

4. RENEWABLE ENERGY SOURCES

Use of renewable energy (RE) could help farmers to increase agricultural productivity as well as to generate revenue by value addition to their produces. The primary sources of energy such as electricity and high-speed diesel (HSD) has always been an important source of energy for production and postproduction agriculture. India faces a challenge in meeting its energy needs and providing adequate energy of desired quality in various forms for different sectors of economy in a sustainable manner and at reasonable costs. Hence, harnessing renewable energy sources have been increasing to ensure quality of power supply, reduction in environmental pollution, increase self-reliance on energy availability and use locally available non-conventional resources. The Government of India has given greater emphasis on harnessing renewable energy and is capitalizing different programmes on solar energy, wind energy, biomass energy, hydropower, waste to energy, etc. Agricultural crop residues as well as other biomass resources have a potential to generate enormous power. Considering above aspects, this section containing 25 tables, indicating targets for different RE installation, potential of RE, achievements in RE installations and global information on RE installations have been compiled and presented

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Table 4.1: Targets for Renewable Energy Generation in India

	Technology	Target
Targets for Specific Amount of Installed Capacity or Generation		
India	Electricity	175 GW by 2022; 450 GW by 2030
	Bio-power	10 GW by 2022
	Hydropower (small scale) ^a	5 GW by 2022
	Solar PV and CSP	100 GW by 2022
	Wind power	60 GW by 2022
Andhra Pradesh ^b	Electricity	18 GW capacity added by 2020-21
Delhi ^b	Solar PV	5000 MW added 2015-2020
	Solar power	1 GW by 2020; 2 GW by 2025
Rajasthan ^{b,c}	Hybrid (solar PV and wind)	3.5 GW by 2024-2025
	Wind	2 GW by 2024-2025
	Solar power	25 GW by 2020; 30 GW by 2024-2025
Jharkhand ^b	Solar PV	2650 MW installed by 2019-2020
Technology-specific Share of Electricity Generation		
Bihar	Solar power ^{d,e}	2% by 2019-20; 2.5% by 2020-21; 3% by 2021-22
Himanchal Pradesh	Solar power ^{d,e}	1% by 2019-20; 2% by 2020-21; 3% by 2021-22
Kerala	Solar power ^{d,e}	0.25% by 2021-22
Text in bold indicates new/revised in 2019.		
^a India does not classify hydropower installations larger than 25 MW as renewable energy sources. Therefore, national targets and data for India do not include hydropower facilities >25 MW.		
^b Text in <i>italics</i> indicates policies adopted at the state/provincial level.		
^c Utility or grid-scale solar parks are to account for 24 GW, distributed generation for 4 GW, solar rooftops for 1 GW and solar pumps for the remaining 1 GW.		
^d India has established state-specific solar power purchase obligations		
^e Text in <i>italics</i> indicates mandates adopted at the state/provincial level.		

Source: REN21. 2020. Renewables 2020 Global Status Report (Paris: REN21 Secretariat). ISBN 978-3-948393-00-7. https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf. Accessed on 23.07.2020.

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Table 4.2:Medium-Term Estimated Potential for Renewable Energy in India (Upto 2032)

Resource	Estimated Potential*(MW_{eq})
Solar Power	>1,00,000 ¹
Wind Power	49,000 ²
Small Hydro Power (Upto 25 MW)	20,000 ³
Bio-Power	
Agro-Residues	16,000 ⁴
Cogeneration-Bagasse	5,000 ⁵
Waste to Energy	
Municipal Solid Waste to Energy	1,700 ⁶
Industrial Waste to Energy	1,000
Total	1,92,700⁷

MW_{eq}:Megawatt equivalent.

*All of this potential may be suitable for grid-interactive power for technical and/or economic reasons.
 Note: 1. The potential for solar power in most parts of the country is around 30-50 MW per square kilometer of open, shadow free area covered with solar collectors.

2. Potential based on areas having wind power density (wpd) greater than 200 W/m² assuming land availability in potential areas @ 1% .Revised estimate by C-WET is ~1,00,000 MW at 80 m height (being validated). The lower end of the potential might be suitable for off-grid applications. Preliminary surveys do not at this juncture suggest a sizeable grid-interactive off-shore wind power potential.

3. Technically feasible hydro potential of all sites upto 25 MW station capacity. Technically feasible and economically viable hydro potential is generally accepted at 40% of the total estimated potential.

4. Based on surplus agro-residues. In practice, however, there are several barriers in collection and transportation of such agro-residues to the generation site and biomass power generation units prefer to use fuel-wood for techno-economic reasons. A potential of 45,000 MWe from around 20mha of wastelands assumed to be yielding 10MT/ha/annum of woody biomass having 4000 k-cal/kg with system efficiency of 30% and 75% PLF has not been taken into account.

5. With new sugar mills and modernization of existing ones, technically feasible potential for surplus power is assessed at 5000 MWe.

6. With expansion of urban population post census 2001, current technically feasible municipal waste-to-energy potential is assessed at 1700 MWe.

7. Potential for solar power is dependent on future developments that might make solar technology cost-competitive for grid-interactive power generation applications.

