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GREEN ENERGY SOURCES IN INDIA: CURRENT STATUS AND FUTURE POTENTIAL

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Abstract: Renewable energy sources are gradually touching everyone's life in different ways. Renewable energy sources are not only an alternative sources but an exotic option to move towards the clean and green energy. Renewable energy can bring not only carbon free energy but also provide affordable electricity to all, social equality and sustainable development. Exponential growth in population, increasing energy demand, draining of fossil fuels and environmental concerns, led to strides toward alternative sources of energy. Looking towards drastic climatic changes, India has moved forward to use renewable energy sources for electricity generation as the country has plenty of renewable energy sources. India has announced world's biggest programmes in all states for renewable energy development. This chapter summarizes the status of accessibility of renewable energy sources in India. The current status and estimated potential of renewable energy sources in India and government policies, initiatives and major achievements are summarized in this chapter. This study will be helpful for researchers, developers and investors to identify the scope of improvement in technologies for better harnessing energy from renewable resources and chart a path to expand production of power from renewable energy.
Keywords: solar power, wind power, biomass and renewable energy sources

1. INTRODUCTION

India is already moving on the energy transition path by harnessing renewable energy sources for affordable and emission free energy. These sources provide energy independency, cleaner environment and economical growth [1]. Exponential growth in population, increasing per capita consumption of energy and drying up of natural resources has forced to look for alternative sources of energy. Melting of ice caps, overabundance of greenhouse gases, global warming and other drastic climatic changes worldwide, has turned attention towards environmental issues [2]. Looking towards global environmental problems, various countries around the world came together with climatic negotiations, namely, UNFCCC. India is an active participant of this novel drive and decided to generate clean, green and carbon free energy [3]. The government is making impressive progress to increase electricity generation as per growing demand as well as reducing carbon emissions by producing clean energy for balanced development of the country. India has implemented several energy policies to bring renewable energy market in line with an ambitious vision of energy affordability, safety and reliability [4]. According to IRENA report on April 2019, the world has recorded a growth of 171 GW renewable energy in the year 2018, 84% of this growth comprised of new solar and wind power. Today, renewable energy has become third most important power of the world [5]. In the last few years, from 2014, renewable energy generation in India has grown significantly, with more than 89.22 GW of renewable energy installed in different part of the country. India is on track to reach the goal of 100 GW by 2022. Currently India has the world's third largest installed renewable energy capacity after USA and Brazil [6].

Rise in the energy consumption in recent years is frightening. Due to consistent growth in India GDP, consumer purchase power has increased which resulted in increased use of energy in domestic comfort. Table 1 illustrates India's power consumption from 1990 to 2020 and projected power consumption between 2020 and 2040 [7]. Figure 1 shows India's source-wise electricity generation capacity installed in MW.

Solar energy, wind energy, geothermal energy, tidal energy and hydropower are natural energy sources. These energy sources are carbon free sources, which do not last on a human timescale and get replenished naturally. These emissions free sources used for electricity production gives clean energy, improve air quality and reduce pollution. It also gives an opportunity of employment, research and technological development [8].

Table 1. India's projected power consumption between 2020 and 2040

Year	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040
Oil	58	75	106	122	155	212	251	308	359	419	485
Gas	11	17	24	32	54	45	57	72	89	106	128
Coal	110	140	164	211	290	412	485	593	710	824	955
Nuclear	1	2	4	4	5	9	11	16	27	35	44
Hydro	15	17	17	22	25	29	36	43	47	50	52
Renewable	0	0	1	2	7	17	41	86	133	191	256
Total	195	251	316	394	537	724	880	1118	1365	1624	1921

