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Renewable energy for sustainable development in India:current status,future prospects,challenges,employment,and investment opportunities

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Abstract

Energy security and access, economic growth, and mitigation of climate change are the key goals of adopting renewable energy in India. The utilisation of sustainable energy and the provision of people with inexpensive, dependable, sustainable, and contemporary energy are essential to achieving sustainable development. India has become one of the world's most appealing renewable energy markets because to strong government backing and an increasingly favourable economic climate. As a result of the government's policies, initiatives, and a permissive atmosphere, the country's renewable energy sector is growing rapidly. Using renewable energy sources is expected to result in a huge number of new household employment in the coming years. As India's renewable energy sector grows, so do the potential benefits, problems, and job creation that come with it. This study tries to highlight these and other important aspects. The renewable energy industry faces a number of challenges, which we have addressed in this report. We hope that our findings and suggestions will be valuable to governments; innovators; project developers; investors; industries; linked stakeholders; and researchers and scientists; among others.

Achievements; Initiatives; Barriers; Recommendations; Investment; Employment; Developers; Policymakers; and Investors are all included.

Introduction

Electricity generation from fossil fuels including coal, oil, and oil and gas is responsible for around a third of the world's total emissions of greenhouse gases. In order to improve the quality of life, it is vital to provide cleaner and more dependable power. In order to carry out the country's economic growth ambitions, India's energy consumption is expected to rise. A country's economic development depends on its ability to produce growing amounts of energy [2]. The Ministry of Power (MoP) produced the National Energy Plan [NEP] [3], which outlines a 10-year action plan to provide electricity throughout the nation and a second plan to guarantee that power is delivered to residents effectively and affordably. As per the World Resource Institute Report 2017 [4, 5], India accounts for about 6.65 percent of global carbon emissions, ranking fourth after China (26.73%), the United States (14.36%), and the European Union (EU) (9.66 percent). The world's natural equilibrium might be thrown off kilter by climate change. The UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement have both received submissions of intended nationally determined contributions (INDCs). The latter aims to keep global temperatures from rising by more than 2°C [6, 7]. It is predicted that worldwide power consumption will peak

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in 2030 according to the World Energy Council [8]. India is a major user of coal, and as a result, it must rely on expensive foreign imports [8]. Coal and oil make up around two-thirds of the nation's energy needs. An analysis by the Centre for Monitoring Indian Economy shows that the country imported 171 million tonnes of coal from the United States between 2013 and 2014. The country imported 215 million tonnes between 2014 and 2015. It imported 207 million tonnes between 2015 and 2016. It imported 195 million tonnes between 2016 and 2017. As a result, there is a pressing need to identify alternative energy sources.

For the nation to achieve sustainable development and prevent catastrophic climate change, it will need to make a swift and worldwide shift from fossil fuels to renewable energy. Sustainable energy with reduced emissions is made possible in large part by the use of renewable energy sources [10]. Renewable energy technologies have been widely regarded as a viable option for meeting the country's energy needs and reducing greenhouse gas emissions. The country's energy supply has been reimagined in the last several years. Efforts have been made to enhance the usage of renewable energy sources such as solar, wind, compost, waste, and hydropower. Clean energy is clearly less hazardous and often cheaper. India is attempting to reach its full potential.

By the year 2022, 175 GW of renewable energy will be generated, of which 100 GW will come from solar energy, 10 GW from biopower, 60 GW from wind power, and 5 GW from small hydropower facilities [11]. More than 270 GW has been pledged by investors, well exceeding the lofty goals. The following commitments have been made: 58 GW by international firms, 191 GW by private firms, 18 GW by private sectors, and 5 GW by the Indian Railways [12]. More than 750 GW will be generated by solar power and more than 410 GW will be generated by wind power in 2047, according to recent predictions. 330,000 additional employment and livelihood possibilities are needed to meet the government's ambitious goal of producing 175 GW of renewable energy by 2022.

The development of renewable energy technology should be encouraged by a combination of policies and tactics that include push regulations and pull mechanisms. One approach to ensure that renewable resource bases are utilised efficiently and cost effectively is via technological advancements, suitable regulatory laws [17], tax deductions, and efforts at efficiency improvement through research and development (R&D) [18]. As a result, methods for promoting investment prospects and employment for unskilled employees, technicians, and contractors in the renewable energy industry are presented. In addition to demonstrating government-led technology and financial efforts [19], policy and regulatory frameworks, and training and education activities [20, 21], this article demonstrates how renewable energy sources are growing and developing. There is a need to address the hurdles that have been experienced in the development of renewable technologies. To help overcome these obstacles, researchers have made specific recommendations for promoting the steady expansion of renewable energy sources [22–24]. It is possible that India might become a worldwide leader in clean and green energy if the country's policies are well-coordinated and the government is welcoming to investors.

Global primary energy consumption projections A source of energy is essential to the growth of

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society and the economy. In the past several decades, the economic progress of emerging countries has resulted in a rise in energy demand. In the future, this tendency is expected to increase [25]. The investigation of appropriate environmental and economic strategies requires a forecast of future power usage [26]. With this information, future renewable energy expenditures may be made more informed. To understand the evolution of human society, it is vital to understand the development of international economic and political patterns [27]. There are several factors to consider when making comparisons across countries in terms of electricity usage.

Based on BP Energy Outlook 2018 data, Table 1 illustrates the global primary energy consumption. Over the course of the next 30 years, India's entire energy consumption will climb from 724 million tonnes of oil equivalent (Mtoe) to 1921 million tonnes of oil equivalent (Mtoe). Different major countries' energy consumption is made up of economically traded fuels and contemporary re-newables that are utilised to generate electricity. After China, the United States, and the European member countries of the Organization for Economic Cooperation and Development (OECD), India was the world's fourth-largest energy user in 2016 [29].

Energy usage in India is expected to continue rising till the year 2035/ 2040, according to the estimated world energy consumption [28]. By 2040, India's share of global energy demand will rise from 5 percent to 11 percent as a result of an increase in energy consumption. Exports of manufactured goods to developed nations have expanded dramatically as a result of the growing industrialization of emerging economies like China, India, and Brazil. [30] The country's energy usage is also affected by this change in economic activity.

ProjectedprimaryenergyconsumptioninIndia

The amount of energy that a nation needs is directly proportional to its population size and growth. As of January 2019, India has 1.368 billion residents, making it the second most populated country in the world. Nearly 17.74% of the world's population may be attributed to this growth rate. In 2020, the nation will have 1.383 billion people, 1.512 billion people, 1.605 billion people, and 1.658 billion people, respectively. As the population of various nations grows, India's population continues to grow at a faster rate than any other country in the world.

By 2040, India's energy consumption is expected to expand at the highest rate among the world's major economies, with coal accounting for the majority of this demand. By 2020, renewable energy sources will overtake gas and oil as the second most important source of domestic electricity generation. Table 2 shows that by 2040, India's demand for renewable energy would have increased to 256 Mtoe from the current level of 17 Mtoe, representing a compound annual growth rate of 12 percent.

BRIC nations (Brazil Russia India and China) are shown in Table 3 with their main energy consumption of renewables from 2016 to 2040. By 2040, India is expected to use 256 Mtoe of renewable energy, up from the current use of 17 Mtoe in 2016. Coal is expected to play the largest role in satisfying this need, followed by renewables, as India's energy consumption rises the quickest among the world's major countries by 2040. In 2016,

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renewable energy accounted for 2% of total consumption; by 2040, that figure is expected to rise to 13%.

Table1Projectedprimaryenergyconsumptionoftheworldbetween1990and2040[28]

Region	Consumption(milliontonesoilequivalent)											Change(percentageperannum)	
	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040	1990–2016	2016–2040
UnitedStates	1966	2119	2310	2349	2284	2273	2334	2344	2341	2325	2299	0.6%	0.0%
Brazil	126	158	188	211	268	298	330	378	419	451	477	3.4%	2.0%
EU	1672	1661	1732	1819	1754	1642	1667	1623	1570	1513	1460	–0.1%	–0.5%
Russia	865	662	620	647	673	674	711	720	723	722	716	–1.0%	0.3%
MiddleEast	264	351	423	565	734	895	980	1085	1189	1287	1382	4.8%	1.8%
Africa	222	244	274	327	389	440	509	603	710	840	1002	2.7%	3.5%
China	683	889	1008	1800	2491	3053	3387	3753	4017	4207	4319	5.9%	1.5%
India	195	251	316	394	537	724	880	1118	1365	1624	1921	5.2%	4.2%

Howrenewableenergysourcescontributetotheenergydemand inIndia

Despite the country's impressive economic progress, energy is still in short supply. Energy consumption is increasing as a result of strong economic expansion in India. New energy sources are needed to meet this need. But with a growing population and deteriorating environmental conditions, the nation must also grapple with the issue of long-term growth. It's predicted that the deficit of electricity would widen over time [32]. From 2009–2010 to 2018–2019, the country's electricity supply is shown in Table 4. (until October 2018). As of 2018, the energy demand was 1,212,134 GWh, while the supply totaled 1,203.567 GWh [33].

At least 1915 terawatt hours of electricity (TWh) would be needed in 2021–2022, as per the Load generation and Balance Report of the Central Electricity Authority of India (CEA). Urbanization and growing income levels have led to a rise in the demand for electrical equipment, which in turn has led to an increase in the residential sector's electrical demand. Industrial demand for electricity is being driven by an increase in demand for construction materials, transports, capital goods, and infrastructure. There has been a rise in agricultural automation and a move to groundwater irrigation,

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resulting in a huge diesel and power demand in the industry.

Table 5 shows that demand for electricity will rise as a result of the increasing use of electric cars and the conversion to electrical and induction cooktops.

Table2Projectedprimaryenergyconsumptionof India(includingrenewableenergy)from2016to2040[28]

	Level(Mtoe)												
	1990	1995	2000	2005	2010	2016	2020	2025	2030	2035	2040	1990–2016	2016–2040
Total	195	251	316	394	537	724	880	1118	1365	1624	1921	5.2%	4.2%
Oil(Mb/dl)	58	75	106	122	155	212	251	308	359	419	485	5.1%	3.5%
Gas(Bcf/dl)	11	17	24	32	54	45	57	72	89	106	128	5.6%	4.5%
Coal	110	140	164	211	290	412	485	593	710	824	955	5.2%	3.6%
Nuclear	1	2	4	4	5	9	11	16	27	35	44	7.1%	7.0%
Hydro	15	17	17	22	25	29	36	43	47	50	52	2.6%	2.5%
Renewables	0	0	1	2	7	17	41	86	133	191	256	35.1%	12.0%

Table3Renewableenergyconsumption-BRICcountries(percentage):2015–2035:source:BPEnergyOutlook2017[28]

Between 2016and2040	India		China		UnitedStates		Russia		Brazil	
	2016	2040	2016	2040	2016	2040	2016	2040	2016	2040
Primaryenergyconsumptionrenewables(including biofuels)	2%	13%	3%	18%	5%	17%	0%	2%	13%	24%

The International Renewable Energy Agency (IRENA) estimates that renewable energy sources may provide a quarter of India's energy needs. Over one-third of the country's electricity might come from renewable sources by 2030 [35].

Renewable energy sources are anticipated to make up around 10% of the overall energy demand, according to Table 6. According to the 2016 draught national electricity plan, with 175 GW of built renewable power capacity by 2022, the predicted electricity output would be 327 billion units (BUs), which will contribute to 1611 BU energy demand. This means that by 2022, 20,3% of the world's energy needs will be met by renewable sources of energy, and by 2027, 24,2% will be [36]. Figure 1 depicts MoP's new, far-reaching goal for India's renewable energy consumption as a percentage of the country's total power consumption. By March 2022, the nation must have 21% of its total power

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consumption come from renewable sources, in accordance with the amended RPO (Renewable Purchase Obligations, legislative act of June 2018). In 2014, the aim was 15%, and by 2018, it had risen to 21%. By 2030, India aims to have 40% of its energy supply come from renewable sources.

India's potential for renewable energy

In 1995 [37], it was estimated that the country's wind power potential was 20,000 MW (20 GW), its solar energy potential was 5 1015 kWh/pa, and its bioenergy potential was 17,000 MW.
10,000 MW, 8000 MW of bagasse cogeneration, and 10,000 MW of minor hydropower. Renewable potential in 2006 was projected at 85,000 MW, including 4500 MW wind, 35 MW solar, 25,000 MW biomass/bioenergy, and 15,000 MW small hydropower [38]. At 100-meter mast heights, the Ministry of New and Renewable Energy (MNRE) estimated that wind power had a potential of 302.251 GW, small hydropower had a potential of 19.749 GW, biomass power had a potential of 17.536 GW, bagasse cogeneration had a potential of 5 GW, and waste to energy (WTE) had 2.554 GW. A total of 1096.080 GW of renewable capacity was calculated.

as seen in Table 7 (assuming a 3 percent wasteland). Because it is a tropical nation that gets a lot of sunlight, India has a lot of solar potential [40–42].

India's total installed renewable energy capacity
To meet its goal of 175 GW in the Paris Agreement, the government wants to build 225 GW of renewable electricity capacity by 2022. The renewable energy industry is the fourth most appealing in the world. According to data from October 2018, India ranks sixth in the world in terms of installed renewable energy capacity.

Table4Thepowersupplystatusinthecountryfrom2009–2010to2017–2018[33]

Year	Energy				Peak			
	Requirement (GWh)	Availability GWh)	Surplus(+)/Deficits(—) (GWh)	(%)	PeakDemand (MW)	PeakMet (MW)	Surplus(+)/Deficits(—) (MW)	(%)
2009–2010	830,594	746,644	–83,950	−10.11	119,166	104009	–15,157	−12.72
2010–2011	861,591	788,355	–73,236	−8.50	122,287	110256	–12,031	−9.84
2011–2012	937,199	857,886	–79,313	−8.46	130,006	116,191	–13,815	−10.63

2012–2013	998,114	911,209	–86,905	−8.71	135,453	123,294	–12,159	−8.98
2013–2014	1,002,257	959,829	–42,428	−4.23	135,918	129,815	–6103	−4.49
2014–2015	1,067,085	1,028,955	–38,130	−3.60	148,166	141,160	–7006	−4.70
2015–2016	1,114,408	1,090,850	–23,558	−2.10	153,366	148,463	–4903	−3.20
2016–2017	1,142,928	1,135,332	–7596	−0.66	159,542	156,934	–2608	−1.63
2017–2018	1,212,134	1,203,567	–8.567	−0.7	164,066	160,752	–3314	−2.0
2018–2019(31.10.2018)	769,399	764,627	–4773	−0.6	177,022	175,528	–1494	−0.8

Table5Electricitydemandindifferentdemandsectors[35]

TWh	2012	2022	2030	2047
Industry	336	494	703	1366
Residential	175	480	842	1840
Commercial	86	142	238	771
Agriculture	136	245	336	501
Others	29	71	121	233
Total	762	1433	2239	4712

Grossinstalledcapacityofrenewableenergy—accordingtoregion

Renewable and conventional sources are shown in equal measure in Table 8. As of December 31st, 2018, a total of 74081.66 MW of renewable energy capacity has been installed. Hydro power, wind, biomass, and WTE contributed for around 21% of total installed power capacity, while coal, gas-diesel, nuclear, and big hydropower accounted for the remaining 78.791% [44]. [page needed] The southern states, which contain the country's greatest levels of solar radiation and wind power, are the finest places to locate new sources of renewable energy. The Southern area accounts for 49.121 percent of the total deployed capacity additions, followed by the Western region (29.742 percent), the Northern region (18.890 percent), the Eastern region (1.836 percent), the North-Easter region 0.394 percent, and the Islands (0.004 percent) (0.017 percent). According to conventional energy, the Western area has 33.452 percent; the Northern region has 28.484 percent; the Southern region has 24.967

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percent; the Eastern region has 11.716 percent; the Northern-Eastern region has 1.366 percent; and the Islands have 0.1 percent (0.015 percent).

