International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 10 | Oct 2021 www.irjet.net p-ISSN: 2395-0072

Current scenario of renewable energy in India

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Abstract - *Energy is one of the major factors responsible for the economic development of the country. India being a developing country shortage of electricity has always acted as a barrier in its way toward development. India's energy consumption has increased every year due to population growth. Presently, most of India's energy demands are fulfilled by fossil fuels like coal, petroleum, natural gas, etc. Due to such high demand for fossil fuels, these fossil fuels will soon get depleted. Within the next few decades, fossil fuels will become scarcer resulting in energy shortage due to an increase in energy prices and energy insecurity. Increased use of fossil fuels also degrades the environment by releasing greenhouse gases.*

Thus there is a need to enhance energy security along with reducing greenhouse gas emissions. Hence in today's time harnessing renewable energy has become the need of the hour. India is blessed with plenty of sunlight, water, and biomass which can be used to provide a sustainable power supply all over the country.

Key Words: Renewable energy, Solar energy, Wind energy, Hydropower, Biomass energy

1. INTRODUCTION

India's growth rate for renewable energy is the highest in the world. India has achieved a cumulative installed renewable energy capacity of 92.54 GW out of which 5.47GW was recently added in the period April 2020 till January 2021. This data does not include energy capacity from large-scale hydropower plants. During the period from April 2014 to January 2021, the capacity of installed renewable energy in India has increased by two and half times. Globally today India stands 4th in the renewable energy power capacity. India generated 111.92 (BU) power from renewable energy sources in December 2020. As per the Global Trends in Renewable Energy Investment 2020 report, during the period 2014-2019, renewable energy programs and projects in India attracted an investment of 64.2 billion US Dollars which is approximately equal to Rs.4.7 lakh crore [1].

By the year 2022 India's electrical power targets include achieving 227GW (earlier 175 GW) of energy from renewable sources, which includes maximum energy from solar power (nearly 113 GW), 66 GW from wind power, biomass power to contribute 10 GW and 5GW from small hydropower [2].

The government has announced that between the period 2017-2022 no new coal-based capacity addition is required beyond the 50 GWs under different stages of construction likely to come online between 2017 and 2022. The Indian Government has made a comprehensive policy for compulsory use of renewable energy within the country, particularly for commercial establishments, as well as Government establishments. The major contribution to renewable energy investment comes from the participation of the private sector. This is thanks to the support from the govt., which leverages private investment [3].

Year	Installed RE Capacity (in GW)	% Share of RE in total Installed Capacity	Generation from Renewable Sources (in BU)	Total Generation from all sources (in BU)	% Share of RE in Generation
2014-15	**39.55**	**14.36**	61.78	1110.18	**5.56**
2015-16	46.58	15.23	65.78	1172.98	5.60
2016-17	57.90	17.68	81.54	1241.38	6.56
2017-18	69.77	20.24	101.83	1303.37	7.81
2018-19	78.31	21.95	126.76	1375.96	9.21
2019-20	87.07	23.52	138.32	1390.93	9.95
2020-21	**92.54**	**24.53**	111.92	1017.81	**11.00**
	(Up to Jan, 2021)	(Up to Jan, 2021)	(Up to Dec, 2020)	(Up to Dec, 2020)	(Up to Dec, 2020)

Table1: India's RE Sector at a Glance

2. Types of Renewable energy

Renewable energy is also known as a non-conventional source of energy is generally categorized into five parts in India by the Ministry of new and Renewable Energy which are solar energy, wind energy, small hydro energy, bioenergy, and waste to energy.

Source	Total Installed Capacity (MW)	2022 target (MW)
Solar power	38,794	100,000
Wind power	38,684	60,000
Biomass power (Biomass & Gasification and Bagasse Cogeneration)	10,145.92	*10,000
Waste-to-Power	168.64	
Small hydropower	4,739.97	5,000
TOTAL	**89,229.42**	**175,000**

Table-2: grid-interactive renewable power capacity (excluding large hydropower)

Table-2 shows the installed renewable power energy power capacity in India for above mentioned renewable energies. The data mentioned above was collected and upload on 28th February 2021. The figures show the new and fast-developing renewable energy sources managed by the Ministry for New and Renewable Energy (MNRE) [4].