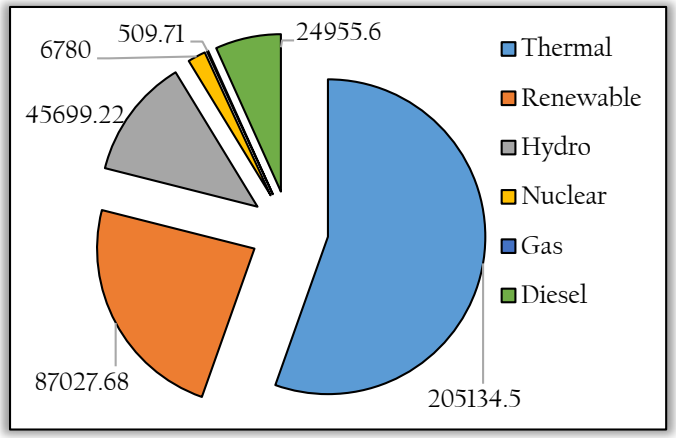

Figure 1. Conventional and Renewable energy Generation Capacity of India in MW

2. RENEWABLE ENERGY IN INDIA

There is an abundance of renewable as well as conventional energy resources in India, but coal has been a major source for electricity generation because it is readily available, suitable for the need and inexpensive. Even with half of skilled labor in coal generation compared to solar generation, coal generates more electricity than solar energy due to lack of technological development. Although India has 300 cloudless bright sunny days, many perpetual rivers and about 7500 Km seacoast, except hydropower, wind and solar energy are remained untapped for long time due to unavailability of relevant technologies [9]. India has announced to increase the power generation by renewable energy towards a target of 450 GW at the United Nation's Climate Summit 2019 (India 2020 Policy). To reach these figures by 2022, India needs to increase its solar generation by 100 GW, wind energy by 60 GW, biomass power generation to 10 GW and 5 GW power from small hydropower. From recent reports of MNRE, there will be more than 750 GW generations from solar energy and 410 GW from wind energy by the year 2047 [4-5].

Table 2. Estimated Renewable Energy Potential in States of India

State	Solar	Wind energy	Small hydro	Biomass energy	Waste to energy and others	Total
Andhra Pradesh	38.44	44.229	0.978	0.578	0.423	84.648
Arunachal Pradesh	8.65	0	1.341	0.008	0	9.999
Assam	13.76	0	0.239	0.212	0.0008	14.219
Bihar	11.2	0	0.223	0.619	0.373	12.415
Chhattisgarh	18.27	0.077	1.107	0.236	0.024	19.714
Gujarat	35.77	84.431	0.202	1.221	0.462	122.086
Haryana	4.56	0	0.11	1.333	0.374	6.377
Himachal Pradesh	33.84	0	2.398	0.142	0.002	36.382
Jammu & Kashmir	111.05	0	1.431	0.043	0	112.524
Jharkhand	18.18	0	0.209	0.09	0.01	18.489
Karnataka	24.7	55.857	4.141	1.131	0.45	86.279
Kerala	6.11	1.7	0.704	1.044	0.036	9.594
Madhya Pradesh	61.66	10.484	0.82	1.364	0.078	74.406
Maharashtra	64.32	45.394	0.794	1.887	1.537	113.932
Manipur	10.63	0	0.109	0.013	0.002	10.754
Meghalaya	5.86	0	0.23	0.011	0.002	6.103
Mizoram	9.09	0	0.169	0.001	0.002	9.262
Nagaland	7.29	0	0.197	0.01	0	7.497
Odisha	25.78	3.093	0.295	0.246	0.022	29.436
Punjab	2.81	0	0.441	3.172	0.345	6.768
Rajasthan	142.31	18.77	0.057	1.039	0.062	162.238
Sikkim	4.94	0	0.267	0.002	0	5.209
Tamil Nadu	17.67	33.8	0.66	1.07	0.45	53.801
Telangana	20.41	4.244	0	0	0	24.654
Tripura	2.08	0	0.047	0.003	0	2.132
Uttar Pradesh	22.83	0	0.461	1.617	1.25	26.334
Uttarakhand	16.8	0	1.708	0	0.005	18.537
West Bengal	6.26	0.002	0.396	0.396	0	7.202
Total	748.99	302.251	19.749	5	20.09	1096.08

