

Present Senario And Future Aspects of Distribution And Production of Solar Power In India

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Abstract- *Solar energy is the energy obtained by capturing heat and light from the Sun. Energy from the Sun is referred to as solar energy. Technology has provided a number of ways to utilize this abundant resource. It is considered a green technology because it does not emit greenhouse gases. Solar energy is abundantly available and has been utilized since long both as electricity and as a source of heat. Solar energy can be harnessed directly or indirectly for human use. These solar panels mounted on a rooftop harvest solar energy and convert it to electricity. Since the sun provides more energy than we'll ever need, electricity from solar power is a very important energy source in the move to clean energy production.*

Solar power is a 100% clean, renewable energy source. It reduces reliance on oil, coal, and natural gas for electricity production. These fossil fuels produce harmful emissions that affect the quality of air, water, and soil and are responsible for global warming. In contrast, solar energy produces no pollution.

It is the most important source of energy for life forms. It is a renewable source of energy unlike non-renewable sources such as fossil fuels. It is therefore important to go for reliable, cost effective and everlasting renewable energy source for energy demand arising in future. In this connection this article is intended to study the solar energy development in India and analyze the distribution and production pattern of solar energy in India.

Keywords- abundant, emit, greenhouse, fossil fuels, non-renewable

I. INTRODUCTION

Solar power is a fast developing industry in India. The country's solar installed capacity was 35,739 MW as of 31 August 2020. The Indian government had an initial target of 20 GW capacity for 2022, which was achieved four years ahead of schedule. In 2015 the target was raised to 100 GW of solar capacity (including 40 GW from rooftop solar) by 2022, targeting an investment of US\$100 billion. India has

established nearly 42 solar parks to make land available to the promoters of solar plants.

- Rooftop solar power accounts for 2.1 GW, of which 70% is industrial or commercial. In addition to its large-scale grid-connected solar photovoltaic (PV) initiative, India is developing off-grid solar power for local energy needs. Solar products have increasingly helped to meet rural needs; by the end of 2015 just under one million solar lanterns were sold in the country, reducing the need for kerosene. That year, 118,700 solar home lighting systems were installed and 46,655 solar street lighting installations were provided under a national program, just over 1.4 million solar cookers were distributed in India.
- The International Solar Alliance (ISA), proposed by India as a founder member, is headquartered in India. India has also put forward the concept of "One Sun One World one Grid" and "World Solar Bank" to harness abundant solar power on global scale.

Objectives

- To study the solar energy development in India.
- To analyze the distribution and production pattern of solar energy in India.

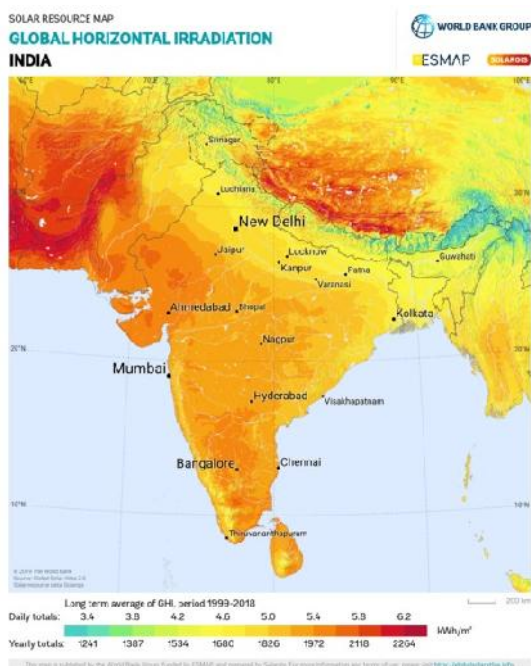
Methodology

- The present study is based on secondary data. To study the development, distribution and production pattern of solar energy in India, data has been collected between 2000 and 2020 from

National solar potential

- With about 300 clear and sunny days in a year, the calculated solar energy incidence on India's land area is about 5000 trillion kilowatt-hours (kWh) per year (or 5 EWh/yr). The solar energy available in a single year exceeds the possible energy output of all of the fossil fuel energy reserves in India. The daily average solar-power-plant generation capacity in India is 0.30 kWh per

m² of used land area, equivalent to 1400–1800 peak (rated) capacity operating hours in a year with available, commercially-proven technology.



Solar power capacity and generation in India

The country's solar installed capacity was 35,739 MW as of 30 June 2020. Solar electricity generation from April 2019 to March 2020 was 50.1 TWh, or 3.6% of total generation (1,391 TWh).