Source:www.indiastat.com

<https://www.indiastat.com/table/physical-progress-of-various-renewable-energy-programmes/resource-wise-estimated-medium-term-potential-rene/727965>.Accessed on 31.05.2021.

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Table 4.3: Source-wise Installed Power Generation Capacity as on 28.02.2021

Fuel	Capacity (MW)	% of Total
Total Thermal	2,33,171	61.5%
Coal	2,01,085	53.0%
Lignite	6,620	1.7%
Gas	24,957	6.6%
Diesel	510	0.1%
Hydro (Renewable)	46,209	12.2%
Nuclear	6,780	1.8%
RES* (MNRE)	91,154	24.5%
Total	3,79,130	

* Installed capacity in respect of RES (MNRE) as on 28.02.2021.

RES (Renewable Energy Sources) include Small Hydro Project, Biomass Gasifier, Biomass Power, Urban & Industrial Waste Power, Solar and Wind Energy.

Source:Ministry of Power, GoI, <https://powermin.gov.in/en/content/power-sector-glance-all-india>. Accessed on 27.05.2021.

Table 4.4: Cumulative Achievements in Installation of Renewable Energy Systems in India as on 28.02.2021

I. Grid-Interactive Power Capacities (MWp)	
Wind Power	38,789.15
Solar Power - Ground Mounted	34,759.13
Solar Power - Roof Top	4,324.58
Small Hydro Power	4,783.06
Biomass (Bagasse cogeneration)	9,373.87
Biomass (non-bagasse cogeneration)/Captive Power	772.05
Waste to Power	168.64
Total	92,970.48
II. Off-Grid/ Captive Power Capacities (MW_{eq})	
Waste to Energy	218.13
SPV Systems	1,123.51
Total	1,341.64
III. Other Renewable Technologies Capacities (Nos.)	
Biogas Plants (in Lakhs)	51.65

Source:<https://mnre.gov.in/the-ministry/physical-progress>. Accessed on 23.04.2021.

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Table 4.5: Estimated Installable Wind Power Potential in Major States of India and Installed Capacity as on 28.02.2021

Sl. No.	State	^a Wind Potential (MW) at Above Ground Level			^b WindPower (MW)
		100 m	80 m	50 m	
1	Gujarat	84,431.33	35,071	10,609	8,306.42
2	Rajasthan	18,770.49	5,050	5,005	4,326.82
3	Maharashtra	45,394.34	5,961	5,439	5,000.33
4	Tamil Nadu	33,799.65	14,152	5,374	9,431.54
5	Madhya Pradesh	10,483.88	2,931	920	2,519.89
6	Karnataka	55,857.36	13,593	8,591	4,912.60
7	Andhra Pradesh	44,228.60	14,497	5,394	4,096.65
8	Kerala	1,699.56	837	790	62.50
9	Telangana	4,244.29	-	-	128.10
10	Odisha	3,093.47	1,384	910	4.30
11	Chhattisgarh	76.59	314	23	
12	West Bengal	2.08	22	22	
13	Puducherry	152.83	120	-	
14	Lakshadweep	7.67	16	16	
15	Goa	0.84	-	-	
16	Andaman & Nicobar	8.43	365	2	
Total		3,02,251.49	94,313	43,045	38,789.15

Source:^a<https://mnre.gov.in/wind/current-status/> Accessed on 24.07.2020.

https://niwe.res.in/department_wra_est.php. Accessed on 24.07.2020.

^b<https://mnre.gov.in/the-ministry/physical-progress>. Accessed on 23.04.2021.

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Table 4.6: Generation of Electricity from Wind Energy Sources (2014-15 to Nov 2020)

Sl. No.	Year	Generation (MU)
1	2014-15	33,768
2	2015-16	33,029
3	2016-17	46,004
4	2017-18	52,666
5	2018-19	62,036
6	2019-20	64,639
7	2020-21 (upto Nov, 2020)	46,367

Source: Annual report 2020-21, Ministry of New and Renewable Energy, GoI,
https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf. Accessed on 24.04.2021.

Table 4.7: Tariffs for Wind Power in Tender Auctioned by Central and State Agencies

Sl. No.	Bid	Capacity Awarded (MW)	Type	Min. Tariff (Rs/kWh)
1	SECI-I	1,049.9	Central	3.46
2	SECI-II	1,000	Central	2.64
3	SECI-III	2,000	Central	2.44
4	SECI-IV	2,000	Central	2.51
5	Tamil Nadu	450	State	3.42
6	Gujarat (GUVNL)	500	State	2.43
7	Maharashtra (MSEDCL)	500	State	2.85
8	SECI-V	1,190	Central	2.76
9	NTPC	850	Central	2.77
10	SECI-VI	1,200	Central	2.82
11	SECI-VII	480	Central	2.79
12	SECI-VIII	440	Central	2.83
13	Gujarat (GUVNL)	202.6	State	2.80
14	SECI-IX	970	Central	2.99
	Total	12,832.5		

Source: Annual report 2020-21, Ministry of New and Renewable Energy, GoI.
https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf. Accessed on 24.04.2021.