India is planning to shift its 40% of the total generation capacity on renewable energy sources by the year 2030, as indicated in Intended Nationally Determined Contributions (INDCs) [10]. Year wise Cumulative growth in RES in the last decade (till 2019) is shown in fig.2 [11-12]. There's a lot to look forward to since approximately 293 companies worldwide and nationally are dedicated to the production of 266 GW of energy with renewable energy sources. With the growth of electric vehicles in India, the cost of storage is expected to reduce and this will give robust growth in the renewable energy market [13-14]. Estimated renewable

energy potential in different states of India is shown in table 2. Table 3 illustrates the cumulative capacity of grid-connected renewable energy at the end of the year 2019 and 2020. There is a growth of approximately 6 GW of renewable energy capacity in the year 2019-20. Table 4 shows the total installed capacity of India Including thermal, renewable, hydro power and nuclear power with their respective sectors.

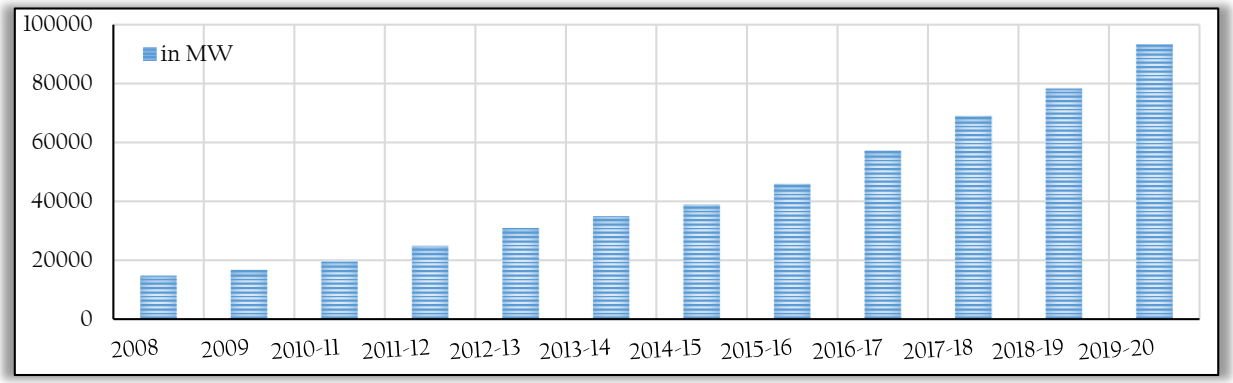

Figure 2. Year wise Cumulative growth in RES in the last decade

Table 3: Growth in Grid Connected Renewable Power

Sector	Total Capacity at the end of 2019	Total capacity till November 2020
Wind Power	37505.18	38433.55
Solar power- Ground mounted	31379.30	33508.31
Solar power- Roof top	2333.23	3402.18
Small hydropower	4671.55	4740.47
Biopower	9861.31	10145.92
Waste to power	139.80	168.64
Total	85908.37	90399.07

Table 4: Sector-wise total installed capacity of India (in MW)

Sector	Hydro	Thermal	Nuclear	RES	Total (31.12.2019)	Total (30.11.2020)
State	29878.8	71829.13	0	1990.37	103698.30	104117
Private	3394.0	87000.30	0	70563.99	160958.29	176655
Central	12126.4	64197.91	6780.0	1527.30	84631.63	93427
Total (2019)	45399.2	223027.34	6780.0	74081.66	349288.22	
Total (2020)	45699	231321	6780	90399		3740199

Karnataka, Tamil Nadu, Maharashtra, Gujarat and Rajasthan are India's top five states in installed renewable capacity. Those five states have about 66.991% of renewable energy capacity. Karnataka ranked 1st at 12,953.24 MW (17.485%), Tamil Nadu 2nd at 11,934.38 MW (16%), Maharashtra 3rd at 9,238.78 MW (12.532%), Gujarat 4th at 7,882.5 MW (10.6%) and Rajasthan 5th at 7,573.86 MW (10.224%). Alongside these five states, Andhra Pradesh, Madhya Pradesh, Telangana and Uttar Pradesh are the other most important Indian state of installed renewable capacity. These nine states account for 91.655% of total Indian installed capacity [15-16].