In terms of meeting its ambitious 2022 targets, as of 31 March 2017, wind power has reached more than halfway towards its goal, while solar power was 13% below its target, although expansion is expected to be dramatic soon. Bioenergy was at just above the 80% mark whilst small hydropower was already 85% of the way to meet its target. Overall India was at 25.44% from its target of 227 GW in 2022 for renewable installed power capacity. Now let's discuss the current scenario of each energy and its actual potential in detail [5].

2.1 Solar Energy

Indians have worshiped the sun from ancient times. The understanding of sunlight as an energy source was given for ages. About 5,000 trillion kWh per annum of energy is incident over India's acreage with most parts receiving 4-7 kWh per sq. m per day. Hence India has vast potential in the field of solar power. If Solar photovoltaic power is effectively harnessed it could resolve the problem of huge energy scalability in India. There has been a clear impact of solar power within the Indian energy scenario during the previous couple of years. Solar energy is one of the most secure sources of energy from an energy security perspective since it's abundantly available. Practically, only a little amount of the incident solar radiation (if captured effectively) can meet the entire country's power requirements [6].

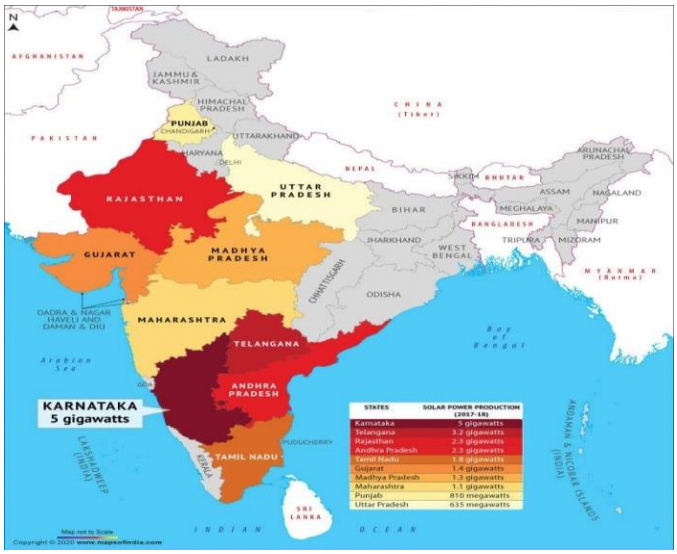

Fig 1: Solar potential of India (2018)

Recently, India achieved 5th position within the global scenario for solar energy deployment surpassing Italy. the rise in solar energy capacity started in 2014-2015 when the Narendra Modi government revised the target of harnessing solar energy across the country from 20,000 MW to 1,00,000 MW of grid-connected solar energy by the year 2022. According to the Ministry of New and Renewable energy, only 1112.08 MW of solar power capacity was installed in 2014-15, which increased to 9362.67 MW of solar power capacity in 2017-18.6884 MW of solar power capacity was installed from April 2019 till February 2020 across various states. Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Telangana, and Rajasthan are some of the states that have topped the list with the highest capacity of installed solar power in the country. The southern states are very ahead in terms of solar power installations according to a report in 2018, outpacing states like Gujarat and Rajasthan. Karnataka is one such southern state leading in the front since 2018. The solar photovoltaic (PV) installed capacity of Karnataka crossed the mark of 5 gig watts in March 2018 making it India's top solar PV state. If we consider a bifurcated figure of the total solar power production in the state in 2017-18, Karnataka installed more than 2 gig watts of solar PV capacity in 2017 and also similar installation in the first quarter of 2018. This result was due to the solar projects formulated under Karnataka's solar policy and also under the National Solar Mission with a capacity of 600 megawatts [7].

India's installed solar power capacity was 39,083 MW as of 28 February 2021. Solar electricity generation from April 2019 to March 2020 was 50.1 TWh or 3.6% of total generation. The report also says that India has one of the most competitive and lowest per-unit costs of solar power in the world. To achieve the target of 1,00,000 MW by the year 2022, various schemes have been launched by the government to encourage the generation of solar power in the country like Solar Park Scheme, VGF Schemes, CPSU Scheme, Grid Connected Solar Rooftop Scheme, etc [8].