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Table 4.8: State-wise Solar Energy Potential and Installed Grid Interactive Solar Power Plants in India as on 28.02.2021

Sl. No.	State/UT	Solar Potential (MWp)	Installed Solar Power Plants (MW)		
			Ground Mounted	Roof Top	Total
1	Andhra Pradesh	38,440	3,858.24	138.26	3,996.50
2	Arunachal Pradesh	8,650	1.27	4.34	5.61
3	Assam	13,760	10.67	32.32	42.99
4	Bihar	11,200	138.93	20.58	159.51
5	Chhattisgarh	18,270	222.64	29.84	252.48
6	Delhi	2,050	8.96	184.01	192.97
7	Goa	880	0.95	6.49	7.44
8	Gujarat	35,770	3,125.17	943.13	4,068.30
9	Haryana	4,560	130.80	277.03	407.83
10	Himachal Pradesh	33,840	24.00	18.73	42.73
11	Jammu & Kashmir	1,11,050	8.49	12.24	20.73
12	Jharkhand	18,180	19.05	29.58	48.63
13	Karnataka	24,700	7,091.75	255.10	7,346.85
14	Kerala	6,110	150.00	107.00	257.00
15	Madhya Pradesh	61,660	2,386.31	76.91	2,463.22
16	Maharashtra	64,320	1,642.24	647.73	2,289.97
17	Manipur	10,630	0.00	6.36	6.36
18	Meghalaya	5,890	0.00	0.12	0.12
19	Mizoram	9,090	0.10	1.43	1.53
20	Nagaland	7,290	0.00	1.00	1.00
21	Odisha	25,780	383.56	18.16	401.72
22	Punjab	2,810	828.58	118.52	947.10
23	Rajasthan	1,42,310	5,053.58	419.00	5,472.58
24	Sikkim	4,940	0.00	0.07	0.07
25	Tamil Nadu	17,670	4,090.15	313.33	4,403.48
26	Telangana	20,410	3,784.27	152.09	3,936.36
27	Tirupura	2,080	5.00	4.41	9.41
28	Uttar Pradesh	22,830	1,410.25	257.25	1,667.50
29	Uttarakhand	16,800	239.78	113.63	353.41
30	West Bengal	6,260	100.00	49.84	149.84
31	UTs	790	44.39	86.08	130.47
	Total	7,48,980	34,759.13	4,324.58	39,083.71

Source: <https://mnre.gov.in/the-ministry/physical-progress>. Accessed on 23.04.2021.

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Table 4.9: State-wise Installed off-grid Solar Power Plants as on 28.02.2021

SI. No.	States	Power Plants (kWp)
1	Andhra Pradesh	3,815.60
2	Arunachal Pradesh	963.20
3	Assam	1,605.00
4	Bihar	6,800.00
5	Chhattisgarh	31,372.90
6	Goa	32.72
7	Gujarat	13,576.60
8	Haryana	2,321.25
9	Himachal Pradesh	1,905.50
10	Jammu & Kashmir	8,129.85
11	Jharkhand	3,769.90
12	Karnataka	7,854.01
13	Kerala	16,078.39
14	Madhya Pradesh	3,654.00
15	Maharashtra	3,857.70
16	Manipur	1,580.50
17	Meghalaya	2,004.00
18	Mizoram	3,864.60
19	Nagaland	1,506.00
20	Orissa	2,191.51
21	Punjab	2,066.00
22	Rajasthan	30,449.00
23	Sikkim	850.00
24	Tamil Nadu	13,052.60
25	Telangana	7,450.00
26	Tripura	867.00
27	Uttar Pradesh	10,638.31
28	Uttarakhand	4,059.53
29	West Bengal	1,730.00
30	Andaman & Nicobar	167.00
31	Chandigarh	730.00
32	Delhi	1,269.00
33	Lakshwadeep	2,190.00
34	Puducherry	121.00
35	Others states	23,885.00
	Total	2,16,407.67

Source: <https://mnre.gov.in/the-ministry/physical-progress>. Accessed on 23.04.2021.

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Table 4.10: State-wise Installed off-grid Solar Energy Systems/Devices as on 28.02.2021

States	Street Light System	Home Light System	Solar Lanterns
Andhra Pradesh	15,795	22,972	77,803
Arunachal Pradesh	13,741	35,065	1,25,581
Assam	17,384	46,879	6,47,761
Bihar	47,152	12,303	17,35,227
Chhattisgarh	3,730	42,232	3,311
Goa	707	393	1,093
Gujarat	5,004	9,253	31,603
Haryana	34,625	56,727	93,853
Himachal Pradesh	92,500	22,592	33,909
Jammu & Kashmir	24,904	1,44,316	51,224
Jharkhand	13,916	9,450	7,90,515
Karnataka	50,69	52,638	7,781
Kerala	1,735	41,912	54,367
Madhya Pradesh	14,258	7,920	5,291,01
Maharashtra	10,420	3,497	2,39,297
Manipur	22,367	24,583	9,058
Meghalaya	5,800	14,874	40,750
Mizoram	10,117	12,060	1,07,217
Nagaland	15,125	1,045	6,766
Orissa	17,955	5,274	99,843
Punjab	43,448	8,626	17,495
Rajasthan	7,114	1,87,968	2,25,851
Sikkim	504	15,059	23,300
Tamil Nadu	40,324	2,98,641	16,818
Telangana	2,208	0	12,000
Tripura	6,887	32,723	2,88,941
Uttar Pradesh	2,91,392	2,35,909	23,51,205
Uttarakhand	3,4218	91,595	1,63,386
West Bengal	15,605	1,45,332	17,662
Andaman & Nicobar	1,135	468	6,296
Chandigarh	901	275	1,675
Delhi	301	0	4,807
Lakshadweep	4,465	600	5,289
Puducherry	417	25	1,637
Others*	9,150	1,40,273	1,25,797
Total	8,30,373	17,23,479	79,48,219

Source: <https://mnre.gov.in/the-ministry/physical-progress>. Accessed on 23.04.2021.