— **Solar energy**

Government of India announced National Solar Mission for National Action Plan on climate change on November 2009. A target of 20 GW grid solar capacity and 2 GW off-grid installations by 2022 was set. Later this target was raised in 2015 to 100 GW solar power by 2022. The solar power sector is growing rapidly in India. Growth of installed solar capacity in India is shown in table 7.

Table 7. Growth in Installed solar power in India

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cumulative capacity (MW)	161	461	1205	2319	2632	3744	6763	12289	21651	28181	35739

Table 8. Constituents of total solar power in India

Solar Power	Capacity till July 2019 (MW)	Capacity till November 2020 (MW)
Ground mounted solar power	27930.32	33508.31
Rooftop Solar power	2141.03	3402.18
Off-Grid solar power	919.15	1171.49
Total	30990.50	35739

The solar installed capacity of India is 34.404 GW up to February 2020 with minimum capital cost per MW globally. The solar generation capacity of the country in 2014 was 2650 MW, added 3 GW in 2015, 5 GW in 2016, over 10GW in 2017 and 20 GW in 2018 with a reduced cost of energy with solar power plants. From 2014 to 2018, solar generation capacity is grown 8 times. India has set around 42 solar parks to promote solar plants by making land available [17-18]. Constituents of solar power in India are shown in table 8. The solar

installation capacity achieved new heights by the supportive initiative of government "Made in India", to encourage domestic manufacturing of solar panels. Now India ranked fifth in solar installations worldwide. To achieve remaining targets of 100 GW, MNRE planned for bidding of the solar generation capacity. Large section of land has been characterized for solar parks in India, out of that 47 solar parks are developed. The solar generation capacity of these 47 parks is around 26 GW and 2.6 GW projects are already commissioned. Tariffs were also determined by a competitive bidding process. This has reduced solar energy tariff from INR 18 per kWh in 2010 to INR 2.44 per kWh in 2018 [19-20].

— **Wind energy**

Wind energy is combined effect of several phenomena like earth's rotation, solar energy; ocean's cooling effects, difference in temperature gradient of land and sea etc. It is broadly dispersed sources of energy. Wind energy is emerging out as a bright source of energy due to technological advancements in turbine system. India stood fourth in introducing a wind power limit on the planet with the total installed capacity of 38.124 GW in 2020 [7]. Although India is latecomer to wind industry if compared with other developed countries, but due to government policy support, wind power generation has grown significantly in India. Wind power generation has grown by 14% during the period of year 2007-16 [21]. The Growth of wind energy generation in India is shown in Figure 5. A target of 60GW electricity by 2022, from wind power is set by the country out of that 38.124 GW has been achieved till 2020 [22]. The leading states in wind power installed capacity in India are Tamil Nadu (7269.50MW), Maharashtra (4100.40MW), Gujarat (3454.30MW), Rajasthan (2784.90MW), Karnataka (2318.20MW), Andhra Pradesh (746.20MW) and Madhya Pradesh (423.40MW). Installed wind Capacity of different states of India as per MNRE 2019 is given in table 10.