According to ownership, the total capacity of renewable energy.

The Indian energy industry is driven by the state, federal, and private sectors. Renewable energy investment is dominated by the private sector. Ownership-wise, the proportion of installed gross renewable and conventional energy capacity is shown in Table 9. Figure 2 shows that private enterprises account for 95% of the installed hydropower potential, while the federal and state governments account for 2% and 3%, respectively. Tata Power Solar, Suzlon, and ReNew Power are the leading private enterprises in the sector of non-conventional energy generating. Among India's major integrated solar power businesses, Tata Power Solar System Limited is the most significant; Suzlon specialises in wind energy; and ReNew Power Ventures uses solar and wind energy.

State-by-state renewable energy capacity As shown in Table 10, the cumulative installed capacity of renewable energy is 74,081.66 megawatts, with Karnataka having the highest share (17.485), Tamilnadu having the second highest share (16%), Maharashtra having the third highest share (12.532%), Gujarat having the fourth highest share (10.641%), and Rajasthan having the fifth highest share (7573.86 MW) (10.224 percent). The total installed capacity of renewable energy in these five states is around 66.991 percent. Andhra Pradesh (9.829 percent), Madhya Pradesh (5.819 percent), Telangana (5.137 percent), and Uttar Pradesh (5.819 percent) are the other significant states in the country (3.879 percent). 91.655 percent is covered by these nine states.

According to the cited source, the installed power renewable energy capacity

Grid-interactive renewable electricity plans and projects received INR 3762 crore (USD 581.09 million) as part of India's 2018–2019 union budget. The country's total renewable power capacity (excluding major hydropower) was 74.08166 GW as of December 31, 2018. Small hydropower (SHP) of 0.105 gigawatts and biomass power of 8.7 gigawatts were added in 2017–2018, totaling around 9.363 gigawatts of solar and wind power, respectively. Over the last 10 years, Table 11 displays the installed capacity of renewable energy. To far, wind energy (35,138.15 MW) has continued to dominate the country's renewable energy sector. Solar power has a 34 percent share (25,212.26 MW), biomass power and cogeneration has a 12 percent share (9075.5 MW), and small hydroelectricity has a 6 percent share (4517.45 MW). India came in

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fourth place in the 2018 RECAI (Renewable Energy Country Attractiveness Index). A CAGR of 19.78 percent has been recorded between 2014 and 2018 in the installed capacity of renewable energy generation. [45]

Installation capacity estimations for alternative power sources Table 12 shows the percentage of installed renewable energy capacity compared to installed conventional capacity. It is expected that renewable energy capacity would account for 32% and 35% of the total capacity in 2022 and 2032, respectively.

Table6Estimatedcontributionofrenewableenergysourcestothetotalenergydemand[35]

Year	Installed capacity of renewable energy Sources (GW)	Expected Generation (Billion Unit) Solar	Wind	Biomass	Small hydropower	Total	Total energy requirement (Billion Unit)	% The Contribution of renewable energy source
2021-22	175	162	122	38	15	327	1611	20.3
2026-27	275	243	188	64	21	516	2132	24.2

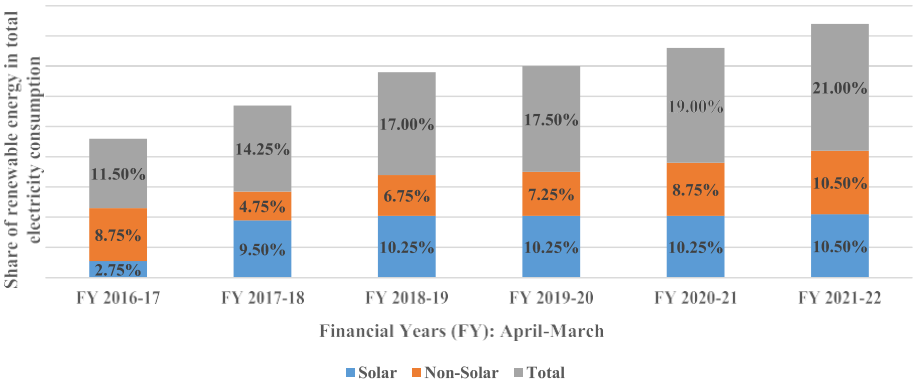

Fig.1TargetshareofrenewableenergyinIndia'spowerconsumption

India is embarking on the world's largest renewable capacity expansion programme. Next, we'll talk about how to increase the amount of clean energy in the country via a massive increase in renewable energy production.

In India, the amount of renewable energy used to generate power.

Overall generation in the nation, including that from grid-connected renewable sources, has expanded at an astronomical rate. It scored 1110.458 BU in 2014–2015 and 1173.603 BU in 2015–2016. Similarly, 1241.689 BU and 1306.614 BU were observed in 2015–2016 and 2016–2017 and 2017–2018, respectively, over the same period. In comparison to conventional power generation, the yearly output of renewable energy rose at a quicker rate (see Figure 3). In 2015–2016, the increase was 6.47 percent; in 2017–2018, it was 24.88 percent. A comparison of energy production from conventional and renewable sources is shown in Table 13. As a result, in 2010,

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conventional energy production reached 811143 BU and renewable energy production reached 9.860 BU, however in 2017, these numbers were 1.206.306 BU and 88.945 BU, respectively [48]. The cost of producing power from renewable sources is now more expensive than from traditional sources, although this is expected to decrease as the technologies involved gain more expertise [49].

Production of renewable energy-based power as a percentage of total electricity

Gross power production from renewable sources is shown by region in Table 14. The southern half of the country generates the most renewable energy, followed by the west. Energy production accounted for 50.33 percent of total output by November 2018; the remainder was split between the southern region and the island (29.37 percent), Western Canada (18.05 percent), Northern Canada (2%), and the North-Eastern Canada (0.24%). According to the states, the total amount of renewable energy generated in the United States.

Table 15 displays the total amount of renewable energy generated per region. As of November 2018, Karnataka (16.57 percent), Tamilnadu (15.82 percent), Andhra Pradesh (11.92 percent), and Gujarat (10.87 percent) were the states with the most renewable energy production. In spite of an extra 4 years from 2015–2016 to 2018–2019, Tamilnadu [50] remains the top state, following by Karnataka, Maharashtra (in second place), Gujarat (in third place), and Andhra Pradesh.

According to several sources, the total amount of renewable energy generated in the United States.

Gross power production from renewable energy sources is shown in Table 16 (source-by-source). Figures from the 2017–2018 table show that wind-based energy production (51.71 percent), followed by solar energy (25.40 percent), Bagasse (11.63%), small hydro-power (7.55%), biomass (3.34%), and waste to energy generation (0.54%). (0.35 percent). Since 2014–2015, the total amount of renewable energy generated has increased steadily. As usual, wind energy was the most significant source of the overall amount of renewable energy generated. During the monsoon months, the proportion of solar energy generated in the total renewable power production is often lowered. There is a correlation between an increase in wind energy output and a "good" monday. High-speed winds are made possible by cyclonic activity during these months. Wind power output in the southern areas of the nation has increased significantly due to monsoon winds.

Table7Theestimatedrenewablepotentialin India[40]

Sl.No	States/UTs	Windpow	Smallhydro	Bio-energy	Solar	Tota

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.		er (MW)	power	Biomasspower	Bagassecogeneration	Wastetoenergy		l
1	AndhraPradesh	44.229	0.978	0.578	0.3	0.123	38.44	84.648
2	ArunachalPradesh	0	1.341	0.008	0	0	8.65	9.999
3	Assam	0	0.239	0.212	0	0.008	13.76	14.219
4	Bihar	0	0.223	0.619	0.3	0.073	11.2	12.415
5	Chhattisgarh	0.077	1.107	0.236	0	0.024	18.27	19.714
6	Goa	0.001	0.007	0.026	0	0	0.88	0.914
7	Gujarat	84.431	0.202	1.221	0.35	0.112	35.77	122.086
8	Haryana	0	0.11	1.333	0.35	0.024	4.56	6.377
9	HimachalPradesh	0	2.398	0.142	0	0.002	33.84	36.382
10	Jammu&Kashmir	0	1.431	0.043	0	0	111.05	112.524
11	Jharkhand	0	0.209	0.09	0	0.01	18.18	18.489
12	Karnataka	55.857	4.141	1.131	0.45	0	24.7	86.279
13	Kerala	1.7	0.704	1.044	0	0.036	6.11	9.594
14	MadhyaPradesh	10.484	0.82	1.364	0	0.078	61.66	74.406
15	Maharashtra	45.394	0.794	1.887	1.25	0.287	64.32	113.932
16	Manipur	0	0.109	0.013	0	0.002	10.63	10.754
17	Meghalaya	0	0.23	0.011	0	0.002	5.86	6.103
18	Mizoram	0	0.169	0.001	0	0.002	9.09	9.262
19	Nagaland	0	0.197	0.01	0	0	7.29	7.497
20	Odisha	3.093	0.295	0.246	0	0.022	25.78	29.436

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21	Punjab	0	0.441	3.172	0.3	0.045	2.81	6.768
22	Rajasthan	18.77	0.057	1.039	0	0.062	142.31	162.238
23	Sikkim	0	0.267	0.002	0	0	4.94	5.209
24	TamilNadu	33.8	0.66	1.07	0.45	0.151	17.67	53.801
25	Telangana	4.244	0	0	0	0	20.41	24.654
26	Tripura	0	0.047	0.003	0	0.002	2.08	2.132
27	UttarPradesh	0	0.461	1.617	1.25	0.176	22.83	26.334
28	Uttarakhand	0	1.708	0.024	0	0.005	16.8	18.537
29	WestBengal	0.002	0.396	0.396	0	0.148	6.26	7.202
30	Andaman&Nicobar	0.008	0.008	0	0	0	0	0.016
31	Chandigarh	0	0	0	0	0.006	0	0.006
32	Dadra&NagarHaveli	0	0	0	0	0	0	0
33	Daman&Diu	0	0	0	0	0	0	0
34	Delhi	0	0	0	0	0.131	2.05	2.181
35	Lakshadweep	0.008	0	0	0	0	0	0.008
36	Puducherry	0.153	0	0	0	0.003	0	0.156
37	Others	0	0	0	0	1.022	0.79	1.812
	Total	302.251	19.749	17.536	5	2.554	748.99	1096.08

Estimationofgrosselectricitygenerationfromrenewableenergy

On the basis of the National Institution for Transforming India (NITI Aayog) 2015 report, Table 17 presents an estimate of the total amount of renewable energy generated in India. Renewable energy is expected to account for 10.2% of India's total power generation by 2022, but as of August 31st, 2018, it has contributed a record 13.4% of

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India's total power output. India generated 122.10 TWh and 16.30 TWh of that was generated by renewables as of August 31st, 2018, according to a power ministry data. Around 49% of total power would be generated by renewable sources by the year 2040, according to a forecast by the India Brand Equity Foundation.

Table 8 All India installed capacity (MW) of power stations as on the 31st of December 2018

Region	Mode-wise breakup							Total
	Thermal				Nuclear	Hydro	Renewable	
	Coal	Lignite	Gas	Diesel				
Northern	49700.20	1580.00	5781.26	0	1620.00	19,707.77	13,994.37	92383.60
Western	70,328.62	1540.00	10,806.49	0	1840.00	7547.50	22,033.01	114,095.62
Southern	43,342.02	3240.00	6473.66	561.58	3320.00	11,774.83	36,389.87	105,101.96
Eastern	27,201.64	0	100.00	0	0	4942.12	1359.98	33,603.74
North-Eastern	520.02	0	1775.81	36.00	0	1427.00	291.87	4050.70
Islands	0	0	0	40.05	0	0	12.56	52.61
All India	191,092.50	6360.00	24,937.22	637.63	6780.00	45399.22	74,081.66	349,288.22

Currentachievementsinrenewableenergy2017–2018

Last four years have seen a ground-breaking shift in India's approach to renewable energy [52, 53]. With the support of a dedicated ministry, financial institutions, and technical organisations, India has increased its use of sustainable power and diversified its energy supply. To assure a substantial increase in green energy, the government is actively growing the usage of renewable energy sources.

In the past four years, India's renewable electricity capacity has doubled. In 2013–2014, the total renewable electricity capacity was 35,500 MW; in 2017–2018, it was 70,000 MW.

According to the cumulative installed power of wind and solar, India is ranked fourth and sixth in terms of total installed capacity. Furthermore, as of December 31st, 2018, it has the fifth-largest installed renewable capacity in the world.

3. As previously stated, 175 GW of total renewable energy capacity is set as a goal for 2022. The total built capacity for 2017–2018 was 70 GW, including 15 GW under construction and 25 GW that was put out to bidding. As may be seen in Fig. 4, the objective is shown alongside the installed, operational, and proposed capacities.

4. The use of solar electricity is on the rise. The total installed solar capacity has risen from 2.630 GW in 2013–2014 to 22 GW in 2017–2018, a factor of more than eight. It has a total installed capacity of 25.2122 GW as of December 31 of this year.

In 2017–2018, 101839 BUs of renewable power were produced.

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Region	Energy	StateGovernment	Private	CentralGovernment	Total
Northern	Renewable(MW)	689.56	12975.81	329	689.56
	Conventional(MW)	27,510.75	25,832.83	25,045.65	27,510.75
Western	Renewable(MW)	317.69	21,054.03	661.3	317.69
	Conventional(MW)	30,236.32	40,042.67	21,783.62	30,236.32
Southern	Renewable(MW)	521.02	35,376.95	491.9	521.02
	Conventional(MW)	33,087.19	17,720.3	17,904.6	33,087.19
Eastern	Renewable(MW)	225.11	1124.87	10	225.11
	Conventional(MW)	10,587.92	6774	14,881.84	10,587.92
North-Eastern	Renewable(MW)	231.74	30.13	30	231.74
	Conventional(MW)	955.71	24.5	2778.62	955.71
Islands	Renewable(MW)	5.25	2.21	5.1	5.25
	Conventional(MW)	40.05	0	0	40.05
AllIndia	Renewable(MW)	1990.37	70564	1527.3	1990.37
	Conventional(MW)	102,417.93	90,394.29	82,394.33	102,417.93

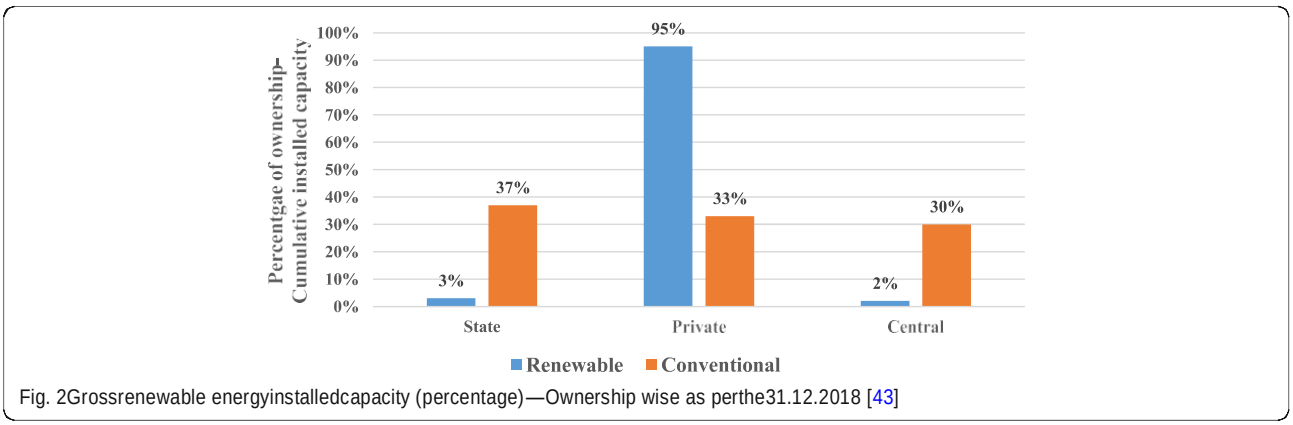

Fig. 2Grossrenewable energyinstalledcapacity (percentage)—Ownership wise as perthe31.12.2018 [43]

Renewable energy production guidelines were issued for competitive bidding. Renewable energy costs per unit decreased significantly as a consequence of the elimination of the lowest tariff and transparent bidding technique.