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Table 4.11: State-wise Solar Pumps Installed as on 28.02.2021

Sl. No.	States	Solar Pumps (Nos)
1	Andhra Pradesh	34,045
2	Arunachal Pradesh	22
3	Assam	45
4	Bihar	2,813
5	Chhattisgarh	61,970
6	Goa	15
7	Gujarat	11,577
8	Haryana	8,461
9	Himachal Pradesh	24
10	Jammu & Kashmir	39
11	Jharkhand	4,832
12	Karnataka	7,476
13	Kerala	818
14	Madhya Pradesh	24,684
15	Maharashtra	11,315
16	Manipur	40
17	Meghalaya	19
18	Mizoram	37
19	Nagaland	3
20	Orissa	9,661
21	Punjab	4,970
22	Rajasthan	55,195
23	Tamil Nadu	6,394
24	Telangana	424
25	Tripura	214
26	Uttar Pradesh	30,847
27	Uttarakhand	26
28	West Bengal	653
29	Andaman & Nicobar	5
30	Chandigarh	12
31	Delhi	90
32	Puducherry	21
33	Others states	4,621
	Total	2,81,368

Source: <https://mnre.gov.in/the-ministry/physical-progress>. Accessed on 23.04.2021.

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Table 4.12: Benchmark for Different Solar Collectors

Types of Solar Collectors	Benchmark Cost (Rs/m ²)
Concentrator with manual tracking (dish solar cookers)	7,000
Solar collector system for direct heating and drying and non- imagine/ Compound Parabolic Concentrators(NIC/CPC)	12,000
CSTs with single axis tracking (including Scheffler dish)	15,000
CSTs with single axis tracking, solar grade mirror, reflector and evacuated tube collectors	18,000
CSTs based on double axis tracking	20,000

Source:Annual report 2019-20, Ministry of New and Renewable Energy, Gol,
https://mnre.gov.in/img/documents/uploads/file_f-1597797108502.pdf. Accessed on 17.07.2020.

Table 4.13: Benchmark Cost of off-Grid Solar PV Systems for the Year 2020-21

i) Standalone Solar Pumps

Pump Capacity, hp	Pump type	Benchmark cost (Rs. Per Pump)	
		General category States/UTs	North Eastern states/Hill States & UTs/ Island UTs
0.5	AC/DC Surface	53,000	58,300
	AC/DC Submersible	68,000	74,800
1	AC/DC Surface	92,400	1,01,700
	AC/DC Submersible	1,03,700	1,14,100
2	AC/DC Surface	1,22,200	1,34,600
	AC/DC Submersible	1,31,400	1,44,600
3	AC/DC Surface	1,63,200	1,79,700
	AC/DC Submersible	1,68,300	1,85,400
5	AC/DC/Surface/Submersible	2,36,500	2,60,500
7.5	AC/DC/Surface/Submersible	3,52,500	3,87,750
10	AC/DC/Surface/Submersible	4,45,000	4,45,000

ii) Solar Lighting Systems

System	Benchmark Cost (Rs. Per system)	
	General category States/UTs	North Eastern states/Hill States & UTs/ Island UTs
Solar Study Lamps*	395	437
Solar Street Lights# (with Li batteries)	19,400	21,340

*Solar study lamp with 2.5 Wp solar panel, 1 W LED luminaire and 3.2 V – 2000mAh Li batter as per MNRE specifications.

#Solar Street lights with 75 Wp solar panel, 12 W LED luminaire and 12.8 V -30 Ah Li battery as per MNRE specifications.

iii) Standalone Solar Power Plants/Packs

Capacity	Battery backup (h)	Benchmark Costs (Rs. per Wp)	
		General category States/UTs	North Eastern states/Hill States & UTs/ Island UTs
Upto 10 kW	6	94	103
	3	74	81
	1	62	68
Above 10 kW and up to 25 kW	6	84	92
	3	66	72
	1	55	60

Source:Office order no. 318/38/2018-GCRT date 25.06.20, MNRE, Gol

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https://mnre.gov.in/img/documents/uploads/file_f-1593090586363.pdf. Accessed on 23.09.2020.

Table 4.14: Benchmark Costs for Grid Connected Rooftop Solar Power Plants for the Year 2019-20

Capacity	Benchmark cost (Rs/Wp) other than Special Category States	Benchmark costs (Rs/Wp) for Special Category States which includes North Eastern States, Hilly states of Uttarakhand , Himachal Pradesh, J&K and UTs of Andaman & Nicobar Island and Lakshadweep
Above 1 kW and upto 10 kW	54	59
Above 10 kW and upto 100 kW	48	53
Above 100 kW and upto 500 kW	45	50

Source:Office order no. 318/33/2019-Grid Connected Rooftop date 16.07.2019, MNRE, Gol.