2.2 Wind Energy

The wind is a periodic and site-specific resource of energy. Wind generation development began in India within the 1990s and from then it increased significantly. The wind being site-specific, and extensive wind resource assessment is usually essential for the choice of potential sites. One of the main factors for the choice of the potential site is wind speed. The govt., through the National Institute of Wind Energy (NIWE), has installed over 800 wind-monitoring stations everywhere in the country and issued wind potential maps at 50m, 80m, and 100m above ground level. The recent assessment indicates a gross wind generation potential of 302 GW within the country at 100 meters above ground level [9].

Currently, India has the fourth-highest wind installed capacity within the world with a complete installed capacity of 38.789 GW (as of 28th February 2020) and has generated around 52.66 Billion Units during 2017-18. As of 30 June 2018, the installed capacity of wind generation in India was 34,293 MW mainly spread across Tamil Nadu with 7,269.50 MW, Maharashtra with 4,100.40 MW, Gujarat with 3,454.30 MW, Rajasthan with 2,784.90 MW, and Karnataka with 2,318.20 MW. Wind power is responsible for 10% of India's total installed power capacity. Hence, the best-installed capacity within the country is in Tamil Nadu with around 7.5 GW since its state regulations are considered favorable to wind generation development. Followed by Maharashtra with an installed capacity of about 5 GW followed by Gujarat with the 3rd highest installed capacity of around 4 GW within the country. The table below shows the electricity produced by wind energy in India (April 2018 to March 2019) [10,11].

The map below shows the state-wise distribution of wind speed in India.

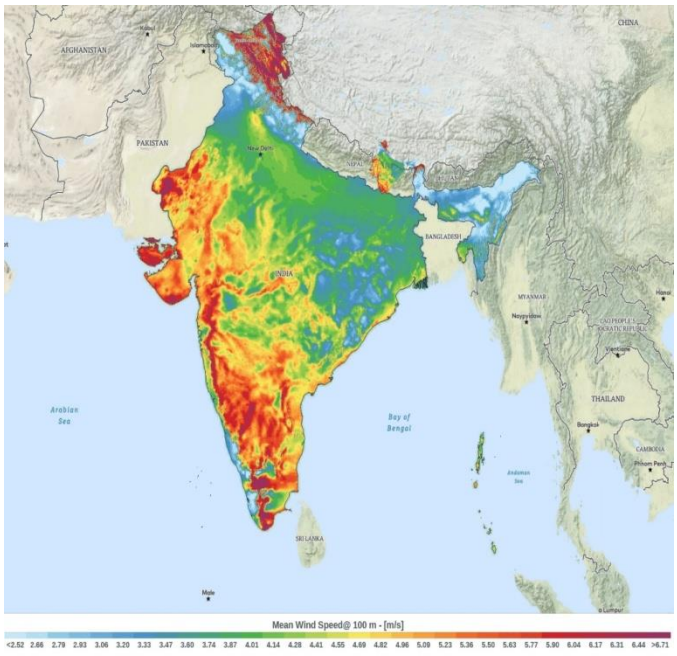

Fig 2: Mean wind speed in India (m/s)

India's wind energy sector is led by the native wind generation industry and has shown consistent progress. The expansion of the wind industry has resulted in a manufacturing base of about 10,000 MW per annum, a strong ecosystem, and project operation capabilities. Through private sector investments, the government is promoting wind generation projects within the entire country by providing various fiscal and financial incentives. To promote the installation of wind capacity in the country following steps have been taken by the government:

i. Wind resource assessment, identification of potential sites, and technical support if required would be provided. This would be done with the help of the National Institute of Wind Energy, Chennai.
ii. For the projects commissioned in the year 2022, all the inter-state transmission charges and losses have been waived off for wind and solar projects to facilitate the inter-state sale of wind power.