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2. The MNRE has already authorised 41 solar parks in 21 states with a combined capacity of over 26,144 MW. The 1000 MW Kurnool solar park and the 2000 MW Pavagada (Karnataka) long-term solar park have both been completed.
For 2018–2019, the aim for ground-mounted solar power is 10 GW, while the target for roof-top solar power is 1 GW.

The aim for solar parks (projects with a capacity of 500 MW or more) was increased from 20 to 40 GW by the MNRE.

In the previous four years, wind power's installed capacity has grown by 1.6 times. It was 21 GW in 2013–2014, 34 GW in 2017–2018, and 48 GW as of December 31st, 2018, respectively.

35.138 gigawatts of power. This demonstrates that significant progress has been made in the usage of wind power.

6. A policy on offshore wind has been unveiled. 34 businesses participated in the "expression of interest" (EoI) launched on the idea to build India's first 1 GW mega off-shore wind farm (most important global and local wind power players).

682 MW of minor hydropower projects, 600 watermills (mech- anical applications), and 132 projects currently in construction totaled 7,682 MW in the previous four years alone.

MNRE is expanding the transmission grid by incorporating green corridors. 9400 kilometres of green energy corridors have either been finished or are in the process of being completed or implemented. An amount of INR 10141 crore (101,410 million INR = 1425.01 USD) was spent on the project. In addition, a network of 19,000 MVA substations is now expected to be fully operational by the end of March 2020.

Solar pumps (off-grid applications) are being installed by MNRE, and 90% of the pumps will be installed by 2014–2015 and 2017–2018. The number of solar streetlights has more than doubled in the last several years. Lighting systems for solar homes have improved by around 1.5 times. Students have received more than 2,575,000 solar lights. Figure 5 depicts the finer points.

There were more than 2.5 million biogas plants installed in rural houses between 2014 and 2018 to provide families with access to clean fuel.

16. Tariff policy man-dated purchase and generation responsibilities were amended as a result of new policy measures (RPO and RGO). It was decided to eliminate fees for four interstate wind and solar transmissions. The RPO trajectory for 2022 was established, as was the renewable energy strategy.

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Solar PV manufacturing capacity associated with a 20 GW guaranteed off-take were solicited in the form of EoIs. EoI said that 10 GW floating solar farms were being considered.

As a result of this announcement, the solar-wind hybrid policy was established. A request for proposals for the installation of 2 GW of solar-wind hybrid systems was issued.

The MNRE established a national lab strategy on testing, standardisation, and certification in support of R&D in renewable power technology.19.

Solar panel installation, commissioning, operation, and administration are all included in the Surya Mitra programme. ISA's new headquarters in Gurgaon, India, will mark a fresh beginning for solar energy development in India.

Foreign and local investors alike are increasingly interested in renewable energy, and the government anticipates a total of USD 80 billion in investment over the next four years (from 2018–2019 to 2021–2022).

Since 2013, solar power capacity has grown from 2.63 GW to 22 GW, an increase of more than eight times.

It was stated that 115 GW of renewable energy projects will be out for bids until March 2020.

StatesinIndia	Cumulativerenewableinstalledcapacity(MW)
Delhi	176.21
Haryana	411.99
HimachalPradesh	864.5
Jammu&Kashmir	188.88
Punjab	1282.42
Rajasthan	7573.86
UttarPradesh	2873.61
Uttarakhand	590.5
Chandigarh	32.4
Goa	1.74
Daman&Diu	13.38
Gujarat	7882.85
MadhyaPradesh	4310.45
Chhattisgarh	535.35
Maharashtra	9283.78
Dadra&NagarNavali	5.46
AndhraPradesh	7281.68

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Telangana	3805.83
Karnataka	12,953.24
Kerala	413.01
Tamilnadu	11,934.38
Puducherry	1.73
Bihar	326.15
Jharkhand	36.46
WestBengal	440.82
Odisha	504.43
Sikkim	52.12
Assam	50.79
ArunachalPradesh	112.49
Meghalaya	31.11
Tripura	21.1
Manipur	8.04
Nagaland	31.67
Mizoram	36.67
Andaman&Nicobar	11.81
Lakshadweep	0.76
Total	74,081.66

The Bureau of Indian Standards (BIS) was founded to work on behalf of solar photovoltaic systems and components.

Prizes and awards are given out by the government to honour and promote breakthrough ideas in the renewable energy industry. Prototyping should follow naturally from the generation of new concepts and ideas. Award name: "Abhinav Soch-NayiSambhawanaye," which translates as "Innovative ideas—New possibilities.".

Photovoltaic (PV) power

From 20 GW to 100 GW by 2021–2022, the MNRE has updated its goal for grid-connected solar power projects under the National Solar Mission. In the years 2008–2009, it was just 6 MW. It was because to the "Made in India" effort that India's solar installation capacity climbed to such a high level. India now has the fifth-largest installed solar capacity in the world. By the end of 2018, solar energy has reached 25,212.26 MW, far ahead of its 2022 goal, and an additional 22.8 GW of capacity has been offered for sale or is currently being put into operation. The extra solar energy capacity will be auctioned off every year from 2018 to 2019 and 2019 to 2020 in order to build 100 GW of capacity by March 2020. Projects might be completed in two years this manner. Competitive bidding (reverse e-auction) will be used to drive tariffs down dramatically. In July 2018, it was discovered that the lowest solar rate was INR 2.44 per kWh. Solar rates were INR 18 per kWh in 2010. Land for many proposed solar parks totaled over 100,000 lakh acres (10,000 million acres in imperial units);

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approximately 75,000 acres of that total were subsequently acquired. There were 47 solar parks with a total capacity of 26,694 MW as of November 2018, according to the latest data. More than 4195 MW of solar projects have been installed in different solar parks around the country (floating solar power). Comparison of capacity additions to targets is shown in Table 18. It suggests that capacity additions grew at an accelerating rate.

Using wind power is an environmentally friendly way to generate

India's total installed capacity was at 35,138.15 MW as of December 31st, 2018, well short of the 60 GW goal set for the year 2022. For installed wind power capacity, India is now at fourth place in the global rankings. There has also been or is now being implemented a total of 9.4 GW of additional capacity. As a result, the MNRE is gearing up to put out bids for 10 GW of wind energy capacity each year in 2018–2019 and 2019–2020, giving it enough time to complete 60 GW of new capacity by March 2020. At a height of 100 metres above the earth, the country's gross wind energy potential is 302 GW. Feed-in-tariff (FiT) has been replaced by the bidding procedure for capacity increase in the management of tariffs.

Financialyear	Smallhydropower(MW)	Wind(MW)	Biomasscogeneration (MW)	Waste-to-energy (MW)	Solar(MW)	Totalrenewablecapacity (MW)
Asof31.12.2018	4517.45	35,138.15	9075.50	138.30	25212.26	74,081.66
2017–2018	4485.81	34,046.00	8700.80	138.30	21651.48	69,022.39
2016–2017	4379.86	32,279.77	8181.70	114.08	12288.83	57,244.23
2015–2016	4273.47	26,777.4	4831.33	90.58	6762.85	45,924.04
2014–2015	4055.36	23,354.35	4418.55	90.58	3743.97	38,959.16
2013–2014	3803.68	21,042.58	4013.55	90.58	2631.93	34,988.00
2012–2013	3643.17	18,484.99	3601.03	126.08	1686.44	27,541.71
2011–2012	3410.52	16,896.6	3135.33	119.68	941.31	24,503.44
2010–2011	2913	12,806.54	2600.13	102.46	32.39	18,454.52
2009–2010	2604.92	10,647.45	2167.73	95.01	6	15,521.11
2008–2009	2160.48	9344.13	1650.43	85.25	2.12	13,242.41
2007–2008	2045.07	7666.84	1325.63	85.75	2.12	11,125.41

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Regulations for competitive bidding for grid-connected wind energy project energy purchases were released by the ministry on December 8th, 2017. The tariff for wind electricity has been reduced to its lowest possible level ever thanks to a transparent bidding procedure. There is a strong ecosystem in place to support the growth of the wind sector. Wind turbines may currently be manufactured using cutting-edge technology. India is home to all of the world's leading wind power companies. There are more than 12 businesses in India that produce more than 24 distinct kinds of wind turbines. Wind turbines and components manufactured in India are exported to the United States, Europe, Australia, Brazil, and other Asian nations. Domestic manufacturing firms have been responsible for 70–80 percent of total output inside the country. As may be seen in Table 19, the actual capacity increase vs the planned increase is shown. Despite a decrease in new wind energy in the first half of 2018–2019 and 2017–2018, power production from wind-based capacity has increased.

Our nation's long-term energy storage goal for the year 2018

There is a National Energy Storage Mission being pursued by the government. It was recommended in February 2018 that a complete policy and regulatory framework be developed for the National Energy Storage Mission. There have been 115.8 million rupees worth of energy storage R&D projects initiated in the previous four years, and a corpus of 48.2 million rupees worth of funds has been issued. Battery manufacturing in India will benefit from the country's energy storage agenda. Battery manufacturing knowledge and production capacity can be significantly increased in the country, allowing it to contribute significantly to the economy in this critical sector. The goal of the mission is to determine the entire market size, imports, and local manufacture of batteries. The National Institution for Transforming India, also known as NITI Aayog, which provides relevant technical guidance to govt while trying to design strategic and long-term policies and programmes for the Indian government, provides the economic opportunity from battery manufacturing in Table 20.

The three-year action plan for small hydropower is due in 2017.

It is possible to divide hydro projects into four categories: big hydro, small hydro, micro-hydro (100 kW to 2 MW), and mini-hydropower (up to 2 MW). The 2022 aim for India in SHP is 5 GW, however the projected potential of SHP is 20 GW.

Table12Cumulativeinstalledrenewableenergycapacityshares[46,47]

Sources(GW)	2002	2007	2012	2017	2022	2027	2032
Thermal	74.4	86.0	131.6	218.3	296.1	389.3	552.4
Renewables	3.4	10.2	24.9	57.3	175.0	250.4	350.4
Nuclear	2.7	3.9	4.7	6.78	11.84	19.1	23.3

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						0	0
Largehydropower	26.20	34.60	38.90	44.48	60.90	67.10	74.60
Total	106.7	134.7	200.1	326.86	543.84	725.9	1000.7
Percentageofrenewableenergysharesinthetotalinstalledcapacity	3%	8%	12%	18%	32%	34%	35%

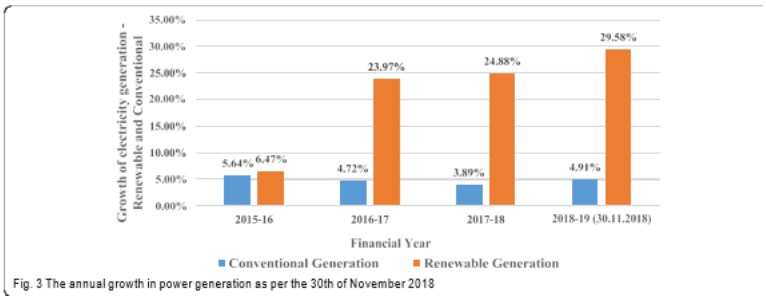

Fig. 3 The annual growth in power generation as per the 30th of November 2018

There was a total of 4.5 GW of production in December 2018, which is steadily growing. To achieve this goal, the NITI Aayog announced a three-year action plan (2017–2018 to 2019–2020) on the first of August 2017, which includes funding for infrastructure projects and tariff assistance. The MNRE is giving central financial assistance (CFA) to both the public and commercial sectors to build up small/micro hydro projects. Surveys and in-depth project studies are created to identify new viable sites, and financial assistance is offered to renovate and modernise older projects. Based on the Alternate Hydro Energy Center (AHEC) at the Indian Institute of Technology (IIT) in Roorkee, a specialised entirely autonomous supervisory control and data acquisition (SCADA) has been built. The lab's construction cost INR 40 crore (400 million INR, 95.62 million USD), and it will be used for design and validation. These hydro-mechanical devices are examined in accordance with the relevant national and international regulations [54, 55].
Listed in Table 21 are the goals and accomplishments from 2007 to 2019.

Biofuel policy in the United States in 2018

With the advent of modern technology, India now has the possibility to make a long-term shift in its reliance on bioenergy. Biomass policy was revised by the MNRE in May of this year. Crop wastes, bagasse, wood from energy plantations, wood waste from industrial activities and weeds are among the biomass sources eligible for CFA under the legislation. INR 2.5 million (USD 35,477.7) for bagasse cogeneration and INR 5 million (USD 70,955.5) for non-bagasse cogeneration would be supplied under the policy.

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	Energygenerationfromconventionalsources(BU)	Energygenerationfromconventionalsources(BU)
2010–2011	811.143	9.860
2011–2012	876.887	51.226
2012–2013	912.056	57.449
2013–2014	967.150	65.520
2014–2015	1048.673	61.719
2015–2016	1107.822	65.781
2016–2017	1160.414	81.548
2017–2018	1206.306	101.839
2018–2019(30.11.2018)	749.173	88.945

Table14Cumulativeelectricitygenerationfromrenewableenergy—region-wise[48]

Cumulativegenerationachieved during the year up to thereportingmonth(MU)	2018–2019 (April–November 2018)	2017–2018 (April–March)	2016–2017 (April–March)	2015–2016 (April–March)
Northern	16,055.27	21,388.22	18,184.54	15,917.51
Western	26,124.98	31,564.48	27,603.54	22,958.91
Southern	44,768.78	46,077.26	33,137.87	24,162.83
Eastern	1779.46	2516.78	2611.19	2425.30
North-Eastern	216.85	292.75	331.55	316.30
GrandTotal	88,945.34	101,839.48	81,868.69	65,780.85

According to a memorandum released by the MNRE in November of 2018, the CCDC will be extended to projects that use non-conventional components such as bio-waste, agrarian wastes, forestry wastes, chicken litter, agro-industrial and industrial by-products, municipal and urban wastes for energy production. In August of this year, the government enacted the National Biofuels Policy. In order to assess the country's potential for biomass energy and bagasse cogeneration, the MNRE welcomed expressions of interest (EOI). In addition, in May of this year, a programme was started to stimulate the use of biomass-based co - generation in sugar industry and other businesses. As can be seen in Table 22, the goal of 10 GW of biomass power generation by 2022 is on track to be achieved by the end of 2019.

