



Solar Energy Potential and Future Energy of India: An Overview

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Abstract:

Once time after the oil crisis in 1973, the world has to think about the alternative resource of energy apart from conventional energy resources (coal, gas, and petroleum etc.). Solar energy is the most important alternative resource of the world and has a large potential of green energy. India has a huge potential for generating green electricity from the renewable energy sources. To promote the green energy, the government of India launching many schemes for the renewable energy resources. The Jawaharlal Nehru National Solar Mission was launched on the 11th January 2010 by the Prime Minister. The Mission has set the ambitious target of deploying 20,000 MW of grid-connected solar power by 2022 is aimed at reducing the cost of solar power generation in the country through (i) long-term policy; (ii) large-scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products, as a result to achieve grid tariff parity by 2022. Mission will create an enabling policy background to achieve this objective and make India a global leader in solar energy. This paper provides an overview of solar energy in India. It reviews the current status of solar energy in terms of existing capacity, along with historical trends of solar energy and future potential of a different form of solar energy in India.

Keywords: Solar Energy, Solar policy and Renewable policy in India, policy; management.

I. INTRODUCTION

In recent years, the world the fastest growing thing is the energy requirement by the world, with the reduction in the conventional resource. The most challenging thing in front of the world is how to fulfill the requirement of energy. Due to the limitation of the conventional resources, the world has to think about the alternate source of energy. Now a day's most of the countries are emphasizing the development of renewable energy resources. In the renewable energy resources, solar energy plays an important role and it is a tremendous source of energy. The sun is the planet's most powerful source of energy and also the most unused source of energy by humans. The National Solar Mission is a major initiative of the Government of India and State Governments to promote ecologically sustainable growth while addressing India's energy security challenge. It will also constitute a major contribution by India to the global effort to meet the challenges of climate change. IN launching India's National Action Plan on Climate Change on June 30, 2008, the Prime Minister of India, Dr. Manmohan Singh stated: "Our vision is to make India's economic development energy-efficient. Over a period of time, we must pioneer a graduated shift from economic activity based on fossil fuels to one based on non-fossil fuels and from reliance on non-renewable and depleting sources of energy to renewable sources of energy[1]. In this strategy, the sun occupies center-stage, as it should, being literally the original source of all energy. We will pool our scientific, technical and managerial talents, with sufficient financial resources, to develop solar energy as a source of abundant energy to power our economy and to transform the lives of our people. Our success in this endeavor will change the face of India. It would also enable India to help change the destinies of people around the world. "The National Action Plan on Climate Change also points out: "India is a tropical country, where sunshine is available for longer hours per day and in great intensity. Solar energy, therefore, has great

potential as a future energy source. It also has the advantage of permitting the decentralized distribution of energy, thereby empowering people at the grassroots level". Based on this vision a National Solar Mission is being launched under the brand name "Solar India [2].

Presently, India has installed capacity of 276.783GW out of which 69.6 % is from thermal, 15.2 % from hydro, 2.1% from nuclear and about 13.2% from renewable energy sources (as on August 2015) [3]. Table-1 shows the electricity requirement and availability in India. Thus, Indian power sector is basically based on fossil fuels, with about three-fifths of the country's power is generating reserves of coal. The thermal power station emits a high amount of toxic gases such as NO_x, CO_x and SO_x gases which is ingenious to health and environment [4]. In last few decades Indian government has taken many steps to reduce the use of fossil fuel-based energy and promote renewable energy generation [5].

II. SOLAR POTENTIAL IN INDIA

India was the first country in the world to set up a Ministry of non- conventional energy resources in early 1980 [1]. The Solar and wind energy are freely available and they are environment-friendly. The wind energy systems are not possible at all sites because of low wind speeds and it is more unpredictable than solar energy [6]. Solar energy is the most important renewable energy resource which is available in most of the country of the world. Even its technically available potential is much higher than the current total primary energy demand [7]. Table.II. shows Solar Power in India.