<https://mnre.gov.in/img/documents/uploads/2a4e2c9c7c6a47b098255d07fd752264.pdf>.

Table 4.15 Specification for Solar Photovoltaic Water Pumping Systems

Table 4.15a Indicative technical specifications of Shallow Well (surface) Solar Pumping Systems with Brushes or Brushless DC (BLDC)

Description	Model-I	Model-II	Model-III	Model-IV	Model-V	Model-VI	Model-VII	Model-VIII	Model-IX	Model-X	Model-XI	Model-XII	Model-XIII
PV array (Wp)	900	1,800	2,700	2,700	4,800	4,800	4,800	6,750	6,750	6,750	9,000	9,000	9,000
Motor Pump-set capacity (hp)	1	2	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (m)	12	12	12	25	12	25	45	12	25	45	12	25	45
Water output * (l/ day)	99,000	1,98,000	2,97,000	1,48,500	5,28,000	2,64,000	1,82,400	7,42,500	3,71,250	2,56,500	9,90,000	4,95,000	3,42,000
Total head, m	10	10	10	20	10	20	30	10	20	30	10	20	30

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Source:<https://mnre.gov.in/img/documents/uploads/72e996ab81bc4e0a9e51eb73d5f4835a.pdf>. Accessed on 23.09.2020.

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Table 4.15b Indicative Technical Specifications of Solar Deep Well (Submersible) Pumping Systems with DC Motor Pump Set with Brushes or Brushless DC (BLDC)

Description	Model-I	Model-II	Model-III	Model-IV	Model-V	Model-VI	Model-VII	Model-VIII	Model-IX	Model-X	Model-XI	Model-XII	Model-XIII	Model-XIV
PV array (Wp)	1,200	1,800	3,000	3,000	3,000	4,800	4,800	4,800	6,750	6,750	6,750	9,000	9,000	9,000
Motor Pump-set capacity (hp)	1	2	3	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (m)	45	45	45	70	100	70	100	150	70	100	150	70	100	150
Water output * (l/ day)	45,600	68,400	11,4000	69,000	45,000	1,10,400	72,000	50,400	1,55,250	1,01,250	70,875	2,07,000	1,35,000	94,500
Total head, (m)	30	30	30	50	70	50	70	100	50	70	100	50	70	100

Source: <https://mnre.gov.in/img/documents/uploads/72e996ab81bc4e0a9e51eb73d5f4835a.pdf>. Accessed on 23.09.2020.

Table 4.15c Indicative Technical Specifications of Shallow Well (Surface) Solar Pumping Systems with A.C. Induction Motor Pump Set

Description	Model-I	Model-II	Model-III	Model-IV	Model-V	Model-VI	Model-VII	Model-VIII	Model-IX	Model-X	Model-XI	Model-XII	Model-XIII
PV array (Wp)	900	1,800	2,700	2,700	4,800	4,800	4,800	6,750	6,750	6,750	9,000	9,000	9,000
Motor Pump-set capacity (hp)	1	2	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (m)	12	12	12	25	12	25	45	12	25	45	12	25	45
Water output * (l/day)	89,100	1,78,200	2,67,300	1,32,300	4,75,200	2,35,200	1,68,000	6,41,025	3,30,750	2,36,250	8,90,000	4,41,000	3,24,000
Total head, (m)	10	10	10	20	10	20	30	10	20	30	10	20	30

Source: <https://mnre.gov.in/img/documents/uploads/72e996ab81bc4e0a9e51eb73d5f4835a.pdf>. Accessed on 23.09.2020.

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Table 4.15d Indicative Technical Specifications of Solar Deep Well (Submersible) Pumping Systems with A.C. Induction Motor Pump Set

Description	Model-I	Model-II	Model-III	Model-IV	Model-V	Model-VI	Model-VII	Model-VIII	Model-IX	Model-X	Model-XI	Model-XII	Model-XIII	Model-XIV
PV array (Wp)	1,200	1,800	3,000	3,000	3,000	4,800	4,800	4,800	6,750	6,750	6,750	9,000	9,000	9,000
Motor Pump-set capacity (hp)	1	2	3	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (m)	45	45	45	70	100	70	100	150	70	100	150	70	100	150
Water output * (l/day)	42,000	63,000	1,05,000	63,000	42,000	1,00,800	67,200	43,200	1,41,750	94,500	60,750	1,89,000	1,26,000	81,000
Total head,(m)	30	30	30	50	70	50	70	100	50	70	100	50	70	100

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Source:<https://mnre.gov.in/img/documents/uploads/72e996ab81bc4e0a9e51eb73d5f4835a.pdf>. Accessed on 23.09.2020.