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Biogas and organic manure programme (NNBOMP) for 2018

In 2012–2013, the National Biogas and Manure Management Program (NBMMP) was first implemented in the United States. Clean gaseous fuel for cooking was the primary goal, with the leftover slurry being rich in nitrogen, phosphorous, and potassium organic bio-manure. An additional 49.8 million (49.8 million) cumulative biogas plants were constructed in 2014, bringing the total to 47.5 million (4.75 million) (4.98 million). The goal for 2017–2018 was to build 1.10 lakh biogas plants, however only 0.15 lakh were built (0.015 million). Refilling gas cylinders with LPG (liquefied petroleum gas) has been considerably decreased as a result. As wood is typically utilised as energy in country and semi-urban homes, a huge amount of wood was saved from being cut down. Traditional cooking fuels may be replaced with biogas. Almost 300 skilled employees were employed in the construction of the biogas plants as a result of the initiative. [56] The NNBOMP implementation instructions for 2017–2018 to 2019–2020 were announced by the Ministry on May 30th, 2018.

Renewableenergygeneration(MU)	2018-19(April-November2018)	2017-18(April-March)	2016-17(April-March)	2015-16(April-March)
HimachalPradesh	1989.26	1903.05	2110.71	1921.77
Punjab	1544.73	2343.87	2149.49	1474.2
Rajasthan	7912.68	9484.23	7973.85	6600.24
UttarPradesh	2554.50	4606.29	3638.26	3201.49
Gujarat	9670.07	11759.63	9497.99	8003.73
MadhyaPradesh	5406.34	6292.9	5268.67	2910.42
Maharashtra	9811.79	12036.98	11292.7	10756.58
AndhraPradesh	10602.81	10597.47	5488.26	3106.61
Telangana	4503.35	4632.28	1999.89	1027.9
Karnataka	14734.92	13463.98	9585.68	10061.03
Tamilnadu	14073.94	16179.86	15153.87	9331.47
WestBengal	1093.37	1590.54	1569.77	1608.15
Others	5047.58	6948.4	6138.86	5777.26
TotalGeneration(MU)	88945.34	101839.48	81868.69	65780.85

Table16Cumulativeenergygenerationfromrenewableenergy—source-wise,2014–2019[48]

	Renewablegeneration (MU)	Wind	Solarenergy	Biomass	Bagasse	SmallHydropower	WTE
2014–2015	61719	33,768	4599	3160	11,785	8060	348
2015–2016	65781	33,029	7448	3727	12,953	8355	269
2016–2017	81,548	46,004	13,499	4198	9960	7673	213

2017–2018	101,839	52,666	25,871	3405	11,847	7692	358
2018–2019(upto30.11.2018)	88,945	50,335	24,506	1789	5140	6894	282

Theoff-gridanddecentralizedsolarphotovoltaicapplicationprogram—2018

A variety of solar-powered devices such as lanterns, streetlights, residential lights, and pumps are used to meet energy demands under the programme. Off-grid PV capacity was to reach 118 MWp by 2020. An expenditure of 50 MWp in 2017–2018 and 68 MWp in 2019–2020 was the sanctioning aim. INR 1895 crore (265.547 million USD) was the entire estimated cost, and the ministry planned to contribute 637 crores (6370 million INR, 89.263 million USD) with its central financing aid. A 25 KWp solar power plant was marketed in places where grid electricity does not reach houses or is unreliable. School districts, panchayats, youth hostels, and police stations all stand to gain from this initiative. In addition to solar study lights, the programme featured others. Solar power plants received a third of the money they requested. In order to cover the remaining 85 percent of the lamp's cost, the ministry requested that each student contribute 15 percent of the total cost. Over 40 lakhs (4 million) lanterns and lamps were installed in October 2018, as well as more than 16 lakhs (1.672 million) residential lights, 6.40 lakhs (0.64 million) street lights, 1.96 lakhs (0.196 million) solar pumps and 187.99 MWp stand-alone devices.

Renewing the nation's economy via major government programmes Initiatives in technology

An effort was made to stimulate RD&D in the renewable energy industry via the Technology Development and Innovation Policy (TDIP), which was unveiled on October 6th, 2017. Resources, technological advancement, commercialization, and the dissemination of renewable technologies throughout the country were among the goals of the RD&D programme. Renewable energy gadgets and systems were to be manufactured in the United States. By using RD&D, we were able to assess and improve upon existing practises as well as develop new ones. Through RD&D, the market was developed, efficiency was improved, costs were reduced, and commercialization was aided (scalability and bankability). It was also self-sustaining, industrially competitive, and lucrative via R&D because of the high amount of renewable electricity in the whole electrical mix. Additionally, RD&D supported the research and demonstration of wind, photovoltaic, wind-solar combination, biofuel, biogas, fuel cells, and geothermal energy for technological development and testing. RD&D aided educational institutions, businesses, and non-profits in their research and development efforts (NGOs). The adoption of the technology development programme enabled the sharing of knowledge, information, and institutional structures for cooperation (TDP). Policymakers, industry innovators, connected stakeholders and departments, researchers, and scientists were all participating in this effort. Research

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and development institutions in India include the National Institute of Solar Energy (NISE), Gurgaon, the National Institute of Bio-Energy (NIBE), Kapurthala, and the National Institute of Wind Energy (NIWE) in Chennai, among others. With the TDP strategy, new ideas and potential for long-term gains were fostered.

Table17Thepastgenerationcapacityandtheestimationofthegenerationcapacity(electricitymix)ofrenewableenergyinIndiacomparedwithconventionalenergy[51]

TWhgeneration(BU)	2011–2012	2021–22	2029–2030	2046–2047
Coal	708.3	1444.7	1848	3153.6
Gas	115.4	127.7	155	198.1
Nuclear	26.7	82.5	109	183.1
Hydro	143.8	213.9	227	263
Renewables	58.6	213.1	424	1187.5
Imports	4.6	15.3	40	92
Total	1057	2097	2803	5077
Shareofrenewableenergy	5.50%	10.20%	15%	23.40 %

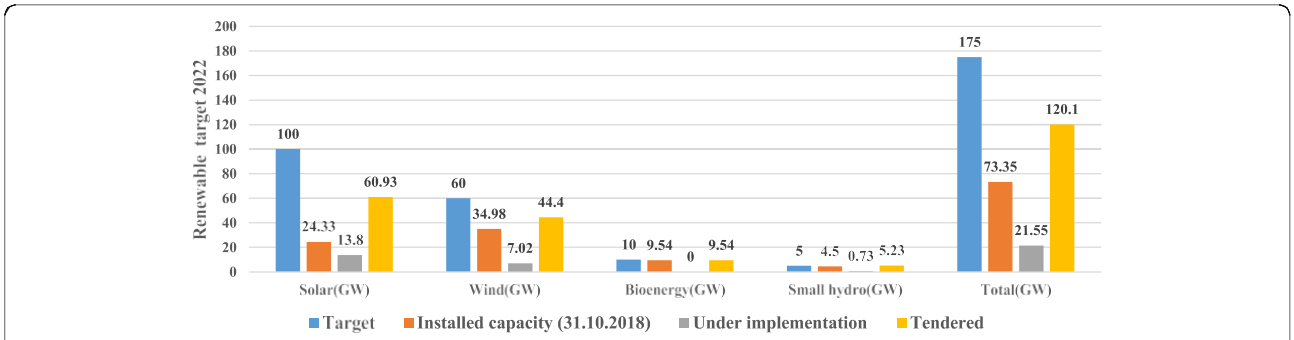

Fig.4Renewableenergytarget,installedcapacity,underimplementationandtendered[52]

As a result, a very well monitoring system for the expansion of alternative technology that satisfies India's electrical demands was effectively supported. It was decided that the TDI projects would be supported in order to improve R&D through a research centre of excellence. Training and seminars were made possible thanks to grant money. The MNRE is currently compiling a database of renewable energy R&D achievements.

As part of its mission to advance national engineering and technology (prototype/process development), the Impacting Research Innovation and Technology (IMPRINT) initiative has been set up. Imprint is overseen by the Indian Institute of Technology (IITs) and the Indian Institute of Science (IISc), both of which are located in India (IISCs). Engineering and technology, as well as renewable energy, are included in the growth. Up to half of the project's total cost is covered by the Ministry of Human Resource Development (MHRD). MNRE's RD&D programme for

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renewable projects covers the rest of the expenses of the project. More than 36.9 million Indian rupees ($0.518426 million) and IMPRINT funding are now being used to carry out five studies in the areas of solar thermal systems, storage for SPV, biofuel and hydrogen/fuel cells. The 7th of December 2017 saw the publication of lab policies that encourage the development of local technologies and quality control. Renewable energy goods and initiatives have been put through rigorous testing and standardisation in laboratories. They aided in enhancing the projects' dependability and quality. In addition, well-established lab procedures ensure that Indian test laboratories conform to international standards and practises. Those researchers and scientists who have made outstanding contributions to renewable R&D since 2015 have been recognised by the MNRE with the "The New and Renewable Energy Young Scientist's Award".

Initiatives to raise money

The MNRE provides 100% financial aid to the government and non-profit organisations, while providing only 50% financial help to the private sector. Project selection, formulation, monitoring evaluation, approval and finance are all guided by the policy framework... The MNRE provided financial assistance of 4467.8 million INR ($62.52 million USD) between 2012 and 2017. For the current 3 yr plan term, the MNRE sought to increase funding for renewable energy technology development by twofold. It is clear from Table 23 that the gvot is increasing its investment in renewable energy. Various R&D initiatives received funding. In particular, projects working in hazardous or dangerous environments received special attention. Also included in the budget were awareness-raising activities such as public displays, training sessions, seminars, surveys, and evaluations. Cash rewards will be given to those who come up with new ideas. Prizewinners will be given assistance in turning their concepts and models into marketable goods, such as business start-ups for entrepreneurship growth.. Start-up assistance methods, including a contractual obligation with investors, will be used to fund innovative ventures. The MNRE offers funding for renewable energy policy and performance evaluations.

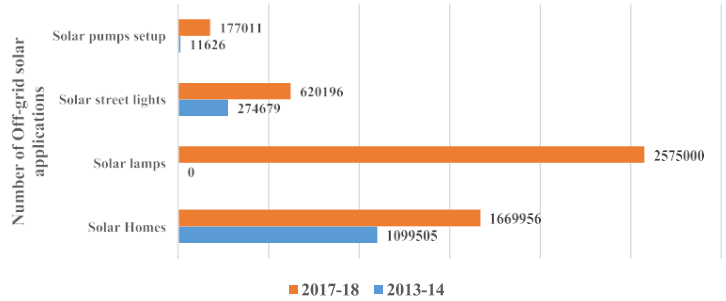

Fig.5Off-gridsolarapplications[52]

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Table18Solarcapacityadditioncomparedtothetargetbetween2013–2014and2018–2019.

Year	SolarpowercapacityadditionsinMW	
	Target	Achievements
2013–2014	1100	962.1
2014–2015	1100	1112
2015–2016	1400	3019
2016–2017	9100	5526
2017–2018	10,000	9363
2018–2019(31stofDecember2018)	10,000	3270

Financial support of 50% of the project cost was given to technology validation as well as demo projects and other creative renewable energy initiatives. Cooperative agreements with industry and private institutions were covered by the CFA. Accredited by a government agency, private academic institutions were also qualified to receive a 50% sup- port. The remaining 50% of the costs should be borne by the relevant companies and organisations. Off-grid/distributed and decentralised renewable electricity received an INR 3762.50 crore (INR 37625 million, 528.634 million USD) and INR 1036.50 crore (INR 10365 million, 145.629 million USD) from the MNRE for 2018–2019 [60]. The Reserve Bank of India (RBI) was urged by the Ministry of New and Renewable Energy (MNRE) to help finance renewable power projects under "priority sector lending" (priority lending should be done for renewable energy projects and without any restriction). China and Malaysia have been subject to a 25% safeguard tariff on solar panels and modules imported for a year by the Ministry of Finance in July 2018. For the next six months, the tax rate might be cut to 20% and 15% for the next six months.

Table19Windpowercapacityadditioncomparedtothetargetbetween2013–2014and2018–2019

Year	WindpowercapacityadditioninMW	
	Target	Achievements
2013–2014	2500	2083.3
2014–2015	2000	2312
2015–2016	2400	3423
2016–2017	4000	5502
2017–2018	4000	1766.25

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2018–2019(31stofDecember2018)	4000	993.15

Policyandregulatoryframeworkinitiatives

In order to promote the growth of renewable energy, there are four regulatory interventions: tariff setting, defining RPO, boosting grid connection, and encouraging market expansion.

Amendments to the tariff policy for 2018

The Ministry of the Presidency (MoP) published proposed revisions to the tariff policy on May 30th, 2018. The goal of these regulations was to encourage the use of renewable energy sources for power generating. Represented in Table 24, the long-term RPO trend was disclosed by the MoP and MNRE. Due to the SERC's RPO rules, which were developed in conjunction with the MNRE, the renewable energy industry has seen an increase in both its beneficial and neutral/off-putting effects. The Ministry of New and Renewable Energy (MNRE) established an RPO compliance cell on May 25, 2018, in order to meet India's solar and wind power objectives. Several Indian states were unable to reach their RPO goals because of the lack of RPO legislation. RPO compliance statements will be obtained periodically by working with the Central Electricity Regulatory Commission (CERC) as well as the regional energy regulators (SERCs). Additionally, it will bring up issues about non-compliance with those in charge.

2016: the year of policy resurgence

Repowering policies for wind energy plants were announced by India on August 9th, 2016. According to the policy, a 27 GW turnaround was achievable. This policy encourages the replacement of outdated wind generators with more contemporary and powerful ones (fewer, bigger, and higher), in order to increase energy output. The goal of this strategy is to streamline the regulatory process while also encouraging the most efficient use of available wind power resources. It's required since the installed wind turbines in places with strong wind potential were below 500 kW up to the year 2000. Once the replacements are in place, the same area will be able to produce 3000 MW. The policy was first implemented to wind turbines with a capacity of one MW, and the MNRE plans to expand the policy to additional projects in the future depending on the results of this first experiment. The state nodal agencies/organizations engaged in renewable power promotion in their states undertook repowering projects. Policy provided an exemption from Power Purchase Agreement (PPA) for repowering wind farms/turbines owing to the circumstances suited to new wind energy projects, which did not meet the criteria according to generation-based incentive (GBI) [61].

Table20Economicopportunityfrombatterymanufacturing

Stage	Cumulativebatteryrequirements(GWh)	Totalmarketsize(INRlakhcrore)	Imports	Domesticmanufacturing

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I	120	1.3–1.4	Cells	Batterypacks
II	970	6.1–8.9	Somecells,Cathode	Batterypacks+limitedcellproduction
III	2410	11.7–17.1	Cathodes	End-to-endbatterymanufacturing

Thewind-solarhybridpolicy—2018

MNRE issued a national strategy for wind-solar hybrids on May 14 of this year. Large power wind-solar photovoltaic hybrid systems and the hybridization of existing projects were promoted by this strategy. In order to maximise the usage of transmission network and land, several schemes were devised. The fluctuation of renewable power output has been decreased, resulting in improved system stability. The element of the strategy that encouraged the hybridization of already existing plants was the most effective. Included in the new policy was a tariff-based, open bidding procedure. Government agencies should provide standards and guidelines for hybrid systems. As a result, energy storage in hybrid projects was also emphasised as a way to optimise output and reduce unpredictability.