Installed cumulative national solar PV and actual Generation (2010-2020)

Year	Cumulative Capacity (in MW)	Actual Production (in GW)
2010	161	---
2011	461	---
2012	1,205	---
2013	2,319	---
2014	2,632	3.36
2015	3,744	4.60
2016	6,763	7.45
2017	12,289	12.09
2018	21,651	25.87
2019	28,181	39.27
2020	34,627	50.13

Regional and State wise Installations of Solar power plants in India				
Ground mounted and roof top grid connected solar power installed capacity (MW)				
State	31 March 2015	31 March 2016	31 March 2017	31 March 2019
Rajasthan	942.10	1,269.93	1,812.93	3,226.79
Punjab	185.27	405.06	793.95	905.62
Uttar Pradesh	71.26	143.50	336.73	960.10
Uttarakhand	5.00	41.15	233.49	306.75
Haryana	12.80	15.39	81.40	224.52
Delhi	5.47	14.28	40.27	126.89
Jammu and Kashmir	0.00	1.36	1.36	14.83
Chandigarh	4.50	6.81	17.32	34.71
Himachal Pradesh	0.00	0.73	0.73	22.68
Total Northern Region			3318.18	6102.05 (21.43%)
Gujarat	1,000.05	1,119.17	1,249.37	2,440.13
Maharashtra	360.75	385.76	432.37	1,633.54
Chhattisgarh	7.60	93.58	128.86	231.35
Madhya Pradesh	558.58	776.37	857.04	1,840.16
Dadra and Nagar Haveli	0.00	0.00	2.97	5.46
Goa	0.00	0.00	0.71	3.81
Daman and Diu	0.00	4.00	10.46	14.47
Total Western Region			2701.78	6169.03 (21.67%)
Tamil Nadu	142.58	1,061.82	1,691.83	2,575.22
Andhra Pradesh	137.85	572.97	1,867.23	3,085.68
Telangana	167.05	527.84	1,286.98	3,592.09
Kerala	0.03	13.05	74.20	138.59
Karnataka	77.22	145.46	1,027.84	6,095.56
Pondicherry	0.20	0.20	0.08	3.14
Total Southern Region			5948.16	15490.28 (54.42%)
Bihar	0.00	5.10	108.52	142.45
Odisha	31.76	66.92	79.42	394.73
Jharkhand	16.00	16.19	23.27	34.95
West Bengal	7.21	7.77	26.14	75.95
Sikkim	0.00	0.00	0.00	0.01
Total Eastern Region			237.35	648.09 (2.27%)
Assam	0.00	0.00	11.78	22.40
Tripura	5.00	5.00	5.09	5.09
Arunachal Pradesh	0.03	0.27	0.27	5.39
Mizoram	0.00	0.00	0.10	0.50
Manipur	0.00	0.00	0.03	3.44
Meghalaya	0.00	0.00	0.01	0.12
Nagaland	0.00	0.00	0.50	1.00
Total North Eastern Region			17.78	37.94 (0.13%)
Andaman and Nicobar	5.10	5.10	6.56	11.73
Lakshadweep	0.75	0.75	0.75	0.75
Others	0.00	58.31	58.31	0.00
Total Islands and others			65.62	16.78 (0.06%)
Total India	3,743.97	6,762.85	12,288.83	28,180.66

Andhra Pradesh

Installed photo-voltaic capacity in Andhra Pradesh was 3,531 MW as of 31 August 2020. The state is planning to add 10,050 MW solar power capacity to provide power supply to farming sector during the day time. The state has also offered five Ultra Mega Solar Power Projects with a total capacity of 12,200 MW to developers under renewable power export policy outside the state. Andhra Pradesh is endowed with abundant pumped hydroelectric energy storage to make available solar power in to round the clock power supply for meeting its ultimate energy needs. In 2015, NTPC agreed with APTransCo to install the 250-MW NP Kunta Ultra Mega Solar Power Project near Kadiri in Anantapur district. In October 2017,

1000 MW was commissioned at Kurnool Ultra Mega Solar Park which has become the world's largest solar power plant at that time. In August 2018, Greater Visakhapatnam commissioned a 2 MW Mudasarlova Reservoir grid-connected floating solar project which is the largest operational floating solar PV project in India. NTPC Simhadri has awarded BHEL to install a 25 MW floating solar PV plant on its water supply reservoir. APGENCO commissioned 400 MW Ananthapuram - II solar park located at Talaricheruvu village near Tadipatri.

Delhi

Delhi being the Capital and a city state in India, has limitation in installing ground mounted solar power plants. However it is leading in rooftop solar PV installations by adopting fully flexible net metering system. The installed solar power capacity is 106 MW as on 30 September 2018. Delhi government has announced that the Rajghat thermal power plant will be officially shut at the 45 acre plant site and turned into a 5 MW solar power PV plant.