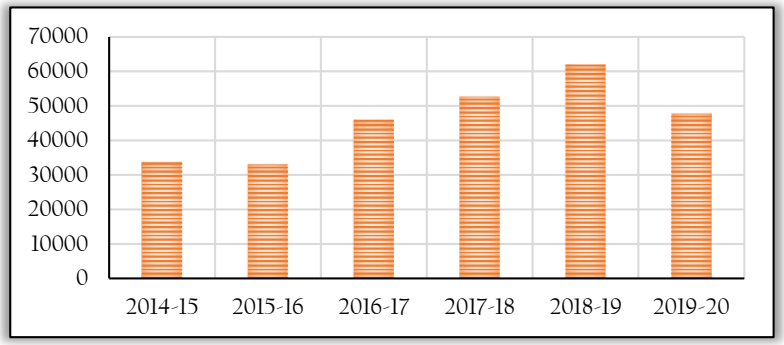

Figure 5. Year-wise growth of Wind energy Generation in India

Table 10. Installed Wind Capacity of states in India

S.No.	State	Installed Capacity (MW)
1	Tamil Nadu	9304.34
2	Gujarat	7541.52
3	Maharashtra	5000.330
4	Karnataka	4790.60
5	Rajasthan	4299.720
6	Andhra Pradesh	4092.450
7	Madhya Pradesh	2519.890
8	Telangana	128.100
9	Kerala	62.500
10	Others	4.300
Total Installation (MW)		37716.75

Table 11. Estimated Wind Potential in states of India

States	Assessed Wind Potential (MW)
Tamil Nadu	33799.65
Maharashtra	45394.34
Gujarat	84431.33
Rajasthan	18770.49
Karnataka	55857.36
Andhra Pradesh	44228.60
Madhya Pradesh	10483.88
Others (Kerala, Telangana, Odisha,Chattisgarh, West Bengal, Puducherry, Lakshadweep, Goa, Andaman & Nicobar)	9285.84
Total	302251.49 (302 GW)

Table 12. List of India's largest wind farms:

S.No.	Wind Farm	State	Capacity (MW)	Producer
1	Jaisalmer Wind Park	Rajasthan	1600	Suzlon Energy
2	Muppandal Wind Farm	Tamil Nadu	1500	Muppandal Wind
3	Brahmanvel Wind Farm	Maharashtra	528	Parakh Agro Industries
4	Dhalgoan Windfarm	Maharashtra	278	Gadre Marine Exports
5	Chakala Windfarm	Maharashtra	217	Suzlon Energy
6	Vankusawade Windfarm	Maharashtra	189	Suzlon Energy
7	Vaspet Windfarm	Maharashtra	144	ReNew Power

MNRE reported another strategy to use the land for wind farms same as solar parks in "New Wind-Solar Hybrid Policy" May 2018 [23]. The Government of India along with "National Institute of Wind Energy" (NIWE), has introduced more than 800 wind-monitoring stations all over nation. The NIWE report gave wind potential maps and assessed a gross capacity of 302 GW in the nation. The assessed capacity of wind energy in the states of India is given underneath in table 11 [24] and some largest wind farms of India are shown in table 12.

— **Biomass Energy**

India is an agrarian country with tropical location, bountiful sunshine and rains that makes ideal conditions for Biomass production. The huge amount of agro waste can be used to meet heat energy and power generation. The approximate potential of electricity generation from biomass energy in India is 16 GW and 3.5 GW from bagasse cogeneration. Agricultural waste like rice husk, cotton stalk, straw, soya husk, de-oiled cakes, coffee waste, jute wastes, groundnut shells, coconut shells, and sawdust are organic waste that can be used for power generation. Biogas, biofuel, biodiesel, bio protein and waste to energy are different biomass that can be used in different forms to substitute energy [25-26]. MNRE amended National policy for biofuels from biomass in May 2018. A target of 10 GW power from biomass is set for the year 2022. Table 14 shows target and achievements of biomass power at the end of the year 2019 [27]. The present installed capacity of biomass in India is around 1 GW and further planned to increase it 10 GW. Andhra Pradesh, Maharashtra, Tamil Nadu, Karnataka and Rajasthan are the major states producing electricity from biomass. Some new capacities of biomass are added by Punjab and Chhattisgarh too. Table 15 shows state-wise installed capacity of biomass energy in India. Requirement of large amount of land for electricity generation from biomass made it a troublesome recommendation. The "National Biogas and Manure Management Programme" was established in 2012-13, with the aim of providing clean fuel for cooking prepared from organic bio-manure [28].