Offshore wind energy strategy for the United States—2015

It was announced in October 2015 that the National Offshore Wind Policy will be launched. A medium-term aim of 5 GW by 2022 was announced by the MNRE on June 19th, 2018, and a long-term target of 30 GW by 2030 was also announced. For the first 1 GW of off-shore wind, the MNRE requested expressions of interest (EoI) (the last date was 08.06.2018). For offshore wind (FOWIND) testing, the consortium installed light detect and ranging (LiDAR) in November 2017 at the Pipavav port in the Gulf of Khambhat, 23 kilometres from the EoI site. Gujarat's Pipavav port is located off the shore. Additionally, in Tamil Nadu and Gujarat, the MNRE intended to put in additional equipment like these. The Ministry of Natural Resources and Environment (MNRE), via the National Institute of Wind Energy (NIWE), issued a tender for environmental impact assessments in the Gulf of Mannar, off the coast of Tamil Nadu, for offshore wind measurement on December 14, 2018. The goal was to initially install 500 MW by 2022, then 2 to 2.5 GW by 2027, and finally 5 GW between 2028 and 2032, according to the plan. In spite of the difficulties associated with installing huge wind turbines in open waters, the government has worked hard to encourage the offshore industry. India's renewable energy mix would be bolstered by the addition of offshore wind generation [63].

Policy on feed-in tariffs for 2018

The new rate policy was announced on January 28th, 2016, after the passage of the Electricity Act. Released on May 30th, 2018, was a change to tariff policy. For the

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benefit of consumers, this tariff policy is designed to provide an affordable electricity rate; (b) to attract investment and financial viability; (c) to guarantee that the conceptions of regulatory risks lessen through predictability, consistency and accountability of policy initiatives; (d) development in quality of supply; increased operational efficiency and better competition;

Table 21 SHP target, achievements and cumulatives [54]

Year	Target(MW)	Achievement (MW)	Cumulative(MW)
2007–2008	200	205	2045.07
2008–2009	250	249	2160.48
2009–2010	300	305	2604.92
2010–2011	300	307	2913.00
2011–2012	350	353	3410.52
2012–2013	350	237	3643.17
2013–2014	300	252	3803.68
2014–2015	250	408	4055.36
2015–2016	250	218	4273.47
2016-17	250	105.9	4379.86
2017-18	100	105.95	4485.80
2018-19 (31st of December 2018)	250	31.65	4517.45

Table 22 Biomass power target, achievements and cumulatives

Year	Target (MW)	Achievement (MW)	Cumulative (MW)
2013–2014	405	412.5	4013.55
2014–2015	400	405	4418.55
2015–2016	400	400	4831.33
2016–2017	400	161.95	8181.70
2017–2018	340	519.10	8700.80
2018–2019 (31.12.2018)	250	374.70	9075.50

Table 24 Amended Tariff Policy, RPO trajectory up to 2019

Year	Solar energy	Non-Solar energy	Total
2016–2017	2.75%	8.75%	11.50%
2017–2018	4.75%	9.50%	14.25%
2018–2019	6.75%	10.25%	17.00%
2019–2020	7.25%	10.25%	17.50%
2020–2021	8.75%	10.25%	19.00%
2021–2022	10.50%	10.50%	21.00%

To increase the production of electricity from wind, solar and biomass; (f) to provide peaking reserves that are acceptable in volume or truly great in quality or performance of grid operation; (g) to achieve better consumer services through effective and convenient electricity infrastructure; (h)

activities to educate and train people

The MHRD has created comprehensive educational and training programmes in the field of renewable energy. Course modules and a Modular Employable Skill programme (MES) are developed by the National Council for Vocational Training to incorporate SPV lighting systems, solar thermal systems, SHP, and the certificate for seven trades following the conclusion of a two-year course. " Plumber, fitter, carpenter, welder, machinist, and electrician" are among the seven crafts included in this list. Skill Development and Entrepreneurship's (MSDE's) national strategy on skill development was established in 2015. With the help of the MNRE, a national society for green jobs (SCGJ), the National Occupational Standards (NOS), and the Qualification Pack, they provide regular training programmes to generate a variety of careers in renewable energy (QP). The SCGJ is supported by the Confederation of Indian Industry (CII) and the Ministry of Natural Resources and Environment (MNRE). Re-New Power is the SCGJ's industry partner [65, 66].

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Table23AllocationbudgetfortheMNRE(unionbudget2018–2019)(R&D)

Table 23 Allocation budget for the MNRE (union budget 2018–2019) (R&D)

Year	Allocation
2017–2018 (Budget estimate)	5473 crore (5473 Million INR, 76.8991 Million USD)
2017–2018 (Revised estimate)	4080 crore (4080 Million INR, 57.3266 Million USD)
2018–2019 (Budget estimate)	5146.83 crore (51466.3 Million INR, 723.134 Million USD)

Table 24 Amended Tariff Policy, RPO trajectory up to 2019

Year	Solar energy	Non-Solar energy	Total
2016–2017	2.75%	8.75%	11.50%
2017–2018	4.75%	9.50%	14.25%
2018–2019	6.75%	10.25%	17.00%
2019–2020	7.25%	10.25%	17.50%
2020–2021	8.75%	10.25%	19.00%
2021–2022	10.50%	10.50%	21.00%

TheglobalstatusofIndiainrenewableenergy

RECAI (Renewable Energy Country Attractiveness Index) reports for 40 countries are shown in Table 25. Renewable energy investment and implementation potential are the focus of this paper. macro vitals such as financial stability, investment climate, and energy imperatives such as security, supply, and affordability are the foundation of RECAI. Political stability and renewable energy assistance are two examples of policy enablement. Energy market access, infrastructure and distributed generation, funding, availability and transaction liquidity are some of the project delivery characteristics that are emphasised. Natural resources, power take-off appeal, possible support, technological maturity, and predicted growth are all taken into account when assessing countries for technology potential. The RECAI-2018 now lists India as the fourth best performing country. In 2017, India added 9629 MW of new large-scale and rooftop solar capacity, more than doubling the previous year's 4313 MW of installed capacity. Investors are becoming concerned about solar import taxes and tensions between

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developers and distributors [67]. Installations of renewable energy throughout the world in 2016 and 2017 are shown in Figure 6. As of 2017, there were more than 2200 gigawatts (GW) of renewable energy installed in the world. Total country capacity additions through 2017 are shown in Table 26. In terms of renewable power capacity, the nation came in fifth place (including hydropower), fourth place (excluding hydropower), and fourth place (including concentrated solar thermal power (CSP) and wind power) [68].

Table 25 Country attractive index of the 52nd edition-201of Renewable energy 8 [67]

Overall rank	Previous rank	Country	RECAI score	Technology-specific score (out of 100)							
				Onshore wind	Offshore wind	Solar PV	Solar CSP	Biomass	Geothermal	Hydro power	Marine
1	1	China	65.7	51	55	53	33	45	21	52	19
2	2	USA	63.8	50	53	49	32	39	39	35	31
3	4	India	63.8	50	20	57	34	44	25	45	21
4	3	Germany	62.7	46	50	49	17	44	34	35	20
5	6	France	62.5	50	51	48	22	48	33	31	36
6	5	Australia	62.3	47	30	54	35	24	21	39	31
7	8	Japan	59.2	43	44	47	18	51	48	36	23
8	7	UK	58.6	47	57	41	14	47	27	32	33
9	9	Netherlands	58.6	44	48	45	15	33	23	24	15
10	13	Argentina	58.6	45	21	50	30	37	32	37	20
11	11	Chile	56.7	43	20	47	32	37	31	41	28
12	15	Morocco	56.6	42	17	51	31	16	15	20	14
13	12	Mexico	56.3	43	19	50	25	45	43	34	19
14	10	Denmark	55.7	44	48	39	15	44	17	22	24
15	20	Egypt	54.9	45	14	52	36	13	12	27	12

Theinvestmentopportunitiesinrenewableenergy inIndia

Bloomberg New Energy Finance (BNEF) released a statement stating that investment in renewable energy in India increased by 22% in the first half of 2018 compared to the first half of 2017, whereas investment in China decreased by 15% during the same time. It is predicted that by the end of 2020, India would have overtaken China as the world's largest market for renewable energy. By 2020, the nation hopes to be in the forefront of the transition to renewable energy, with 175 GW of installed capacity. To meet this goal, the company is stepping up investments in this industry swiftly. When compared to 2017, the nation increased its renewable energy capacity more than its conventional energy capacity in 2018. The first formal ISA summit was held in India on March 11, 2018, with 121 nations represented. This will serve as a uniform framework for achieving the lofty renewable energy goals set by the government. The summit will demonstrate India's commitment to meeting its international obligations in a timely manner. Similar to but bigger than China's solar power farms are being built in the nation. India is home to half of the world's ten largest solar parks now under construction.

The Topaz solar farm in California was the world's biggest solar park in 2014, with a 550 MW plant. Another Californian company, Solar Star, increased its capacity to 579 MW in 2015. With a capacity of 648 MW, India's Kamuthi Solar Power Project in the state of Tamil Nadu ranked first in 2016. (set up by the Adani Green Energy, part of

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the Adani Group, in Tamil Nadu). 850 MW of capacity was the new leader in China's Longyangxia Dam Solar Park as of February 2017 [71]. Currently, 600 MW of operational capacity and 1400 MW of construction capacity are available.

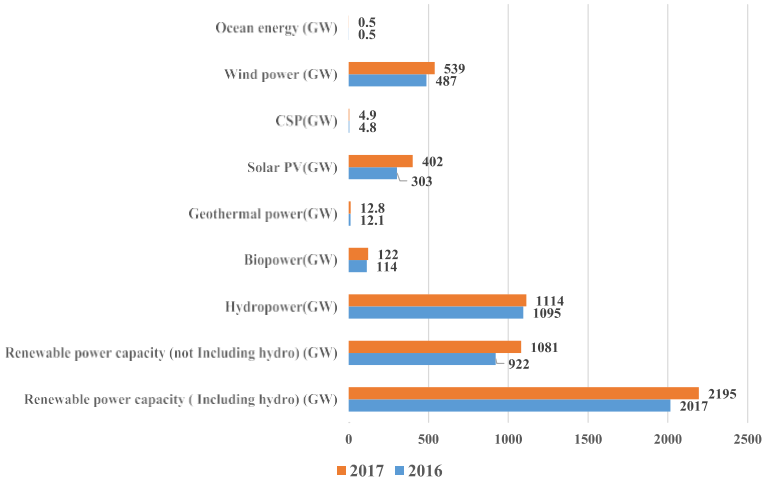

Fig.6Globallyinstalledcapacityofrenewableenergyin2017—Global2018statusreportwithregardtorenewables[68]

Table 26 Globally installed capacity of renewable energy in 2017—Global 2018 status report with regard to the ranking of renewables [68]

Installed capacity	Rank I	Rank II	Rank III	Rank IV	Rank V
Renewable power capacity (Including hydropower)	China	USA	Brazil	Germany	India
Renewable power capacity (not Including hydropower)	China	USA	Germany	India	Japan
Bio power	China	USA	Brazil	Germany	Japan
Geothermal power	USA	Philippines	Indonesia	Turkey	New Zealand
Hydropower	China	Brazil	Canada	USA	Russia
Solar PV	China	USA	Japan	Germany	Italy
CSP	Spain	USA	South Africa	India	Morocco
Wind power	China	USA	Germany	India	Spain

At 2 GW, the Shakti Sthala solar park in Pavagada (Karnataka, India) was launched on March 1, 2018, and it is projected to become the world's most important solar park. An additional 1.5 GW solar park will be created in the Kadappa district of the state. Solar power has come a long way and is proving to be a reliable source of sustainable energy.

Over 700,000 tonnes of CO2 were avoided in October 2018 by the Kurnool ultra-mega solar park, which produced 800 million units (MU) of electricity. In order to clean solar panels and provide water, rainwater was collected in a reservoir. A lot of development is being made in the field of solar energy in the United States. A robot cleans the Kamuthi solar farm every day. There will be 15,280 TWh of power used in 2040 as the Indian economy grows. Green energy goals, i.e., the renewable sector, expand significantly in an appealing way with both international and local investors thanks to the government's intention. In the next four years, up to USD 80 billion in investment is expected. The government of India has

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increased its renewable energy capacity goal from 175 GW to 225 GW by 2022. The country's competitive advantage is its year-round solar exposure and vast hydroelectric potential. According to EY's 2018 Renewable Energy Country Attractiveness Index, India was ranked fourth overall. As part of MNRE's "Solar cities" concept, 60 solar cities will be created in India's countryside.

The country's competitive advantages in a normal auction include reductions in project tariff costs. About 4% of the world's total power generating capacity is generated in India, which has the fourth-largest installed wind energy capacity and the third-largest installed CSP capacity. During the years 2015–2016, 2016–2017, 2017–2018, and 2018–2019, India installed a total of 3.01 GW, 5.52 GW, 9.36 GW, and 6.53 GW of solar power.

$bn	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
USA	16.5	34.6	47.1	43.6	35.1	46.6	62.3	52.9	44.6	52.2	58.4	56.4	56.9
Europe	38.9	53.1	75.2	88.3	91.3	123.1	137.8	96.4	70.2	78.5	73.8	77.7	57.4
China	8.8	11.2	16.8	26.6	38.7	45.0	51.5	62.6	66.9	89.6	125.4	107.2	132.6
Brazil	2.7	5.1	9.8	11.5	7.9	7.5	10.3	8.2	4.4	7.8	6.7	5.7	6.2
Canada	2.1	2.5	4.2	3.3	3.6	6.6	4.0	5.8	6.7	7.0	3.8	2.3	3.3
Mexico	0.2	0.1	0.1	0.7	0.4	2.5	0.4	1.6	1.9	2.3	1.8	1.0	6.2
UK	4.7	6.2	6.8	5.9	11.9	10.8	13.1	11.7	15.1	17.5	25.9	23.4	10.3
Germany	15.2	17.0	20.2	21.7	27.6	40.3	39.0	27.4	18.8	24.0	18.5	19.8	14.6
France	3.2	5.3	4.9	5.6	4.6	6.3	10.5	7.0	5.2	7.3	4.1	4.3	5.0
Spain	5.2	9.9	23.3	23.2	9.9	8.1	10.6	3.0	1.2	0.8	0.1	0.8	1.1
Italy	2.4	2.0	3.8	8.1	8.4	24.3	32.3	15.6	4.3	1.7	2.1	2.2	2.5
Japan	8.4	8.1	9.4	11.3	12.5	14.8	18.6	25.0	37.3	44.3	42.6	27.9	23.4
India	3.2	5.4	6.4	5.8	4.3	9.0	13.8	8.1	6.8	8.5	9.9	13.7	11.0
Australia	1.4	1.8	1.5	1.5	2.3	5.2	6.2	5.4	4.8	2.2	2.2	3.6	9.0

- Over the next two years, the government intends to install 8.5 GW. Located in the solar belt (400 South to 400 North), the nation is one of the greatest recipients of solar energy, with reasonably abundant supply. As of December 2018, the installed capacity of solar power was 25.21226 GW. By 2022, the installed capacity of solar power is expected to reach 100 GW, surpassing the installed capacity of wind power. Solar PV has become the most attractive new investment opportunity

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because of rapidly lowering pricing. A zero-import tax on components used in the production of solar panels was included in the Union Budget 2018–2019 in order to provide an advantage to local solar panel manufacturers. [73]

