in Crore)

Financial year	Expenditure on renewable energy
2020-21 (Actual)	2643.3
2021-22 (Budget)	5753.0
2021-22 (Revised)	7681.8
2022-2023 (Budget)	6900.7

Source: Ministry of Finance, Govt. of India [14]

Table 4. Situation of India in RECAI

Country	RECAI score	Ranking 2021	Ranking 2020
US	72.8	1	1
China	70.7	2	2
India	70.2	3	3
France	67.4	4	5
UK	67.3	5	4
Germany	67.0	6	7
Australia	66.9	7	6
Japan	65.4	8	8

Source: EY Global [15]

9. CONCLUSION

The requirement, as well as the availability of energy in India, has increased continuously. Therefore, the energy deficit in the normal period declined from 11.01 per cent in 2007-08 to merely 0.42 per cent in 2021-22, and in the peak period, the deficit also declined from 19.91 per cent in 2007-08 to 1.23 per cent in 2021-22. To meet energy requirements, renewable energy has a significant contribution, which also helps to protect from environmental issues and encourage economic growth. In India, in 2021-22, renewable energy contributed a 20.3 per cent share of total energy requirements, in which the majority of the ownership owned by the private sector consisted of 69.08 per cent in 2021-22. Due to geographical and environmental advantages, the density of renewable energy highest was among the western coastal states of India. Moreover, renewable energy production faces many obstacles related to low research and development, low innovation, high cost of technology, rigid regulation frameworks, lack of infrastructure, and skewed marketplace. To fulfil the commitment given by the Indian government in Paris Climate Agreement, there is an urgent need for comprehensive policies to attract investment. Moreover, the Indian government spent three times higher than 2020-21 for renewable energy in 2021-22, i.e., 7681.8 crore rupees, which should be increased as well as research activities and research support should be provided to investors. Attention should be paid to the mass production of renewable energy equipment, so renewable energy sources can be made available at affordable prices. Further, the government should provide subsidy support to procure renewable energy and make society aware of installing renewable energy.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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