Gujarat

Gujarat is one of India's most solar-developed states, with its total photovoltaic capacity reaching 1,637 MW by the end of January 2019. Gujarat has been a leader in solar-power generation in India due to its high solar-power potential, availability of vacant land, connectivity, transmission and distribution infrastructure and utilities. According to a report by the Low Emission Development Strategies Global Partnership (LEDS GP) report, these attributes are complemented by political will and investment. The 2009 Solar Power of Gujarat policy framework, financing mechanism and incentives have contributed to a green investment climate in the state and targets for grid-connected solar power. The state has commissioned Asia's largest solar park near the village of Charanka in Patan district. The park is generating 345 MW by March 2016 of its 500 MW total planned capacity and has been cited as an innovative and environmentally-friendly project by the Confederation of Indian Industry. In December 2018, 700 MW Solar PV plant at Raghnesda Solar Park is contracted at 2.89 Rs/unit levelised tariff.

To make Gandhinagar a solar-power city, the state government has begun a rooftop solar-power generation scheme. Under the scheme, Gujarat plans to generate 5 MW of solar power by putting solar panels on about 50 state-government buildings and 500 private buildings.

It also plans to generate solar power by putting solar panels along the Narmada canals. As part of this scheme, the state has commissioned the 1 MW Canal Solar Power Project on a branch of the Narmada Canal near the village of Chandrasan in Mehsana district. The pilot project is expected to stop 90,000 litres (24,000 US gal; 20,000 imp gal) of water per year from evaporating from the Narmada River.

Haryana

State has set the 4.2 GW solar power (including 1.6 GW solar roof top) target by 2022 as it has high potential since it has at least 330 sunny days. Haryana is one of the fastest growing state in terms of solar energy with installed and commissioned capacity of 73.27 MW. Out of this, 57.88 MW was commissioned in FY 2016/17. Haryana solar power policy announced in 2016 offers 90% subsidy to farmers for the solar powered water pumps, which also offers subsidy for the solar street lighting, home lighting solutions, solar water heating schemes, solar cooker schemes. It is mandatory for new residential buildings larger than 500 square yards (420 m²) to install 3% to 5% solar capacity for no building plan sanctioning is required, and a loan of up to Rs. 10 lacks is made available to the residential property owners. Haryana provides 100% waiver of electricity taxes, cess, electricity duty, wheeling charges, cross subsidy charges, transmission and distribution charges, etc. for rooftop solar projects.

In December 2018, Haryana had installed solar capacity of 48.80 MW, and in January 2019 Haryana floated tender for 300 MW grid-connected solar power, and additional 16 MW tender for the canal top solar power.

Karnataka

Karnataka is the top solar state in India exceeding 5,000 MW installed capacity by the end of financial year 2017–18. The installed capacity of Pavagada Solar Park is 2050 MW by the end of year 2019 which was the world biggest solar park at that time.

Kerala

Kerala's largest floating solar power plant was set upon the BanasuraSagar Dam reservoir in Wayanad district, Kerala. The 500 kW (kilowatt peak) solar plants of the Kerala State Electricity Board (KSEB) floats on 1.25 acres of the water surface of the reservoir. The solar plant has 1,938 solar panels which have been installed on 18 Ferro concrete floaters with hollow insides.

Ladakh

Ladakh, though a late entrant in solar power plants, is planning to install nearly 7,500 MW capacity in few years.

Madhya Pradesh

Madhya Pradesh is one of India's most solar-developed states, with its total photovoltaic capacity reaching 1,117 MW by the end of July 2017. The Welspun Solar MP project, the largest solar-power plant in the state, was built at a cost of 1,100 crore (US\$150 million) on 305 ha (3.05 km²) of land and will supply power at 8.05 (11¢ US) per kWh. A 130 MW solar power plant project at Bhagwanpura, a village in Neemuch district, was launched by Prime Minister Narendra Modi. It is the largest solar producer, and Welspun Energy is one of the top three companies in India's renewable-energy sector. A planned 750 MW solar-power plant in Rewa district, the Rewa Ultra Mega Solar plant, was completed and inaugurated on 10 July 2020. Spread over 1,590 acres, it is Asia's largest solar power plant and was constructed at a cost of 4,500 crore.