Table 14. Year-wise Target, achievements and cumulative capacity of Biomass power in India [41]

Year	Target (MW)	Achievement (MW)	Cumulative (MW)
2013-14	405	412.5	4013.55
2014-15	400	405	4418.55
2015-16	400	400	4831.33
2016-17	400	161.95	8181.70
2017-18	340	519.10	8700.80
2018-19	250	374.70	9075.50
2019-20	500	1070.41	10145.91

Table 15. State-wise installed capacity of Biomass power in India (31.10.2020)

State	Installed Capacity (MW)	State	Installed Capacity (MW)
Andhra Pradesh	483.67	Bihar	124.70
Rajasthan	121.30	Chattisgarh	244.90
Madhya Pradesh	107.347	Haryana	210.66
Maharashtra	2584.40	Uttarakhand	130.22
Tamil-Nadu	1012.65	Uttar Pradesh	2117.26
Jharkhand	4.30	Himachal Pradesh	9.2
West-Bengal	319.92	Meghalaya	13.80
Telangana	160.10	Assam	2.0
Gujarat	77.30	Punjab	473.45
Kerala	2.27	Odisha	59.22
Total			10145.917

— **Small Hydropower**

India is world's fifth country for installed hydroelectric power capacity. The total installed utility scale hydroelectric capacity of India is 45699 MW, which is 12.35% of total capacity and 4380 MW small hydroelectric power units have been installed which is 1.3% of total generation capacity [4, 29]. SHP is the projects of generation capacity of 2 to 25 MW capacity. India has huge potential for small hydro plants too.

Table 18. Small Hydropower Projects Installed in States of India

State	Installed Capacity (MW) March 2020	State	Installed Capacity (MW) March 2020
Andhra Pradesh	162.11	Madhya Pradesh	95.91
Arunachal Pradesh	131.105	Maharashtra	379.575
Assam	34.11	Mizoram	32.53
Bihar	70.7	Nagaland	30.67
Gujarat	68.95	Odisha	64.625
Haryana	73.5	Punjab	173.55
Himachal Pradesh	911.51	Rajasthan	23.85
Jammu & Kashmir	180.48	Tamil Nadu	123.05
Karnataka	1280.73	Tripura	16.01
Kerala	222.02	Uttar Pradesh	25.10

The assessed capability of SHP is 20 GW and MNRE set an objective of 5 GW by 2022 and the out this 4.7 GW has been accomplished before the end of the year 2020. Table 18 shows installed capacity of different states of India. NITI Aayog's 3-year activity plan (2018-2019 to 2019-2020) incorporated a goal to satisfy the development of SHP by giving grants for project infrastructure and tariff support. MNRE is also supporting public and private sectors to set up small/ micro hydro projects by providing central financial assistance (CFA). MNRE is searching for new expected areas by reviews and complete project reports and giving funds to redesign and modernization of old projects [30].