- It has been estimated that between April 2000 and June 2018, the Indian government's department of industrial policy and promotion (DIPP) received USD 6.84 billion in foreign direct investment in the renewable energy industry (DIPP). The DIPP has been renamed the Department for the Promotion of Industry and Internal Trade (gazette announcement 27.01.2019). (DPIIT). Business and startup growth and assistance, as well as the well-being of merchants' staff members and the welfare of domestic commerce and retail are all part of its purview. India's renewable energy industry has seen a whopping 42 billion dollars in investment since 2014. A total of $7.4 billion was invested into India's economy in the initial half of 2018. Between April 2015 and June 2018, the renewables industry attracted 3.2 billion dollars in foreign direct investment. It grew from USD 776 million in 2015–2016 to USD 783 million in 2016–2017 and USD 1204 million in 2017–2018. More than $450 million in foreign investment was received between January and March of this year. There are a variety of financial and promotional incentives provided by the nation. These include capital subsidies, accelerated depreciation (AD), waivers of interstate transmission taxes and losses, viability gap financing (VGF), and FDI up to 100% within the automated track..
- The FDI equity intake data received in India is compiled and managed by the DIPP/DPIIT [74]. Figure 7 depicts the entry of FDI equity into the renewable industry from April 2015 to June 2018. It demonstrates that the FDI equity inflow for the three months of 2018–2019 is half that of the whole 2017–2018 period. According to the figure, India has long had a history of receiving FDI equity inflows. Table 28 shows the most important foreign direct investment (FDI) in the renewable energy industry. The Asian Development Bank and Renew Power Ventures private limited partnership with 44.69 million USD placed top, followed by AIRRO Singapore and Diligent power with 44.69 million USD of FDI equity inflow.
- Efforts to encourage investment
- There are several ways to encourage foreign direct investment (FDI) into renewable energy projects.
- Reduce barriers to FDI, create open, transparent, and reliable conditions for both local and foreign enterprises, and include ease of doing business and access to resources.
- Imports, relatively flexible labour markets, and intellectual property protection are all factors that contribute to a more open economy.
- Create an organisation to promote investment (the IPA) that links international investors to the native economy as a stimulus for growth. Promptly provide competent personnel, technicians, engineers, and managers who may be required by such investors in order for the IPA to show top-notch infrastructure. A post-investment care should also be included to recognise the demonstration effects

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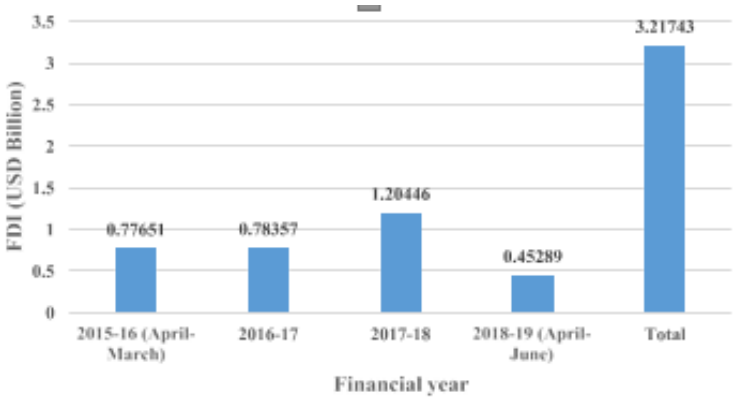
from pleased investors, the possibility for investment growth, and the prospect for cluster growth owing to subsequent investments.

- You must take into account the industry you're aiming for (wind/solar/etc.)
- SPH or biomass) that need monetary outlays of some kind.



Put in place all of the necessary infrastructure to attract a reputable investor, such as convenient access to air and seaports, ample energy supplies to keep operations moving along smoothly, and training facilities for specialist workers that are best built in conjunction with the investor.

Power Purchase Agreements (PPA) serve an important role in enhancing project developers' returns and limiting uncertainty, hence indirectly promoting investment. Investment in renewable power projects has traditionally been a result of relying on government regulations to offer investors confidence in the costs required to create electricity—and hence project earnings. For project developers, negotiating a power purchase agreement (PPA) with a utility or a key corporate buyer of energy provides security of future power prices.

For the last decade, the most common method of encouraging investment has been via the use of financial incentives (FiT).

in the development of new sources of clean energy. These tariffs, which are set by the relevant government, specify an energy price that new project developers may expect to pay for the power generated over the course of 15–20 years. Investment in renewable power plants may be offset by a tax credit that investors can use in their own enterprises.

Table 29 shows the investment in renewable energy in 2018.

Bloomberg New Energy Finance Report 2018 provides a source-wise breakdown of major participants in renewables. Global investment in renewable power in 2017 was USD 279.8 billion, according to this study Chinese investments totaled $126.1 billion,

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followed by the United States with $40.5 billion, Japan with $13.4 billion, India with $10.9 billion, Germany with $10.4 billion, Australia with $8.6 billion, and the United Kingdom with $7.6 billion.

There are $BN, $BN, $BN in Mexico, and $BN in Sweden [75]. Because of their well-established investment promotion programmes, these nations were able to accomplish this success.

According to the Nationally Determined Contributions (NDCs) goals, implementation of the NDC, on the road to achieving Paris promises and the ability of markets to absorb renewable power expansion are the real aims for renewable power expansion, which is a significant factor in the investment strategies, as is shown in this paper.

Even in developing countries, there is a considerable demand for investments in Paris-compliant and climate-resilient energy infrastructure. Energy networks and energy flexibility are of special importance for future investments in these areas. Table 31 details the approaches and provides a side-by-by-side comparison of the US, China, and India.

Table 32 shows France as the G20 leader in the investment attraction of renewables because of the country's overall favourable circumstances for renewables. Both the UK and Germany are demoted one position as a result of the worldwide policy climate for renewables deteriorating and certain policy design flaws. With four European nations at the forefront, Europe leads the way in offering favourable conditions for renewable energy investment. Despite the fact that several countries received great marks, no one government has yet to develop into a model. There is still a lot of potential for nations to increase investment in renewables in order to meet the Paris goals. The table given is based on the Paris compatible long-term goal, the regulatory environment for renewable energy, the prerequisites for infrastructure connectivity, the market absorption capacity, and the general investment conditions.. Between 2017 and 2018, India went from 11th place to 9th place in total investments.

De-carbonization of the power system, renewable power ambition, coal and oil reduction, and renewables policy dependability are all part of a Paris-compliant long-term goal. Indirect assistance policies include medium-term policy certainty, stream-lined administrative processes, assuring project implementation, and enabling the use of the generated power.

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Table 28 Leading FDI investments in the renewable energy sector [74]

Collaborating company	Country	Indian company/Private limited	FDI equity inflow (USD mn)
Asian Development Bank	Philippines	Renew Power Ventures	44.69
AIRRO Singapore Pte Ltd	Singapore	Diligent Power	41.07
ORIX Corporation	Japan	TADAS Wind Energy	37.75
ENEL Green Power Development B.V.	Netherlands	BLP Energy	32.61
DEG - Deutsche Investitions- und Entwicklungsgesellschaft	Germany	WELSPUN Renewables Energy	32.50
ENERK International Holdings Ltd	Seychelles	RKM POWERGEN	32.50
OSTRO Renewal Power Limited	Mauritius	OSTRO Energy	32.21
AREVA Solar Inc.	USA	AREVA Solar India	31.53

Table29Renewable energy investmentreport—developingeconomies—source-wise(BloombergNewEnergyFinancereport 2018)[75]

USDbillion	China	India	Brazil	USA	Europe
Solar	86.5	6.7	2.1	19.8	10.8
Wind	36.1	4.0	3.6	19.2	28.0
Biofuels	0.1	0.0	0.2	0.7	0.6
Biomass	1.5	0.1	0.0	0.4	1.0
Smallhydropower	2.4	0.1	0.1	0.1	0.2
Total($BN)	126.6	10.9	6.0	40.2	40.6

Demand-side management rules, grid integration codes, and storage integration promotion are all examples of prerequisites for system integration. Prior experience with renewable technology, present activity involving renewable installations, and the existence of significant renewable include non-financial drivers, depth of the finance sector as well, and an inflation forecast

India's renewable energy sector provides employment possibilities for its residents.

Situation in the world of work

Global renewable energy employment reached 10.3 million jobs in 2017, up 5.3% from 2016's figures, according to the IRENA's 2018 Annual Review [78]. Renewable energy has several socio-economic benefits, but employment remains disproportionately concentrated in a few number of nations, including China, Brazil, the United States, India, Germany, and Japan. China is the leader in solar PV employment (3.4 million jobs), followed by Japan, the United States, India, Bangladesh, Malaysia, Germany, the Philippines, and Turkey (65 percent of PV jobs).

Table30Targetsrelevantforrenewableenergydevelopment[76]

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Objectives appropriate for renewable power expansion and facilitating investments	China	India	USA
NDC purpose	By 2030, an approx. 20% rise of non-fossil fuels in the primary energy mix, by 2030 carbon intensity of GDP lowered by 60% to 65% under the 2005 levels, by 2020, an approx. 10% rise of natural gas in the primary energy mix, latest by 2030, peak CO_2 emissions.	By 2030, an approx. 40% rise of non-fossil fuels in the primary energy mix, by 2030, the carbon intensity of GDP lowered by 33% to 35% under the 2005 levels.	Reduce the emissions intensity of GDP by 26–28% by 2025 below 2005 levels (incl. LULUCF) and reduce the emissions intensity of GDP by 83% by 2050 below 2005 levels (excl. LULUCF- land use change and forestry)
NDC implementation	In 2015, the installed renewable capacity (including hydro energy) in China amounted to 493 GW and it is planned in the thirteenth renewable energy development five year plan to achieve 680 GW by 2020.	It is recommended in the National Action Plan on Climate Change (NAPCC) to achieve a 15% share of renewables power in the total power generation, and the National solar mission is targeting 175 GW by 2020. In the draft of the National Electricity Plan (2016), it is predicted that the share of the installed capacity (renewables, nuclear and hydro energy) of non-fossil fuels will reach 56.5% by 2026–2027. Furthermore, there will be a 20.3%, 24.2% share of renewables in energy production in 2021–2022 and 2026–2027, respectively.	The individual states power-sector associated emissions reduction cumulatively to 32% below 2005 levels by 2030 is described in the Clean Power Plan (CPP).
On the route of reaching Paris promises	China is anticipated to accomplish its objectives with its contemporary policies.	India is anticipated to accomplish its objectives with its contemporary policies.	A closed-down Obama's Clean Power Plan (CPP) could prevent the US growth for accomplishing its Paris Agreement objectives. Executive order to halt the CPP in March 2017 was signed by the new administration.
Competence of policy	High	High	Low
Reliability of policy	Very high	High	Low
Nationwide investment circumstances	Medium	Very low	Medium
On the path of approaching the Paris promises	Medium	Very low	High

Table31Strategiesofthedevelopmentofrenewableenergyinvestments[76]

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Strategies for investments	China India USA
Adequacy and reliability of renewable power policies (Strong policies) are essential for investors to realize the required range of investments.	The findings in the 2016 Allianz Climate & Energy Monitor's report conclude that China and India are competing more effectively as the USA in implementing a robust, nation-wide green policy environment. This trend is anticipated to continue stable in 2017. Strong policies help to achieve the Paris climate objectives of India and China whereas the USA might miss its goals to fulfill the targets of the Paris Agreement if the current government swiftly performs its current announcements. Without attractive and strong nation-wide policies in the USA, renewable powers encounter headwinds (opposite general direction to a course of movement) and will rely on their state actions and imminent cost competitiveness.
Additions to renewable energy capacity	The level of renewable energy capacity additions goes up currently in all three countries and has in total moved up to an overtook of investments in fossil-fuel based capacity additions. China is decreasing the use of coal at a sharp angle, firstly, to fight against environmental pollution and secondly due to the steady increase of renewables and a structural transformation steering in the economy of China.
Coal power plants decommissioning	China is quickly decommissioning coal power plants to fight against environmental pollution, and carbon emissions, whereas India may not put a hold onto developing new capacities before 2022.
A mature market	Large quantities of renewable power investments in the USA are still in progressive because there are a mature market, an excellent general investment climate, and attractive state-level policies.
Paris agreement intentions	Renewable power leadership of the USA, India, and China is significant to meet the Paris agreement intentions.
The investment volumes	India continued the stable growth in the investment volumes compared to China and the USA. The investment volume fell in the two countries. In China, the drop was 32% (USD 78 billion) because the country was giving priority to integrating the already-existing renewable capacity. In the USA, the decline amounted to 10% (USD 46 billion) because the country was giving priority to pushing installations in 2015 to avoid the potential federal tax credits' expiration in 2016. The total global newly installed capacity still increased from 2015 to 2016, even though the investment costs per unit declined considerably.
Projection of absolute investment	Absolute investment predictions until 2035, however, are only one dimension of the investment demands estimation. The individual energy set-up of all country and current consumption patterns are significant determinants of future demands. For example, the USA has much more substantial power consumption than China and India today, while the consumption is rising in China and India which implicates expanding development needs.
Essential socio-economic indicators.	According to pre-estimation results of 2016, India has the most significant demand for renewable investments among the G20 members as an effect of comparatively low per-capita consumption, a fast-growing population and rising energy demands due to economic development. Despite a mature market and high energy consumption, in terms of investment required, the USA is close to India and China, reflecting a powerful vulnerability of its energy infrastructure to climate effects.
Developing a policy framework of renewable energy for long-term investment	China and India are continually developing its policy framework for long-term renewable energy investments and, at a federal level; the outlook for the USA is worsening. The modern renewable policy environment in China and India is more efficient and stable than the one in the USA. There are ambitious climate and renewable power targets and performances in progressive states, such as Texas and California, and still, the attractiveness for renewable power investments in the USA is foreseen to continue scattered in the future because of inadequate and steady federal policies.

Brazil has the most jobs in biofuels (1.9 million), followed by the United States, Colombia, Indonesia, Thailand, Malaysia, China, and India. Brazil has the most jobs in biofuels. China leads the pack in wind employment (1.1 million jobs), followed by Germany, the United States, India, the United Kingdom, Brazil, Denmark, the Netherlands, France, and Spain.

Table 33 displays the renewable electricity employment in the respective technical areas worldwide. Fig. 8 shows that China has retained its position as the world's most populous country, with 3880 million people working, or 43 percent of the global

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workforce. A record 9.6 GW of additional solar power was added to India's installed base in 2017 as a result of these additions. Solar PV jobs increased by 36% to 164,400, with 92,400 of them being for on-grid installations. A total of 46 percent of these occupations were accounted for by the construction and installation, with 35 percent and 19 percent of the total being accounted for by the operations and maintenance (O&M). Because solar PV can be bought from China at a low cost, India does not create its own solar PV. There was a dramatic decrease in the percentage of domestic enterprises (Indian suppliers to renewable projects) in the market between 2014–2015 and 2017–2018. To begin manufacturing, Indians will have more opportunities for employment. As of 2018, Indian wind capacity was the world's fifth-largest and the fourth-largest, respectively. IRENA expects the wind industry to employ 60,500 people.