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Table 4.16: State-wise Grid Interactive Bio-Power Installed Capacity in India as on 28.02.2021

States / UTs	Bio-Power			
	BM Power/Bagasse Cogeneration	BM Cogeneration (Non-Bagasse)	Waste to Energy	Total
	(MW)	(MW)	(MW)	(MW)
Andhra Pradesh	378.10	105.57	23.16	506.83
Assam	-	2.00	-	2.00
Bihar	112.50	12.20	-	124.70
Chhattisgarh	242.40	2.50	-	244.90
Goa	-	-	0.34	0.34
Gujarat	65.30	12.00	-	77.30
Haryana	121.40	89.26	1.20	211.86
Himachal Pradesh	-	9.20	-	9.20
Jharkhand	-	4.30	-	4.30
Karnataka	1,867.10	20.20	1.00	1,888.30
Kerala	-	2.27	-	2.27
Madhya Pradesh	92.50	14.85	15.40	122.75
Maharashtra	2,568.00	16.40	12.59	2,596.99
Meghalaya	-	13.80	-	13.80
Odisha	50.40	8.82	-	59.22
Punjab	299.50	173.95	10.75	484.20
Rajasthan	119.25	2.00	-	121.25
Tamil Nadu	969.10	43.55	6.40	1,019.05
Telangana	158.10	2.00	45.80	205.90
Uttar Pradesh	1,957.50	159.76	-	2,117.26
Uttarakhand	72.72	57.50	-	130.22
West Bengal	300.00	19.92	-	319.92
Delhi	-	-	52.00	52.00
Total	9,373.87	772.05	168.64	10,314.56

Source: <https://mnre.gov.in/the-ministry/physical-progress>. Accessed on 23.04.2021.

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Table 4.17: Estimated Biogas Potential of Different States and Cumulative Achievements under National Biogas and Manure Management Programme (NBMMP) upto 31.03.2020 and New National Biogas and Organic Manure Programme (NNBOMP) during 2020-21 (upto 31.01.2021)

State/ UTs	Estimated Potential (Nos. of Biogas Plants)	Cumulative Achievement up to 2019-20 (31/03/2020) (Nos. of Biogas Plants)	Targets and Achievements under National Biogas Programme (No. of biogas plants)	
			Target (2020-21)	Total achievements of 2020-21 as 31.01.2021
Andhra Pradesh	10,65,000	2,62,011	4,100	1,089
Arunachal Pradesh	7,500	3,609	200	0
Assam	30,70,00	1,38,483	3,400	400
Bihar	7,33,000	1,29,905	600	0
Chhattisgarh	4,00,000	59,850	2,000	262
Goa	8,000	4,226	200	8
Gujarat	5,54,000	4,35,097	700	0
Haryana	3,00,000	63,221	1,600	177
Himachal Pradesh	1,25,000	47,680	400	0
Jammu & Kashmir	1,28,000	3,195	300	0
Jharkhand	1,00,000	7,823	800	0
Karnataka	6,80,000	5,10,902	7,000	1,525
Kerala	1,50,000	1,53,001	1,500	428
Madhya Pradesh	14,91,000	3,76,538	4,600	1,022
Maharashtra	8,97,000	9,25,235	7,000	912
Manipur	38,000	2,128	200	0
Meghalaya	24,000	11,156	300	0
Mizoram	5,000	5,856	200	1
Nagaland	6,700	7,953	200	0
Odisha	6,05,000	2,71,772	1,400	30
Punjab	4,11,000	1,85,947	3,500	998
Rajasthan	9,15,000	72,438	4,800	132
Sikkim	7,300	9,044	300	0
Tamil Nadu	6,15,000	2,23,792	900	23
Telangana	0	3,16,645	1,000	0
Tripura	28,000	3,710	600	04
Uttar Pradesh	19,38,000	4,40,915	1,000	206
Uttarakhand	83,000	3,64,540	1,000	433
West Bengal	6,95,000	972	800	0
A&N Islands	2,200	97	200	0
Chandigarh	1,400	169	0	0
Dadra & Nagar Haveli	2,000	681	200	0
Delhi/ New Delhi	12,900	578	0	0
Puducherry	4,300	17,541	200	0
KVIC	0	1,344	5,200	673
NDDB, Anand	0	0	3,600	160
Total	1,23,39,300	50,58,054	60,000	8,483

Source: Annual report 2020-21, Ministry of New and Renewable Energy, Gol.

https://mnre.gov.in/img/documents/uploads/file_f-1618564141288.pdf. Accessed on 24.04.2021.

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Table 4.18: State-wise Installed off-grid Biogas Power Plants as on 31.03.2019

Sl. No	Name of the state	Installed		
		Nos	m ³	kW
1	Andhra Pradesh	34	4,320	481
2	Gujarat	2	285	30
3	Haryana	3	2,540	155
4	Karnataka	70	15,670	15,81.5
5	Maharashtra	68	11,690	1,257.5
6	Punjab	41	9,980	1035
7	Rajasthan	2	120	15
8	Tamil Nadu	52	30,360	2,853.5
9	Uttarakhand	17	1,070	124
10	Uttar Pradesh	30	4,400	591
11	Madhya Pradesh	6	735	70
12	Kerala	36	1,010	118
13	West Bengal	1	340	60
14	Odisha	2	60	10
15	Telangana	25	5,410	574
	Total	389	87,990	8,951.5

Source: <https://mnre.gov.in/bio-energy/current-status> Accessed on 28.09.2020.