Maharashtra

The 125-MW Sakri solar plant is the largest solar-power plant in Maharashtra. The ShriSaibabaSansthan Trust has the world's largest solar steam system. It was constructed at the Shirdi shrine at an estimated cost of 1.33 crore (US\$190,000), 58.4 lakh (US\$82,000) which was paid as a subsidy by the renewable-energy ministry. The system is used to cook 50,000 meals per day for pilgrims visiting the shrine, resulting in annual savings of 100,000 kg of cooking gas, and was designed to generate steam for cooking even in the absence of electricity to run the circulating pump. The project to install and commission the system was completed in seven months, and the system has a design life of 25 years. The Osmanabad region in Maharashtra has abundant sunlight, and is ranked the third-best region in India in solar insolation. A 10 MW solar power plant in Osmanabad was commissioned in 2013. The total power capacity of Maharashtra is about 500 MW

Rajasthan

Rajasthan is one of India's most solar-developed states, with its total photovoltaic capacity reaching 2289 MW by end of June 2018. Rajasthan is also home to the world's largest Fresnel type 125 MW CSP plant at the DhirubhaiAmbani Solar Park. Jodhpur district leads the state with installed capacity of over 1,500 MW, followed by Jaisalmer and Bikaner. The Bhadla Solar Park, with total installed capacity of 2,245 MW, is the biggest plant in the world as of March 2020. The only tower type solar thermal

power plant (2.5 MW) in India is located in Bikaner district. In March 2019, the lowest tariff in India is 2.48/kWh for installing the 750 MW solar power plants in the state.

Tamil Nadu

Tamil Nadu has the 5th highest operating solar-power capacity in India in May 2018. The total operating capacity in Tamil Nadu is 1.8 GW. On 1 July 2017, Solar power tariff in Tamil Nadu has hit an all-time low of Rs 3.47 per unit when bidding for 1500 MW capacity was held.

The 648-MW Kamuthi Solar Power Project is the biggest operating project in the state. On 1 January 2018, NLC India Limited (NLCIL) commissioned a new 130 MW solar power project in Neyveli.

Telangana

Telangana ranks second when it comes to solar energy generation capacity in India. The state is trailing behind Karnataka with a solar power generation capacity of 3400 MW and plans to achieve a capacity of 5000 MW by 2022. NTPC Ramagundam has placed work order on BHEL to install 100 MW floating solar PV plant on its water supply reservoir

Month	Regional solar power generation (GWh)					Total (GWh)
	North	West	South	East	North East	
April 2019	839.92	903.75	2,358.89	64.69	1.41	4,168.67
May 2019	942.89	926.49	2,402.74	53.94	1.37	4,327.42
June 2019	932.40	787.48	2,136.10	61.13	1.02	3,918.13
July 2019	785.69	702.83	1,889.87	48.44	1.23	3,428.06
August 2019	796.67	630.70	2,111.37	36.03	0.97	3,575.73
September 2019	885.50	585.18	2,054.69	38.84	0.93	3,565.14
October 2019	988.51	763.85	2,074.86	54.23	0.97	3,882.41
November 2019	807.47	776.97	2,305.09	46.22	1.07	3,936.82
December 2019	851.38	803.72	2,228.86	43.31	1.13	3,928.39
January 2020	945.68	904.87	2,712.82	48.35	1.00	4,612.72
February 2020	1,151.87	979.12	2,906.16	51.97	1.54	5,090.66
March 2020	1,218.18	1,091.06	3,253.81	68.66	1.59	5,633.30
Total (GWh)	11,146.16	9,856.02	28,498.91	615.81	14.2	50,131.10

Installations by application

Photovoltaic (PV) installed capacity by application (MW).	
Application	31 July 2019
Solar power ground mounted	27,930.32
Solar power rooftop	2,141.03
Off-grid solar power	919.15
TOTAL	30,990.50

As of July 2019 by far the largest segment of solar PV installed in India was ground mounted at 27,930 MW

installed capacity. This sector comprises mostly larger scale solar projects and even larger utility solar projects that generate power centrally and disperse it over the grid. The next largest segment was rooftop solar at 2,141 MW which can be divided into residential solar, commercial and industrial solar roofs as well as a range of installations including agricultural buildings, community and cultural centres. 70 percent of rooftop solar in 2018 was in the industrial and commercial sectors, with just 20 percent as residential rooftop solar.^[6] Rooftop solar as a proportion of total solar installations is much less than is typical in other leading solar countries but was forecast to grow to 40 GW by 2022 under national targets.^[4] A rough calculation would imply that India had around just 430 MW of residential rooftop solar, whilst the UK with around half the overall solar capacity of India had over 2,500 MW of residential solar in 2018. The smallest segment was off-grid solar at 919 MW which could help play a role in reaching villages and dwellings without access to the national grid.