3. GOVERNMENT INITIATIVES

With the goal of advancing solar energy innovation across the country, the first 'National Solar Mission' (NSM) was dispatched in 2010, under the 'National Action Plan on Climate Change' (NAPCC). The first goal set up by this mission was to install 20 GW solar plants by the end of the year 2022.In this mission, reverse bidding mechanism was employed to encourage project developers [31]. The government likewise advanced solar oriented water radiators and rooftop solar systems in the government buildings under the National building code. The Central government also provides endowments to encourage off-grid and rooftop solar generation. The ministry had also settled Centers of Excellence to energize research and development activities related to renewable energy sources. The government has also taken various strategy measures like, directions for acquirement of solar and wind power through tariff based competitive bidding process, standards for installing solar PV system, the framework of rooftop solar system, guidelines of smart cities, and amendments for the compulsory planning of rooftop solar plants on buildings [32]. These initiatives have also given employment opportunities in last 5 years. About 36000 suryamitras have been trained in the last five years and 1450 Varunmitras and engineers were given training for rooftop grid connection in 2018-19 [33]. To facilitate reconciliation of renewable generation capacity at large scale, the 'Cabinet Committee of Economic Affairs' (CCEA), authorized GREEN ENERGY CORRIDOR, for intra state transmission in states that are rich in renewable resources. Karnataka, Gujarat, Tamil Nadu Himachal Pradesh, Madhya Pradesh, Maharashtra, Rajasthan and Andhra Pradesh are the states included in green energy corridor [12]. Solar street lights (SSLs) were installed in states, Assam, Bihar, Jharkhand, Odisha and Uttar Pradesh under Atal Jyoti Yojana (AJAY) Phase-I. Under phase-II, the scheme is implemented in North Eastern States of India including Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand. Approximately 3 lakh Solar Street Lights (SSLs) are planned to position [13]. Central Financial Assistance (CFA) is provided to the biomass energy projects in India, in the form of subsidy and incentives by MNRE. Depending on the capacity installed, mode of energy generation and its utilization, CFA is given selectively through a clear and competitive policy [34]. Benefits of net-metering scheme will be applicable for domestic consumer as well as government offices, buildings, schools, hospitals also including banking facility and payment of surplus power to DISCOMs [28]. To encourage farmers to participate in the solar energy sector and raise sources of income of farmer, PM-KUSUM yojna aims to promote farmers to develop decentralized solar power projects on uncultivable land and sale the energy to DISCOMs. To utilize the knowledge into technological development, the 'Technology Development and Innovation Policy' was launched in October 2017. This policy aims to study resources, growth in technology, and commercialization of renewable power generation in the country. It also encourages manufacturing of renewable power devices and system domestically. Technology development program realized the need of collaboration of information, sharing expertise and institutional mechanisms. Policymakers, Industrial innovators, researchers, scientists, stakeholders and related department are mainly involved in the program [15]. As a technological initiative, Indian Institute of Technologies (IITs) and Indian Institute of science (IISCs) conducted a program namely, Impacting Research Innovation and Technology (IMPRINT). The funds for the program were financed by the ministry of human resource development (MHRD) and MNRE. MNRE and IMPRINT are implementing 5 projects for solar thermal system, storage of SPV, biofuels, hydrogen and fuel cells in FY 2018-19. The MNRE is also providing "The New and Renewable Energy Young Scientist's Award" to the exceptional work by the researchers/ scientists in the field of renewable energy.

4. MAJOR ACHIEVEMENTS

Solar Energy Corporation of India (SECI) carried out reverse auction for interstate solar power transmission with the lowest per unit cost in June 2020. Earlier the lowest tariff recorded was INR 2.44 per unit in 2018 and now it is INR 2.36 per unit, which is 3.3% lower. India launched 'Kisan Urja Suraksha evam Utthaan Mahabhiyan' (KUSUM) February 2019 with the aims of providing financial and water security to farmers. This scheme will add 25.75 GW solar power capacity. There are three fully functioning solar parks in India located in Kurnool, Andhra Pradesh with an installed capacity of 1000 MW, Bhadla-II in Rajasthan with an installed capacity of 680 MW and Pavagada in Karnataka with a total generation capacity of 2000 MW.

In March 2017, under solar parks scheme, the capacity of solar parks is increased from 20000 MW to 40000 MW with an objective of establishment of 50 solar parks by 2019-20. The assessment teams identified 995,000

acres of land for development of renewable energy projects in Andhra Pradesh, Karnataka, Madhya Pradesh, Tamil Nadu, Rajasthan, and Gujarat. In the first phase of this scheme, 25% land in Gujarat, Madhya Pradesh, and Rajasthan and 30% land in Andhra Pradesh, Karnataka, and Tamil Nadu are targeted to make a lank bank of 257,000 acres for development of around 50,000 MW capacity of solar/wind/hybrid/other renewable energy power parks [14].