Table 4.19: Installed Capacity and Number of Waste-to-Energy Plants Set up for Generation of Biogas, Bio-CNG and Power in Different States in India (as on 31.12.2020)

States/UTs	Biogas Generation Plants (m ³ /day) (No. of Plants)	BioCNG Generation Plants (kg/day) (No. of Plants)	Power Generation Plants (MW) (No. of Plants)	Total (In MWeq) (No. of Plants)
Andhra Pradesh	90,540 (7)	-	40.82 (15)	48.37 (22)
Bihar	12,000 (1)	-	-	1.00 (1)
Chhattisgarh	-	-	0.33 (1)	0.33 (1)
Delhi	-	-	52.00 (3)	52.00 (3)
Gujarat	24,800 (4)	28,338 (5)	11.28 (10)	19.25 (19)
Haryana	-	4,250 (3)	4.00 (2)	4.89 (5)
Himachal Pradesh	12,000 (1)	-	-	1.00 (1)
Karnataka	58,060 (3)	9,521 (3)	7.80 (5)	14.62 (11)
Kerala	2,760 (1)	-	-	0.23 (1)
Madhya Pradesh	27,014 (5)	1,200 (1)	15.40 (3)	17.90 (9)
Maharashtra	1,09,636 (10)	27,723 (4)	28.71 (15)	43.63 (29)
Punjab	34,800 (5)	1,847 (1)	14.92 (7)	18.20 (13)
Rajasthan	-	4,000 (2)	3.00 (1)	3.83 (3)
Tamil Nadu	1,50,218 (28)	-	10.45 (6)	22.97 (34)
Telangana	37,100 (5)	-	19.50 (4)	22.59 (9)
Uttar Pradesh	62,320 (6)	2,000 (1)	44.63 (22)	50.24 (29)
Uttarakhand	67,260 (5)	5,880 (2)	1.89 (2)	8.72 (9)
West Bengal	14,000 (2)	-	-	1.17 (2)
India	7,02,508 (83)	84,759 (22)	254.73 (96)	330.93 (201)

Source: <https://www.indiastat.com/table/biomass-biogas/selected-state-wise-installed-capacity-number-wast/1302537>. Accessed on 31.05.2021.

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Table 4.20: Installed Capacity and Power Generation from Grid Interactive Renewable Energy Sources in India

Year	Installed Capacity, MW	Generation, MU
2014-2015	38,959.16	61,784.91
2015-2016	45,924.04	65,780.85
2016-2017	57,244.23	81,868.69
2017-2018	69,022.39	1,01,839.49
2018-2019	77,641.63	1,26,759.10
2019-2020	87,027.67	1,38,329.64
2020-2021	89,630.00*	1,11,917.73**

* Renewable energy installed capacity as on 31st October 2020;

**Electricity generation upto December 2020

Source: www.indiastat.com;

<https://www.indiastat.com/table/grid-off-grid-and-decentralised-renewable-energy-programmes/installed-capacity-generation-power-grid-interacti/1318899>. Accessed on 28.05.2021.

<https://pib.gov.in/Pressreleaseshare.aspx?PRID=1685046> Accessed on 31.05.2021.

<https://www.indiastat.com/table/physical-progress-of-various-renewable-energy-programmes/source-wise-power-generation-various-renewable-sou/1227215>. Accessed on 28.05.2021.

Table 4.21: Source-wise Power Generation in Million Units from Renewable Energy Sources in India (Year wise up to December 2020)

Source	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21**
Wind	33,768.31	33,029.39	46,004.34	52,666.09	62,036.38	64,639.00*	50,182.97
Solar	4,599.01	7,447.92	13,498.87	25,871.07	39,268.20	50,131.10	43,346.79
Biomass	3,159.85	3,727.21	4,198.33	3,404.95	2,763.82	2,937.96	2,537.65
Bagasse	11,784.64	12,953.29	9,950.15	11,847.35	13,562.67	10,804.46	5,960.38
Small Hydro	8,059.50	8,354.51	7,924.62	7,691.58	8,702.75	9,451.22	8,768.55
Others	413.60	268.53	292.38	358.45	425.28	365.90	1,121.39
Total	61,784.91	65,780.85	81,868.69	1,01,839.49	1,26,759.10	1,38,329.64	1,11,917.73

* Annual report 2020-21, Ministry of New and Renewable Energy, GoI

** Data is provisional

Source: www.indiastat.com

<https://www.indiastat.com/table/physical-progress-of-various-renewable-energy-programmes/source-wise-power-generation-various-renewable-sou/1227215>. Accessed on 28.05.2021.