India targets to achieve 60 GW of power from wind by 2022 and 140 GW by 2030 but according to the report by Global Wind Energy Council (GWEC), by the year 2022 wind energy capacity in India can only realistically reach 50 GW. Hence, efforts are been made by the government to lower barriers around market design, grid infrastructure, and land allocation is intensified, to revive auction appetite and resolve the execution challenges faced by India's wind market and reach the country's ambitious 175 GW renewable energy target by 2022, of which 60 GW is due to come from wind energy [13].

2.3 Hydropower Energy

Hydroelectric energy is also known as hydroelectric power which is a form of renewable energy that uses the power of flowing or moving water to generate electricity. Hydropower in India is classified into small hydropower and large hydropower. The small hydropower is governed by the Ministry of New and Renewable Energy which have further been classified into micro (100kW or below), mini (101kW-2MW), and small hydro segments (2-25MW). Whereas large hydropower is governed by the Ministry of Power. Large hydropower is often opposed by societies, environmentalists, and non-governmental organizations due to the fear of flooding, desertification, and relocation issues. On the other hand, small hydropower is usually clean, sustainable, and environmentally friendly. Hence most small hydropower plants (SHP) are usually canal-based or run of river type which uses river water to drive the turbine [14].

The first hydroelectric power plant was established in 1898 at Darjeeling and was followed by Shivanasamudram in 1902. They were among the first in Asia and ever since, India has been a dominant player in global hydroelectric power development. The state-wise potential, installed capacity, and the implementation of a small hydropower plant for the year 2019-2020 are stated in the table below. From the table, it can be seen that the State of Karnataka has the highest installed capacity followed by Himachal Pradesh and Maharashtra. The north and northeastern region of India has a high potential of SHP; the northeastern part of India is often called the 'Future Power House' of India [14].

According to the International Hydropower Association, the total hydropower potential in India is 660,000 GWh/year, of which 540,000 GWh/year (79%) is still undeveloped. India is the 5th largest producer of hydropower energy in the world with an installed capacity of 45, 699 MW based on the data collected on April 24, 2020, with more than 80% of the hydropower capacity being distributed among the Himalayan States. In central India, the hydroelectric power potential from various rivers like the Godavari, Mahanadi, Narmada, Nagavali, and Vamsadhara river basins has not been developed on a major scale due to potential opposition from the tribal population. However, hydropower contributes only 12.4% of the total installed capacity in the country [15].

The Ministry has taken various steps to promote the development of SHP in a planned manner and improve the reliability & quality of the projects. By giving various physical and financial incentives, investments are attracted in commercial SHP projects. The Ministry is also emphasizing more on promoting the use of new and efficient designs of water mills for mechanical as well as electricity generation and setting up micro hydel projects up to 100 KW for remote village electrification. These projects are haunted by the involvement of local organizations like the Water Mills Associations, cooperative societies, registered NGOs, village energy cooperatives, and State Nodal Agencies [15].

Sr No.	States	Potential		SHP Installed		SHP under execution	
		No.	Capacity (MW)	No.	Capacity (MW)	No.	Capacity (MW)
1	Andhra Pradesh	359	409.32	44	162.11	0	0
2	Arunachal Pradesh	800	2064.92	156	131.105	10	7.05
3	Assam	106	201.99	6	34.11	1	2
4	Bihar	139	526.98	29	70.7	0	0
5	Chhattisgarh	199	1098.2	10	76	0	0
6	Goa	7	4.7	1	0.05	0	0
7	Gujarat	292	201.97	13	62.352	9	48.81
8	Haryana	33	107.4	9	73.5	0	0
9	Himachal Pradesh	1049	3460.34	195	906.51	18	179.6
10	Jammu & Kashmir	302	1707.45	46	180.48	16	47.1
11	Jharkhand	121	227.96	6	4.05	0	0
12	Karnataka	618	3726.4	170	1280.73	3	13
13	Kerala	238	647.15	34	222.02	8	80.5
14	Madhya Pradesh	299	820.44	12	95.91	2	7.6
15	Maharashtra	270	786.46	70	379.575	9	10.4
16	Manipur	110	99.95	8	5.45	0	0
17	Meghalaya	97	230.05	5	32.53	2	25.5
18	Mizoram	72	168.9	18	36.47	4	8.7
19	Nagaland	98	182.18	12	30.67	1	1
20	Odisha	220	286.22	10	64.625	3	57
21	Punjab	375	578.28	56	173.55	7	4.9
22	Rajasthan	64	51.67	10	23.85	0	0
23	Sikkim	88	266.64	17	52.11	1	3
24	Tamil Nadu	191	604.46	21	123.05	0	0
25	Telangana	94	102.25	30	90.87	0	0
26	Tripura	13	46.86	3	16.01	0	0
27	Andaman & Nicobar Islands	7	7.27	1	5.25	0	0
28	Uttar Pradesh	251	460.75	9	25.1	2	25.5
29	Uttarakhand	442	1664.31	102	214.32	13	7.58
30	West Bengal	179	392.06	24	98.5	0	0
	Total	**7133**	**21133.62**	**1127**	**4671.557**	**109**	529.24