Table 32 Overview of the results of the 2018 Allianz Climate & Energy Monitor [76]

Country	Overview of the results			Direct support policies		Conditions for system integration Score	Paris compatible long-term vision	Market absorption capacity			General investment conditions		
	Score	Rank-2018	Rank-2017	Score	Rank-2018			Score	Rank-2018	Rank-2017	Score	Rank-2018	Rank-2017
France	69	1	3	60	1	67	80	53	7	9	86	4	2
Germany	67	2	1	45	5	83	63	89	1	1	75	8	8
UK	64	3	2	21	12	100	68	80	2	2	91	2	1
Italy	53	4	8	34	10	83	54	53	6	7	64	9	9
China	52	5	4	35	9	100	37	57	4	8	63	10	11
Japan	51	6	6	50	2	50	17	51	8	6	86	5	3
Canada	47	7	10	15	15	100	28	40	10	5	92	1	5
Brazil	46	8	13	50	2	67	49	36	11	10	37	13	14
USA	46	9	7	13	16	100	17	64	3	3	80	7	7
India	44	10	11	50	2	83	50	27	12	14	26	17	17
Australia	39	11	9	13	16	67	00	56	5	4	89	3	4
South Africa	38	12	12	38	7	67	24	19	14	13	56	11	10
South Korea	38	13	5	18	13	67	24	24	13	12	80	6	6
Mexico	34	14	15	45	5	17	50	15	15	15	31	16	13
Turkey	32	15	18	38	7	83	05	45	9	11	14	18	18
Saudi Arabia	23	16	19	18	13	50	14	00	19	19	49	12	12
Argentina	22	17	16	23	11	33	46	03	17	18	13	19	19
Indonesia	15	18	14	05	19	33	16	04	16	16	31	15	16
Russia	13	19	17	09	18	17	09	00	18	17	35	14	15

- Installation/deinstallation, operation, and maintenance are some of the roles in renewable energy. A look at the wind industry's development, manufacture, construction and operations is shown in Tables 34, 35, 36 and 37. Also included in these tables are modest hydro-related occupations in education, training, and re-search. Every worker must keep up with the rapid pace of technological change, and in certain situations may benefit from professional certification as a result. So far, governments have shown a favourable attitude toward a shift to renewable energy because of its obvious benefits. The next wave of job creation in the United States will be in the field of renewable energy. This may be a game-changer for rural communities' economies [79, 80]. Poverty might be alleviated through increased job opportunities in the renewable energy industry. Wind power, for example, is always on the lookout for people with expertise in manufacturing, project planning, construction, and turbine installation, and also financial services, transportation, and logistics.
- Building additional renewable power plants would need a staff, the government says. More employment might be created than in any fossil fuel business as a result of increased investments in renewable energy. Profits for small enterprises and the renewable energy industry will rise dramatically as a result of this development. Many positions in this industry will contribute to stable incomes, healthcare benefits, and possibilities for inexperienced and semi-skilled individuals to

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develop their skills. All renewable energy sources provide a wide spectrum of skilled and unskilled professions, despite the fact that most roles in the renewable energy business need a highly-skilled workforce. For building, operations, and maintenance, the renewable industry uses semi- and unskilled labour. Truck drivers, security guards, cleaners, and maintenance workers all use unskilled labour. Display readings are taken by unskilled workers on a frequent basis. Lack of reliable data on renewables expansion's employment effect makes it difficult to estimate the number of highly trained, semi-skilled, and unskilled workers that may be required.

- Findings on the use of renewable energy sources
- According to the results, the vast majority of renewable sector employment is contract-based and that individuals do not have the benefits of permanent employment or security in their professions. a (a) The sector has the potential to reduce poverty through long-term employment. As a result of a lack of understanding about the positions and their criteria, many low-income residents have difficulties in obtaining entry-level training or employment. It's rare that corporations provide revolving-door programmes to give employees and customers the chance to buy into the company's success.
- It is difficult to establish links between renewable energy jobs and poverty alleviation because of the scarcity of adequate data.
- Employment opportunities in the renewable energy sector: some suggestions
- Focus on empowering the underserved by providing them with hands-on experience in operation and maintenance while expanding the system's capacity.
- Training programmes for residents with little or no education and training should be developed to meet the needs of such persons.
- unable to work in renewable regions because of existing programme restrictions.
- Incorporate women into the green workforce by offering specialised training in their local area

Table 33 Global renewable energy employment for the corresponding technologies in 2012–2017 [79]

Sources (Million Jobs)	2012	2013	2014	2015	2016	2017
Solar photovoltaic	1.36	2.27	2.5	2.77	3.09	3.37
Bioenergy (biofuel, solid biomass, biogas)	2.4	2.5	2.99	2.88	2.74	3.06
Wind energy	0.75	0.83	1.03	1.08	1.16	1.15
Solar heating/Cooling	0.89	0.5	0.76	0.94	0.83	0.81
Others (Geothermal, SHP, CSP, heat pumps, WTE, Ocean)	0.33	0.38	0.4	0.4	0.45	0.45
Total (Million)	5.73	6.48	7.68	8.07	8.27	8.84

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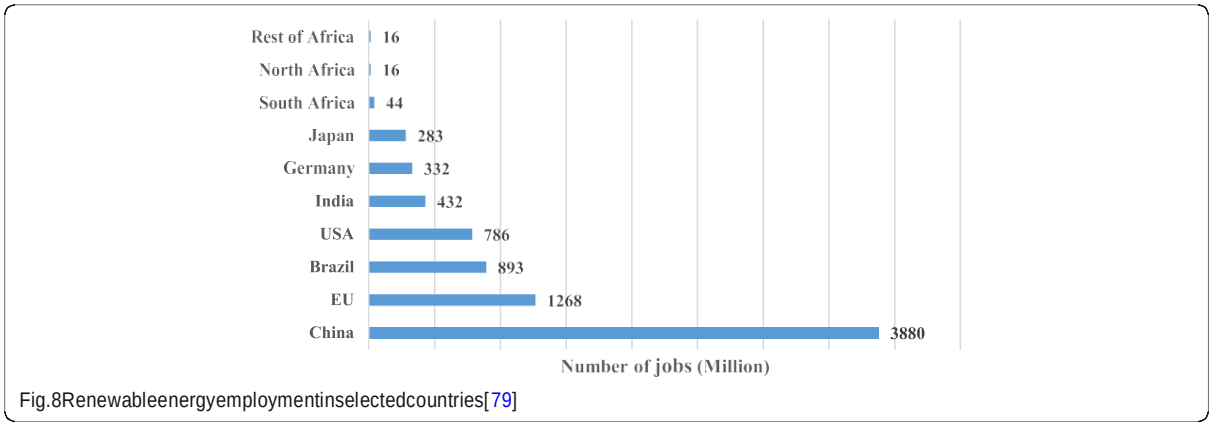

Fig.8Renewableenergyemploymentinselectedcountries[79]

Set up a network of training institutions and renewable power firms to ensure that (a) trained individuals are put in suitable jobs throughout and after completion of the training programme, and (b) training programmes are tailored to meet the needs of the industry.

Poverty impact evaluations might be included into the creation of new initiatives to better understand how they work.

poverty alleviation and how it affects the community.

Allowing consumers to feel like they have a stake in renewable energy projects might help the industry flourish.

the market sector.

Full- or part-time employment, as well as the amount of education and experience necessary for the position.

(skilled, semi-skilled, and unskilled), and data on the employees' socioeconomic condition must be gathered for future investigation.

Investigate the impact of renewable energy employment on the economy by conducting field surveys.

on poverty alleviation and the disparity in living standards.

India's renewable energy industry faces a number of obstacles. The MNRE has been working hard to improve the renewable energy industry and has been successful in identifying a number of roadblocks.

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Regulatory and policy hurdles

The renewable industry does not have a complete policy statement (regulatory framework). When there is a need to encourage the development of a certain kind of organism.

It's possible that policies and technology for renewable energy development may be announced that aren't in line with their goals.

There is a distinct difference in the legal structure and processes.

This sector has a greater risk due to the fact that each states set their own RPOs (Renewable Purchase Obligations). In addition, the policies are only in effect for a limited time period of five years, indicating the high level of risk associated with making investments in this industry. There is no recognised structure for the biomass industry.

Wind developers in India benefit from accelerated depreciation (AD), which is visible in the country's development of wind power. "

ability to generate wind energy. More than a decade after they were first constructed, wind turbines demonstrate that they haven't been properly maintained. Many of the owners of the asset built primarily for tax purposes. After the tax benefits have been obtained, wind farms are no longer required to be maintained under the policy framework.

Table34Windenergyjobclassificationbasedoneducationlevels

Construction project development Metrological Technician, Experts in Regulatory Affairs, Engineer, Power Systems, financial manager, Power marketers, Attorneys Component manufacturing Transportation worker, Trade worker, Assemblers and fabricators, Salespersons, Logistics, Buyers, Quality Engineer, Industrial Engineer, Electrical Engineer, Salesperson Workers in the construction, trades, and construction management industries.
Workers in the fields of wind and environmental science; site/plant manager; quality engineer; electrical engineer; mechanical engineer; asset manager; and attorneys.

Research and education
instructor/trainer in technical fields, instructors, instructors, trainers Professor, Research Scientist/Analyst or Research Engineer

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Table 35: Classification of jobs in the solar energy industry by education level
Advanced manufacturing technician, Instrumentation and Electronics technician, Quality Assurance expert,
High tech manufacturing expert, Instruments and Telecommunications technician, Quality Assurance expert,

Residential PV System Designer; Engineering Technician; Utility Interconnection Engineer; Structural Engineer; Structural Engineer; Solar Energy Systems Designer; Software Engineer.

Development of the project

In addition to being a solar site assessor, a solar sales representative or marketing specialist, a structural engineer with solar expertise, an electrical inspector (solar expertise), a code official, and a lawyer with solar expertise are all examples of solar professionals.
New roof with Solar Competence, Plumber with solar expertise, Solar Service Technician (residential), Solar PV installer, HVAC technician with solar expertise, commercial/utility solar PV technician, engineer with solar expert knowledge, solar project manager, solar installation contractor, solar fleet manager, and solar instructor are all examples of people with solar expertise.

Because they are responsible for all aspects of wind power plant development, including commissioning, operation, and maintenance, they have an advantage over equipment vendors. Suppliers jack up the price of the equipment they sell, making it more expensive for the consumer.

As a result, ready-to-buy projects are also available. To save money, customers fall prey to this sleight of hand

tax. Because foreign investors are immune from income tax, they are reluctant to invest.

A RPO is defined in a variety of ways in each state's regulatory framework. Specified in the RPO percentage is

There is a lack of clarity in the regulatory framework for renewable energy sources.

In accordance with RPO, SERCs and certain private companies can:

rely on renewable energy for just a portion of their energy needs.

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The RPO is not enforced on accessibility (OA) and captive users in all but three states.

The RPO compliance cell has barely begun work, thus its goals and duties are unclear.

A meeting will be held on 22 May 2018 to gather monthly reports on compliance and to address any non-compliance concerns.

Only two indian states (Maharashtra and Rajasthan) have penalty procedures in place.

a system of sanctions of some kind.

Non-compliance concerns with the RPO compliance cell have only begun collecting monthly reports, and the RPO compliance cell has only been operational since 22 May 2018.

A penalty system has not been established, and just two options have been provided.

The Indian states of Maharashtra and Rajasthan, for example, each have penal codes.

The RPO's objectives and responsibilities are unclear.

The compliance cell was established on May 22nd, 2018, and its first task is to gather monthly reports on compliance and take necessary action in the event of non-compliance.

Only two indian states (Maharashtra and Rajasthan) have penalty procedures in place.

a system of sanctions of some kind.

As a result, many SRECs have a tariff that is not clearly defined under the regulatory framework.

instituted a temporary tariff. The FiT is only valid for five years, which has a negative impact on the project's bankability.

Many SERCs have yet to implement the CERC tariff that is indicated in CERCs laws that deal with tariffs. /

Tariff decisions are subject to certain criteria. For this reason, SERCs have examined the plant load factor (PLF), which might vary from area to place. These problems cannot be addressed under the existing framework.

As a result, third-party sales (TPS) are not permitted.

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Commercial customers are not authorised to buy electricity from generators. They are only allowed to sell to businesses. As SRCS does not enable OA for industrial users, the business consumers have a much higher rate. The developers and investors lose money as a result of this.

Table36Bioenergyjobclassificationbasedoneducationlevels

Project development	Design, Resource assessment, Environmental and social assessment, Financing, Land agreements, Permitting, Selection of supplier
Construction and installation	Plant construction, Pre-processing and upgrading, Processing, Quality assurance, Conversion (heat, power, or fuel)
Operation and maintenance	Operation and maintenance
biomass Production	Cultivating, Harvesting, Transport
Cross-cutting/enabling activities	Training, Policymaking, Management & Administration, Insurance, IT, Health and safety Financing, Communication, Bio power transmission, and distribution

Table 37 Small hydropower job classification based on education levels

Equipment manufacture and distribution	R&D, Design and manufacture: of turbines; generators and excitation; other hydro-mechanical components (e.g., valves, penstocks); other electrical components (e.g., transformers, power, electronics, etc.); governor and control systems, Quality, assurance, Marketing and sales, Delivery
Project development	Design, Site investigations, and feasibility studies, Environmental and social assessment, Financing Land agreements, Licensing/Permitting, Selection of the supplier
Construction AND Installation	Project construction, Project commission
Operation and maintenance	Routine operation and maintenance, Minor equipment overhauls, Major equipment overhauls
Cross-cutting/enabling activities	Training, Policymaking, Management & Administration, Insurance, IT, Health and safety, Financing

Institutionalobstacles

A lack of inter-institutional coordination is evident among institutions, agencies, and other stakeholders working under the MNRE. Lack of collaboration, coordination and delays are stifling advances in renewable energy development. The one window plan approval and certification system is not very helpful and unstable since it delays the receipt of clearances for projects and ends in the levying of a penalty on the project developer. Poor coordination causes delays in policy implementation.

State pre-feasibility studies contain various deficiencies, and this may influence the tiny states involved.

developer-types who are prepared to take on renewable energy initiatives on the local level.

There is a shortage of staff in government organisations, institutions, and ministries.

Renewable infrastructure cannot be developed at existing research facilities.

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There are no customer service centres to assist developers with renewable energy projects.

Only in 2018 and 2019 have standards and quality control directives been issued, and there are

Standards and certifications for renewable technologies are lacking since there are not enough organisations or labs to provide these services.

Obstacles to financial and economic security

There are several fiscal restrictions, such as the lack of timely availability of funds and budgets, that must be overcome in order to improve the

energy generation from renewable sources.

It is difficult to finance renewable energy projects at the outset because of the high initial unit initial investment compared to fossil fuels.

There is a dearth of technological understanding and high-risk attitudes that lead to financial hurdles for developers because of these uncertainties.

It's possible that subsidies for renewable energy may be reconsidered because of the lack of transparency in the subsidies.

energy since rates were drastically reduced last year.

There is a difference between the existing bids and PPAs signed between a power purchaser and a power generation on fixed rates.

As of February 1st, 2019, the (Economic Survey 2017–2018 and Union Budget) The tariff for solar electricity, for example, has been reduced to.

Electricity costs 2.44 INR (0.04 USD) in May, 3.46 INR in February, and 2.64 INR in October 2017.

Investors are concerned about the renewable sector's viability.

As a result, even though these returns are quite high by market standards, this industry generates lower gross returns.

Developers aren't really interested in the subject matter.

Projects that use renewable energy. When it comes to developing a project, new

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developers (small and local developers) lack the necessary institutional track record and financial resources (high capital cost). Even banks and other financial institutions are reluctant to lend money because they see it as too hazardous. Lenders only work with well-established contractors, suppliers, and operators that have a track record of success in the building industry.