Table 4.22: Region-wise Electricity Generation in Million Units from Renewable Energy Sources in India (Year wise up to August 2020)

Regions	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
Northern [#]	15,917.51	18,012.02	21,249.96	24,672.04	27,189.51	13,645.29
Western [*]	22,958.91	27,603.54	31,702.73	38,168.01	41,137.31	19,346.73
Southern [^]	24,162.83	33,137.87	46,077.26	60,926.54	67,009.28	33,260.02
Eastern ^{**}	2,425.30	2,498.38	2,516.78	2,708.01	2,719.01	977.54
North Eastern ^{^^}	316.30	296.40	292.75	284.50	281.91	86.81
India	65,780.85	81,548.21	1,01,839.48	1,26,759.09	1,38,329.64	67,316.39

[#] Including power generated by NTPC (Dadri, Faridabad, Unchahar, Singrauli & Bhadla) and Oil India Ltd. (Rajasthan)

^{*} Including power generated by NTPC (Rajgarh, Rajmal and Mandsaur) and Oil India Ltd. (Madhya Pradesh and Gujarat)

[^] Including power generated by NTPC (Ramagundem/Anantapuram)

^{**} Including power generated by Damodar Valley Corporation (DVC) and NTPC (Andaman/Talcher)

^{^^} Including power generated by NEEPCO (North Eastern Electric Power Corporation Limited)

Source: <https://www.indiastat.com/table/energy-generation-by-categories/region-state-wise-electricity-generation-through-r/1316743>. Accessed on 31.05.2021.

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Table 4.23: World's Top Regions/Countries in Renewable Energy Power Capacity, 2019

Technology	World Total	BRICS ^b	EU-28	China	United States	India	Germany	Japan	United Kingdom
	GW								
Bio-power	139	48	44	22.5	16.0	10.8	8.9	4.3	7.9
Geothermal	13.9	0.1	0.9	~0	2.5	0	~0	0.6	0
Hydropower	1,150	530	131	326	80	45	5.6	22	1.9
Ocean power	0.5	0	0.2	0	0	0	0	0	~0
Solar PV ^c	627	256	132	205	76	43	49	63	13.4
Concentrating solar thermal power (CSP)	6.2	1.1	2.3	0.4	1.7	0.2	0	0	0
Wind Power	651	292	192	236	106	38	61	3.9	24
Total renewable power capacity (including hydropower)	2,588	1,127	502	790	282	137	124	94	47

a Table shows the top six countries by total renewable power capacity not including hydropower; if hydropower were included, countries and rankings would differ (the top six would be China, the United States, Brazil, India, Germany and Canada).

b The five BRICS countries are Brazil, the Russian Federation, India, China and South Africa.

c Solar PV data are in direct current (DC).

Capacity amounts of <50 MW (including pilot projects) are designated by “~0”

Source: REN21. 2020. Renewables 2020 Global Status Report (Paris: REN21 Secretariat). ISBN 978-3-948393-00-7.

https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf. Accessed on 23.07.2020.

Table 4.24: Solar PV, Concentrating Solar Thermal Power (CSP) and Wind Power Global Total Capacity at end of 2019

Solar PV		Concentrating Solar Thermal Power (CSP)		Wind Power	
Country	Capacity (GW)	Country	Capacity (MW)	Country	Capacity (GW)
China	204	Spain	2,304	China ^a	210/236.3
United States	76	United States	1,738	United States	105.6
Japan	63	Morocco	516	Germany	61.4
Germany	49	South Africa	500	India	37.5
India	42.8	China	420	Spain	25.8
Italy	20.8	Israel	240	United Kingdom	23.5
Australia	14.7	India	225	France	16.6
United Kingdom	13.4	United Arab Emirates	100	Brazil	15.5
Republic of Korea	11.2	Saudi Arabia/ Kuwait	50/50	Canada	13.4
Spain	9.9	Algeria/ Egypt	20/20	Italy	10.5
World Total Capacity	627		6210		651

For China, data to the left of the “/” are the amounts officially classified as connected to the grid and operational by year's end; data to the right are total installed capacity, most, if not all, of which was connected to substations by year's end.

Source: REN21. 2020. Renewables 2020 Global Status Report (Paris: REN21 Secretariat). ISBN 978-3-948393-00-7.

https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf. Accessed on 23.07.2020.

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Table 4.25: Top Fifteen Countries in Global Biofuel Production including EU-28 during 2019

Country	Ethanol	Biodiesel (FAME)	Biodiesel (HVO)
	Billion litres		
United States	59.1	4.0	2.5
Brazil	35.6	5.9	0.0
Indonesia	0.0	7.9	0.0
China	4.0	0.6	0.0
Germany	0.8	3.8	0.0
France	0.9	2.8	0.2
Argentina	1.1	2.5	0.0
Thailand	1.6	1.7	0.0
Spain	0.5	2.0	0.0
Netherlands	0.4	1.0	1.1
Canada	2.0	0.3	0.0
India	2.1	0.2	0.0
Malaysia	0.0	1.6	0.0
Poland	0.2	1.0	0.0
Italy	0.0	0.8	0.2
EU-28	4.7	12.4	2.9
World total	113.7	40.9	6.5

Production levels are rounded to the nearest 0.1 billion litres. Rounding is to account for uncertainties in available data. Countries are ranked according to the total biofuel production in 2019. FAME: fatty acid methyl esters; HVO: hydrotreated vegetable oil.

Source:REN21. 2020. Renewables 2020 Global Status Report (Paris: REN21 Secretariat).ISBN 978-3-948393- 00-7.
https://www.ren21.net/wp-content/uploads/2019/05/gsr_2020_full_report_en.pdf. Accessed on 23.07.2020.