Table 3: State-wise details of SHP potential, installed capacity, and under implementation (2019-2020)

2.4 Biomass Energy

The term bioenergy refers to the energy derived from biomass or biofuels. Biomass is a term used to describe all organic matter which is water and land-based vegetations and trees. It also includes waste such as municipal solid waste, waste from sewage, animal wastes, forestry and agricultural residues, and certain types of industrial wastes. Biomass can be used for the production of heat, transport fuels, and biomaterials.

Biomass energy is widely used in India and this can be concluded by looking at the stats that say that more than 32% of primary energy used in India is derived from biomass energy and 70% of the Indian population depends on it. Biomass in India is usually converted by either using thermochemical processes or cogeneration in sugar mills. Thermochemical processes may include combustion, pyrolysis, or gasification. Cogeneration is a traditional practice in India where bagasse is used for the production of electricity and steam for their requirement. Using the same quantity of bagasse significant surplus electricity for sale to the grid can also be produced. India has a potential of about 18 GW of energy from Biomass. India has an estimated +5 GW capacity biomass-powered plants, 83% of which are grid-connected while the remaining 17% are off-grid plants. The off-grid plants are divided between cogeneration plants that don't utilize bagasse, biomass gasifiers for rural applications, and biomass gasifiers for thermal applications in the industry[16].

According to the Ministry of New and Renewable Energy India, the current availability of biomass in India is approximately 500 million metric tonnes per year. Studies by the Ministry have estimated surplus biomass availability of about 120-150 million metric tonnes per annum which covers agricultural and forestry residues. These residues have a potential of about 18,000 MW. Apart from this, additional power of 7000 MW could be generated through bagasse-based cogeneration in the country's Sugar mills, if these sugar. In India, there are more than 500 biomass power and bagasse cogeneration projects which have a power capacity of 9806 MW installed in the country for feeding power to the grid. The state-wise installed capacity of biomass can be referred from table 4 [16].

The total capacity of the biomass power and cogeneration sector installed in India in the year 2020 is about 10145 MW. The installed capacity of Biomass IPP is 1826 MW, of Bagasse Cogeneration is 7547 and that of Non-Bagasse Cogeneration is 772 MW. The states leading in cumulative installed capacity of biomass in India are Maharashtra, Uttar Pradesh, Karnataka, and Tamil Nadu [17].

Name of State/UT	Biomass IPP (In MW)	Bagasse Cogeneration (In MW)	Non-Bagasse Cogeneration (In MW)	Cumulative Installed Capacity (as of 31.12.2019)
Andhra Pradesh	171.2	206.9	105.57	483.67
Bihar	12	100.5	12.2	124.7
Chhattisgarh	222.4	20	2.5	244.9
Gujarat	44.5	20.8	12	77.3
Haryana	19.4	102	89.26	210.66
Karnataka	137.3	1729.8	20.2	1887.3
Madhya Pradesh	92.5	0	14.847	107.347
Maharashtra	217	2351	16.4	2584.4
Punjab	138.5	161	173.95	473.45
Rajasthan	114.3	4.95	2	121.25
Tamilnadu	218.7	750.4	43.55	1012.65
Telangana	60.1	98	2	160.1
Uttrakhand	0.12	72.6	57.5	130.22
Uttar Pradesh	28	1929.5	159.76	2117.26
West Bengal	300	-	19.92	319.92
Odisha	50.4	-	8.82	59.22
Himachal Pradesh	-	-	9.2	9.2
Kerala	-	-	2.27	2.27
Meghalaya	-	-	13.8	13.8
Jharkhand	-	-	4.3	4.3
Assam	-	-	2	2
Manipur	-	-	-	0
Nagaland	-	-	-	0
Arunachal	-	-	-	0
Tripura	-	-	-	0
Sikkim	-	-	-	0
Mizoram	-	-	-	0
Goa	-	-	-	0
J & K	-	-	-	0
Total	1826.42	7547.45	772.047	10145.917