If low-performing renewable energy projects get into financial difficulties, they run the danger of failing.

the absence of financing for renewable energy initiatives.

Renewable energy projects are not well understood by financial institutions, such as government banks or private banks, and this is a problem.

prohibits the initiatives from moving forward financially.

Locally based developers have a debt load since moneylenders always operate on a payment schedule.

financing is made possible by the use of credit enhancement tools or the creation of guarantee bonds between lenders and developers.

Obstacles in the market

Subsidies to traditional fossil fuels are amply given, giving the incorrect impression that conventional fuels are more important than renewables (unfair structure of subsidies)

To promote the use of renewable energy in India there are four distinct markets: the government-driven market (providing budgetary support or fiscal incentives to endorse renewable energy), the loan market (taking loan to finance renewable based applications) and cash market (buying the output of the project) (buying renewable- based applications to meet personal energy needs by individuals). In India, there is a lack of promotion of the loan and cash markets.

The bioenergy market is experiencing a demand-supply imbalance, resulting in constantly rising biomass prices due to erratic supply (and the absence of a regulated market for fuel). Biomass demand and price elasticity are high since the kind of bioenergy is not the same in different Indian states.

The cost-plus approach was used to estimate the amount of renewable electricity generated.

and product overhead costs). This does not reflect the environmental costs of clean and green energy, and it hides the ecological advantages.

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There is insufficient infrastructure for evacuating the building.
The lack of grid interconnection has a negative impact on renewable energy initiatives. Because of the lack of an adequate evacuation infrastructure, SERCs are unable to utilise all produced electricity to satisfy their demands. As a result, SERCs are compelled to purchase costly electricity from neighbouring states in order to meet their demands.

It is not viable to extend transmission lines for small-scale projects, and the seasonality of generation from these projects has a direct effect on the market.

In terms of overall production plans, distribution Cap explains and renewable electricity distribution licences, there are minimal restrictions to consider. Renewable energy power evacuation infrastructure is not planned.

Despite the fact that commercially available renewable energy capacity is growing,
Notwithstanding advances in technology, capital costs have not decreased. The cost of electricity continues to rise. Exports of machinery, poor capacity development, and cartelization among equipment suppliers all contribute to the exorbitant capital costs stated by manufacturers and suppliers of equipment (suppliers join together to control prices and limit competition).

For wind, solar, and other renewable energy sources, there is a lack of land.

the inadequate capacity increase in several states caused by solar thermal power plants; and

Obstacles posed by technology
Complex risk concerns arise from environmental uncertainty, natural catastrophes, planning and equipment failure, as well as loss of profit.

On December 11th, 2017, the MNRE released the standardisation of renewable energy projects policy (testing, standardization, and certification). When compared to other countries' practises, they're still at a very basic level. Processes for ensuring quality are still in their infancy. Renewable energy success is built on solid action plans for standardisation, testing and certification.

In order to ensure that produced components are of high quality and dependability, a quality infrastructure must be built. Testing labs, referral institutions, review mechanisms, inspections and monitoring are not clearly defined in the agreement.

Renewable energy R&D facilities are few and far between. There is a lack of progress in reducing subsidies and investing in R&D since industrial facilities are just re-creating

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technology currently in use. In terms of equipment and technology, the country is totally reliant on imports. Spare components are hard to get by since they aren't made locally.

Obstacles to understanding, education, and training

In the development of renewable energy, there is a lack of qualified personnel. In addition, there is a severe lack of workers in this industry.

There is no sufficient follow-up or help for the project personnel to do maintenance after the suppliers have installed renewable projects/applications. In addition, there are not enough qualified and experienced personnel to demonstrate, teach, operate, and maintain the facility.

There is a dearth of information on renewable energy sources, and there are no public education campaigns to raise awareness of this problem.

public. The lack of knowledge about renewable energy technology is a major roadblock to securing large swaths of land for the project. As a result, those who produce crops on their property are reluctant to give it up to build power plants.

As the environment changes, so does public support for renewable energy sources, which makes them less attractive.

There is a perception that the cost of renewables is expensive and that they may not be able to utilise them because of low per capita income.

The storage system raises the price of renewables, and as a result, many individuals do not want to utilise them since they are too expensive.

As a result of misunderstandings and misperceptions about the environmental advantages of renewable technology, they are becoming less popular.

Obstacles in the natural environment

Wind turbines are often positioned in groups of five to ten rotors, which takes up less area than one turbine alone.

diameters from each other, and therefore takes up more space, which includes roads and power cables.

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Offshore wind turbines and blades are the focus of this article.

offshore wind turbines are much larger, occupying much more area, than onshore turbines. Activities in the ocean are affected by offshore installations (fishing, sand extraction, gravel extraction, oil extraction, gas extraction, aquaculture, and navigation). In addition, they have an impact on aquatic life.

Wind turbines have a direct impact on animal populations (birds and bats)

because of the air pressure fluctuations induced by wind turbines and habitat damage, as well as the collisions with them. It is possible to protect birds and bats by keeping wind turbines stationary during periods of low wind, however this is seldom done.

Wind turbines produce sound (aerodynamic and mechanical) and visual affects. There's a dearth of

wind turbine manufacturers' approach to addressing public concerns. The noise from turbines is reduced by flaws in surfaces and sound-absorbent materials. developers do not consider shadow flicker to have a significant environmental issue.

Wind turbine material manufacture, shipping, on-site construction, and installation may all be involved.

There is a delay in considering the link between global warming and the construction, operation, maintenance, dismantling, and decommissioning of nuclear reactors.

Because of the large areas needed for utility-scale solar facilities, there is an increased danger of soil degradation and habitat loss.

Hazardous chemicals including 1-1-1 Trichloroethene, HCL, H2SO4, N2, NF, and acetone are used in the PV cell production process. Workers are at danger from silicon dust inhalation. There is a lack of effective waste disposal in the production process. Thin-film PV cells do not have proper safety safeguards in place when they are used. These materials pose serious risks to human health and the environment. The blades of hydroelectric power turbines wreak havoc on aquatic life (fish and other organisms). Furthermore, the presence of algae and other aquatic plants is unchecked.

The plants may either be harvested by hand or introduced to fish that can consume them.

Based on the findings, here are some thoughts and suggestions.

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Advancements in policy and regulation

For the promotion of renewable energy, the MNRE should develop a detailed action plan or programme

sector in its renewable energy regulation system. This may be done in collaboration with the country's SERCs within a certain time period and the implementation of the policy/action plan.

As part of its policy, the federal and state governments should incorporate a "Must run" designation.

Renewable energy must be used exclusively.

Consumers will benefit from a nationwide merit order list for renewable energy production. An escalating price ranking for renewable energy sources based on merit would benefit each distribution firm by lowering their overall electricity costs (DISCOM). The MNRE should incorporate that notion in its framework and make sure that SERCs do the same.

Policies and regulatory ambiguity related to renewable energy might be removed by SERCs, if that is permitted to happen. SERCs may be able to designate the focus of their renewable energy potential.

Renewable energy-based projects should get a strong push from local governments in order to get the necessary permissions.

It's only possible to have a greater market penetration if the appropriate norms and standards are applied. Reliability, durability, and performance should all be part of MNRE's minimal performance criteria.

For renewable energy projects, a very well renewable energy certificates (RECs) programme may be beneficial. The REC environment must be developed by the government.

There has to be a more efficient "carrot and stick" method for obliged organisations to ensure compliance with RPO regulations. Regulators could consider implementing a system that both rewards and punishes non-compliance.

There should be no other way to trade RECs in India but via an exchange. In other words, "off-exchange" or "OTC" transactions

will enable for more people to become involved in the market. The market players will benefit from a REC forward curve.

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The REC market should be developed and built by policymakers.

The majority of states have established RPO goals. Still, because to the lack of RPO rules and the lack of enforcement,

Many of the state DISCOMs are not meeting their RPO objectives because of inadequate consequences for failure to meet responsibilities. In order for the SERCs' RPO goals to be met, all states must comply.

The government should deal with concerns like this.

on-time payments and payment assurances as well as projected generating advantages are all considered financial factors of DISCOM.

There should be incentives for utility companies to purchase electricity beyond the RPO required by the government.
in the SERC.

To be effective, tariff orders/FiTs must be consistent across time.

Requirements for transmitting data

They are concerned that transmission systems aren't keeping up with the electricity production. ' The substations closest to you are already full, and the transmission lines can't handle any more traffic. MNRE, PGCIL, and CEA were unable to work together as a result of this oversight. Without enough evacuation facilities, the Solar Corporation of India (SECI) is organising auctions for both wind and solar projects. Evacuation preparations must be completed immediately.

Substations and power lines need to be built, however the procedure will take far longer than the present development projects.

The PGCIL erected transmission lines in 2017 and 2018 as part of the green energy corridor project.

The goal for 2018–2019 is 1900 kilometres of circuit. The green energy corridor project was created with the express purpose of connecting renewable energy sources to the nation's grid. According to INR 6 billion allocated for 2018–2019, it should be enhanced.

MNRE and PGCIL, which are in charge of interstate transmission, need to be brought into alignment.

State transmission units (STUs) are in charge of the transmission of renewable energy

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within states, and they must have sufficient funding to do so.

must be accomplished. In addition, STUs that fail to meet their obligations should face sanctions.

Consultations and cooperation

There should be a good relationship between STUs and developers (the nodal entity responsible for renewable energy development).

Investing in the renewable energy industry

The renewable energy industry should get enough funding from the government. The yearly budget of China

There are 128 times more renewables than in India. China spent USD 126.6 billion (INR 9 lakh crore) in 2017, whilst India spent USD 10.9 billion (INR 75500 crore). Although grid-interactive wind and solar budget allocations rose in 2018, they are still not enough to satisfy the renewable objective.

A surplus fund for R&D should be established by the government, which should focus on R&D. The year 2017 had a rise inIn 2016, the budget was lowered from an INR 445 crore to an INR 272.85 crore. The original budget for 2017–2018 was INR 144 crore, which was then cut to INR 81 crore in the reevaluated forecasts. There is a pressing need for frequent oversight of R&D and the budget distribution, even with the smaller quantities.

The newly implemented Goods and Services Tax (GST)

Increased costs and a danger to current projects have been the results of 2017's deteriorating industry performance, which has slowed progress toward meeting goals. These GST problems must be solved.

As a result of putting renewable energy on the Priority Industry list, more capital will be available to the sector.

a larger role for commercial banks.

Requirement of pension funds and insurance firms

their predetermined proportion of their portfolio in renewable energy sources.

Banks should permit a reduction in the interest rate on mortgages.

Solar lights, solar water heaters, and photovoltaic (PV) panels are examples of renewable

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energy applications that the home's owner may want to consider installing. Using renewable energy will be encouraged as a result of this. Income tax credits are also available to those that use renewable energy applications, as well.

Manufacturing/technological advancements

The nation has to shift to indigenous production. As a result, it is imperative to create a strong domestic manufacturing base to meet 90% of its solar cell and module needs.

Only two years of India's "safeguard duty" will be enough to develop a manufacturing base strong enough to compete in the global market. In addition, safeguard duties would only be effective if India already had a bigger local manufacturing base in place.

The safeguard obligation should be reconsidered by the government.

Due to the lack of suitable protections in the existing regulation, many international corporations looking to establish joint ventures in India get only a tepid reaction.

At regular intervals, technical advances need cash, and the government has to find a strategy to deal with this.

R&D capabilities should be improved to take advantage of India's enormous anticipated renewable energy potential.

fix the most pressing issues in the sustainable energy industry.

An all-encompassing manufacturing strategy should be developed. Capital costs might be reduced and the product could be sold across the world.

Industry and academics should form a cooperation to spur new research and development.

and encourage the use of cutting-edge renewable energy technologies to save the planet for next generations.

Promote the exchange of ideas between businesses, universities, and government officials from across the globe in order to hasten the uptake of renewable energy sources.

Energy-renewables-awareness

Renewable energy's social acceptance in India's cities is still lacking. The most important component in the widespread usage of renewable energy is awareness. Society needs to be informed about the environmental advantages of renewable energy and other renewable technologies.

More educational and research institutions should be established by the government to

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assist spread the word about renewable energy. The government should hold frequent awareness initiatives in rural areas and distant regions such as the islands.

People should be continually educated on innovative methods that benefit the society as a whole.

There should be a sufficient number of organisations that can offer renewable goods and provide technical help during installation and maintenance.

Employment prospects must be improved for unskilled and semi-skilled employees, as well as governmental measures.

Installations of renewable energy might be aided by a growth in the quantity of qualified/trained workers.

They prefer to teach new staff because they know that educational institutions are unable to provide the necessary and sufficient training.

This has to be fixed by the training schools. There should be no scarcity of highly qualified human resources.

Achieving the renewable objective will need improving the skills of the current workforce and educating new recruits.

The use of renewables in a hybrid manner

In order to make the most of the nation's transmission infrastructure and land, the government should concentrate on hybrid power projects.

India should look at battery storage in hybrid projects to help optimise output and electricity at competitive costs and reduce unpredictability.

Make hybrid systems, which have been neglected in recent policy announcements, subject to required standards and regulations (wind-solar hybrid policy on 14.05.2018).

Combining 2 or more renewable energy sources with a conventional energy source to create a hybrid electric vehicle

Renewable energy systems may benefit from increased storage capacity.

A system's economic viability depends on its size and storage capacity, thus these issues need to be addressed.

Tax and financial incentives should be raised for hybrid projects.

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Conclusion

The renewable energy industry faces significant challenges. Certain problems may be attributed to a lopsided regulatory and market system, while others are inherent in renewable technologies. Renewable technologies are hindered by a lack of comprehensive legislation and regulations. Investors' interest in the renewable energy sector would be piqued if clear regulations and legal processes are in place. Private sector initiatives are being held up due to a lack of defined rules. In order to entice private investors, the nation should implement steps R&D should be used to overcome the lack of technology and infrastructure necessary to develop renewable technologies. There should be greater funding for research and innovation in this industry from the government. In order to teach, show, maintain, and run renewable energy buildings, there aren't enough qualified people, thus educational institutions should take the initiative to train more people. The cost of imported equipment is far higher than the cost of equipment that is manufactured locally. That's why we need a national effort to manufacture renewable items to lower their cost. Unreliable grid connection is another important infrastructure impediment to the growth of renewable energy technology. As a result, many investors have lost trust in renewable energy technology and aren't willing to invest since they are afraid of losing money on their investments. India needs to improve its methods of transmission and escape.

Some renewable energy solutions are unable to be selected because of a lack of consumer faith in the technology and inadequate service and maintenance of infrastructure. To prevent equipment failures that interrupt the supply of energy, it is necessary to have the necessary expertise to repair/service spare parts and equipment. It is imperative that communities be made aware of the benefits of renewable energy, as well as the importance of their cultural customs. The commercialization of renewable energy technology should be accelerated through government support of investments in renewable energy growth. An established fiscal aid strategy, such as providing credit, deducting loan interest, and imposing tariffs, need to be declared by the Indian government. As a result of improved rules, the government should ensure that all electricity DIS-COMs have power purchase agreements (PPAs) that cover 100% of their RPO duty. We highly recommend the adoption of a hybrid design comprising at least two or more renewable resources with conventional sources and storage devices to achieve a stable system. In order for hybrid systems to function properly, standards and rules must be developed by regulatory bodies. Increased societal well-being will emerge from successful regulations and tax incentives that make investments economically feasible.

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