To enhance solar power programs among common people, 74 lakh solar lanterns and study lamps; about 17 lakh home lights have been distributed. Around 6.8 lakh street lights have been set up in the villages of India. For irrigation and drinking water purpose, more than 2.46 lakh solar PV pumps have been installed in the rural areas.

Under the solar study lamp scheme, 60.61 lakh solar lamps were distributed to the students in Assam, Bihar, Jharkhand, Odisha and Uttar Pradesh. 7436 women were trained as solar lighting technicians, 1769 repair and maintenance centers were established, under the entrepreneurship development program, 1896 people were trained and 832 solar shops have been set up.

1115 hydropower projects are also set up in the various parts of the country with generating capacity of 4593 MW, and 116 projects are in process with the generating capacity of about 650 MW.

Delhi Metro trains are now solar powered as the Delhi Metro Rail Corporation will receive solar power from the Rewa Solar power project, Madhya Pradesh. DMRC also generates 28 MW solar power through rooftop solar projects installed on stations, residential areas and depots. The solar energy generated from rooftop plants on DMRC premises are used for auxiliary purposes. Now DMRC will receive 27 MW solar power from an off-site source, Rewa Solar power projects [15].

Mandironwala Bhuddi village Chakanwala Panchayat, Amroha district, Uttar Pradesh has no electricity poles but completely solar powered. It is totally dependent on solar power for all its needs. As a part of government scheme, solar panels have been installed on the rooftop of every house in the village and solar energy has become a source of electricity in the village for daily household chores. This village is a model of renewable energy usage in the country.

Vidya Dairy, Anand University Campus in Gujarat uses Concentrating Solar Thermal system for pressurized hot water system. There are 19 modules of solar dish costing around 72 lakh and this system saves 66 liters of fuel every day. Natco Pharma limited, Nagarjunsagar, Telangana uses Concentrating Solar Thermal for process heating application. This system saves 120 kg of fuel/day and the total cost of the system is Rs. 82.19 Lakh [16].

5. CONCLUSIONS

With the correct investments in green innovations, India is all around situated to accomplish sustainable power targets. The pursuit towards cleaner energy will have an essential function in empowering the nation's change to a completely supportable energy framework. There are estimates that suggest that renewable energy installations would reach 860 GW by the year 2030. This estimation is based on assessment of renewable energy in the country and growing energy demand. Emission intensities of India have been lowered to 20% compared to the previous decade. This shows a significant advancement even though CO2 emissions is rising continuously. Per capita emission of CO2 in India is 1.6 tonnes which are less than the global average of 4.4 tonnes. The global share of India's CO2 emission is 6.4%. Intended Nationally Determined Contribution under the Paris Agreement sets out focuses to lessen the emissions intensity of its economy and increase the share of renewable sources in its power generation capacity while likewise making an extra carbon sink by expanding woods and tree cover. Advancements in renewable energy in India will create jobs for locale, rural electrification and promote electric mobility too. There is an attempt to summarize the availability of renewable energy sources in India. The current status, installed capacity, government policies to promote them, major achievements and subsequent development are discussed in this chapter. Although data regarding development and installation of renewable energy sources are available on different websites but an attempt is made to collect them all in a meaningful way. The data collected in this chapter will enable researchers and developers to identify a scope of improving technologies to harness renewable energy and chart a path for further expansion of renewable energy production. With this review of renewable energy sources in India, some suggestions are marked as follows:

— Due to the intermittent nature of renewable energy sources, its large-scale integration into the grid is a difficult task. It requires up gradation of transmission and distribution infrastructure.
— Hybrid renewable energy sources should be preferred over usage of single renewable energy sources as it can increase system efficiency and reliability.
— Government is making efforts to bring renewable energy into electricity generation system, but individual efforts and social recognition of renewable energy is necessary for overall development. Public awareness about utilization of renewable energy sources and its environmental benefits should reach society.
— Advancements in renewable energy are not only good for environment but also for society as it will create jobs for locale, rural electrification and promote electric mobility too.

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