Table 4: State-wise Installed Capacity of Biomass IPP/Bagasse Cogeneration/Non-Bagasse Cogeneration in India (2019-2020)

The Government of India has set an ambitious target of 175 GW renewable power installed capacity by the tip of 2022, therefore making it one of the foremost progressive renewable energy policies in the world. This target aims to put in a complete of 10 GW worth of Bioenergy capacity. India's potential in the field of bioenergy is very high and driven largely by overpopulation and vast agricultural pastures. Experts estimate peg this at a complete of 25 GW. India is one of the most important economies with a growing population, big capacities of field and plantation biomass, industrial biomass, forest biomass, urban waste biomass, and aquatic biomass. In addition, the electricity demand is growing per annum because of the economic process, increasing prosperity and urbanization, rise in per capita consumption, and large rural electrification infrastructure. Another critical factor to think about is that India is very captivated with petroleum imports, with approximately 82 percent of total petroleum imports accustomed to fulfill the domestic consumption demand, which makes this vulnerable to price shocks due to unforeseen escalations in petroleum prices. Therefore it seems to be only logical to mix the potential in Bioenergy as a less expensive, greener source of power, with the increasing demand for electricity across the country [17].

3. Impact of COVID-19 on renewable energy

Covid-19 had a large negative impact on the world's economy and human life, it has drastically improved environmental conditions. It improved air quality, water quality, water availability, and flourishing plant and animal life are few positives of the pandemic [18].

In India, large numbers of industries are affected due to lockdown and the renewable energy sector is one of them. Due to a large number of industries and dense population the power requirement is quite high in India. Hence, India's target for the year 2022 of installing 175 GW of renewable energy capacity is now hanging with uncertainty due to the pandemic. The government of India has already haunted great initiatives to market self-sustenance within the country which signals towards the independence of India in terms of imports from other countries as its primary goal during and beyond the COVID-19 period. This is an important step toward the self-reliance of the nation. Due to the curtailing imports from other countries, India has not only boosted the economy but also generated a large number of jobs within the nation to compensate for the losses the utilization sector faced during the lockdown of industries and businesses alike[19].

On close examination of the present and future impact of Covid-19 on renewable energy, it has been found that the maximum issues faced by India are because of its imports of most of its raw material from China while was banned during the lockdown tenure. India's raw material has been exhausted, stalling any quiet progress within the sector. The nation has gone an extended way in establishing itself as a possible leader within the solar power sector within the world. However, to gain absolute supremacy in the world, the country should also bring in measures to solve its internal issues like safeguarding duty, managing taxes, and so on. Covid-19 is a dynamic catastrophe with no complete end of its near sight. Hence, one can only make presumptions based on available data [19].

Fig 3: Overall impact of COVID-19 on Indian renewable sector

4. CONCLUSIONS

There is an urgent need for the transition from fossil fuel energy systems to renewable resource energy systems to decrease reliance on depleting reserves of fossil fuels and to mitigate global climate change. Also, the expansion of renewable energy can improve air quality, reduce global warming emissions, create new industries and jobs, and help India move towards move cleaner and safer place where energy is affordable and in abundance.

As we know Covid-19 has a huge negative impact on the entire world but a positive note is that it has optimized the prospects of renewable energy sectors. The crisis has refocused the attention of the Indian government and policymakers to fight climate change and localize energy supply. Both these factors play to renewable power's advantage. Investors in conventional energy, suffering huge losses due to reduction of output and lower prices, are expected to accelerate the shift towards renewable power. Lastly, valuable lessons have been learned by grid managers in coping with increasing variability in power demand supply.

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