Major photovoltaic power stations of India

Below is a list of solar power generation facilities with a capacity of at least 10 MW.

Plant	State	DC peak power (MW)	Commissioned
Bhadla Solar Park	Rajasthan	2245	March 2020
Pavagada Solar Park	Karnataka	2,050	December 2019
Kurnool Ultra Mega Solar Park	Andhra Pradesh	1,000	2017
NP Kunta	Andhra Pradesh	900	2020
Rewa Ultra Mega Solar	Madhya Pradesh	750	2018
Charanka Solar Park	Gujarat	690	2012
Kamuthi Solar Power Project	Tamil Nadu	648	March 2017
Ananthapuram - II	Andhra Pradesh	400	2019
Galiiveedu solar park	Andhra Pradesh	400	2020
Mandsaur Solar Farm	Madhya Pradesh	250	2017
Kadapa Ultra Mega Solar Park	Andhra Pradesh	250	2020
Gujarat Solar Park-I	Gujarat	221	April 2012
Welspun Solar MP project	Madhya Pradesh	151	February 2014
RaNew Power, Nizamabad	Telangana	143	15 April 2017
Sakri solar plant	Maharashtra	125	March 2013
NTPC solar plants		110	2015
Maharashtra I	Maharashtra	67	2017
Green Energy Development Corporation (GEDCOL)	Odisha	50	2014
Tata Power Solar Systems (TPS), Rajgarh	Madhya Pradesh	50	March 2014
Welspun Energy, Phalodhi	Rajasthan	50	March 2013
Jalaun Solar Power Project	Uttar Pradesh	50	27 January 2016
GEDCOL	Odisha	48	2014
Karnataka I	Karnataka	40	2018
Bitta Solar Power Plant	Gujarat	40	January 2012
Dhirubhai Ambani Solar Park, Pokhran	Rajasthan	40	April 2012
Rajasthan Photovoltaic Plant	Rajasthan	35	February 2013
Welspun, Bathinda	Punjab	34	August 2015
Moser Baer, Patan district	Gujarat	30	October 2011
Lalitpur Solar Power Project	Uttar Pradesh	30	2015
Mithapur Solar Power Plant	Gujarat	25	25 January 2012
GEDCOL	Odisha	20	2014
Kadodiya Solar Park	Madhya Pradesh	15	2014
Telangana I	Telangana	12	2016
Telangana II	Telangana	12	2016
NTPC	Odisha	10	2014
Sunark Solar	Odisha	10	2011
RNS Infrastructure Limited, Pavagada	Karnataka	10	2016

Bolangir Solar Power Project	Odisha	10	2011
Azure Power, Sabarkantha	Gujarat	10	June 2011
Green Infra Solar Energy, Rajkot	Gujarat	10	November 2011
Waa Solar Power Plant, Surendranagar	Gujarat	10	December 2011
Sharda Construction, Latur	Maharashtra	10	June 2015
Ushodaya Project, Midjil	Telangana	10	December 2013

Solar photovoltaic growth forecasts

In August 2016, the forecast for solar photovoltaic installations was about 4.8 GW for the calendar year. About 2.8 GW was installed in the first eight months of 2016, more than all 2015 solar installations. India's solar projects stood at about 21 GW, with about 14 GW under construction and about 7 GW to be auctioned. The country's solar capacity reached 19.7 GW by the end of 2017, making it the third-largest global solar market.

In mid-2018 the Indian power minister RK Singh flagged a tender for a 100GW solar plant at an event in Delhi, while discussing a 10GW tender due to be issued in July that year (at the time, a world record). He also increased the government target for installed renewable energy by 2022 to 227GW.

II. CONCLUSION

Solar power is an immense source of directly useable energy and ultimately creates other energy resources: biomass, wind, hydro power and wave energy. Solar power is energy from the sun that is converted into thermal or electrical energy. Solar technologies can harness this energy for a variety of uses, including generating electricity, providing light or a comfortable interior environment, and heating water for domestic, commercial, or industrial use. Solar energy is clean, mildly affordable and has been used by humans for a long time. It might not produce as much electricity as nuclear, but in the long run solar will cost less and isn't harmful to the environment like nuclear is.

Solar power in India is a fast developing industry. The country's solar installed capacity was 36.9 GW as of 30 November 2020. The Indian government had an initial target of 20 GW capacity for 2022, which was achieved four years ahead of schedule. India is aiming to attain 175 GW of renewable energy which would consist of 100 GW from solar energy, 10 GW from bio-power, 60 GW from wind power, and 5 GW from small hydropower plants by the year 2022. Investors have promised to achieve more than 270 GW, which is significantly above the ambitious targets.

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