The power sector is one of the key sectors contributing significantly to the growth of country's economy. Power sector needs a more useful role to be played in defining, formulating and implementing the research projects with close involvement of all utilities such that the benefit reaches the ultimate consumer.

In India, there is a huge gap between the energy generation and energy consumption. India has a great potential for solar power and it is estimated so many times of the energy requirement which is about 5000 trillion kWh per year. The solar radiation incident over India is equal to 4–8 kWh per square meter per day with an annual radiation ranging from 1200–2300 kWh per square meter. Table. I show the development progress of JNSM. It has an average of 250–300 clear sunny days and 2300–3200 hours of sunshine per year. India's electricity needs can be met on a total land area of 3000 km² which is equal to 0.1% of total land in the country [2-8-9].

Table. I. JNNSM: Three-Phase Approach

Application Segment	Phase-I 2010-13	Phase-II 2013-17	Phase-III 2017-22
Utility grid power	1,000-2,000MW	4000-10000MW	20,000MW
Off-grid applications	200MW	1000MW	2000MW
solar thermal collectors area	7 million sqm	15 million sqm	20 million sqm
manufacturing base	-----	-----	4000-5000MW
solar lighting systems	-----	-----	20 Million
solar RPO	0.25%	-----	3%

a) Overview of Solar Power

Table.II. Solar Power in India

MU	Energy in	Peak in MW
Availability	1,030,785	141,160
Requirement	1,068,923	148,166
Shortage	38,138	7,006

The government of India is trying to improve the share of energy generation from the solar energy and launched Jawaharlal Nehru Solar Mission. Under the First Phase of 200 Jawaharlal Nehru National Solar Mission (JNNSM), the Prime Minister has emphasized the importance of the mission as: “The importance of this Mission is not just limited to providing large-scale grid-connected power. It has the potential to provide significant multipliers in our efforts for transformation of India's rural economy. Now, in its decentralized and distributed applications, solar energy is beginning to light the lives of tens of millions of India's energy-poor citizens. The rapid spread of solar lighting systems, Solar water pumps and other solar power-based rural applications can change the face of India's rural economy. We intend to significantly expand such applications through this Mission. As a result, the movement for decentralized and

disbursed industrialization will acquire an added momentum, a momentum which has not been seen before. “The objective of the Jawaharlal Nehru National Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its large-scale diffusion across the country as quickly as possible. For this purpose, the Mission has adopted a 3-phase approach: the 11th Plan and first year of the 12th Plan (up to 2012-13) has been considered as Phase 1, the remaining 4 years of the 12th Plan (2013-17) are included as Phase 2, and the 13th Plan period (2017-22) is envisaged as Phase 3. An evaluation of progress, review of capacity and targets for subsequent phases, based on emerging cost and technology trends, both domestic and global, would be undertaken at the end of each plan period, and mid-term during the 12th and 13th Plans. The first phase of NSM focused on capturing the low hanging options in solar: on promoting off-grid systems to serve rural populations and a modest capacity addition in grid-based systems. This was partly envisaged as a learning experience for the further, ambitious goals. Now, in the second phase, an aggressive capacity ramp-up is targeted. The aim is to create favorable conditions for up-scaled and competitive solar energy penetration in both at the centralized and decentralized levels.

III. Future of Renewable Energy

New project development for 100 MW capacity of the grid (below 33 kV) connected solar projects (of 100 kW to 2 MW capacities each) have also been selected. It is expected that 150–200 MW of solar power will be installed in the country by December 2011. By the end, September 2014, the installed grid-connected solar power had increased to 2,766 MW and India expects to install an additional 10,000 MW by 2017, and a total of 20,000 MW by 2022. Table.4 Shows a state-wise distribution of renewable energy generation, the tentative target set by the ministry of new and renewable energy under the 12th financial plan. The State Government of Andhra Pradesh is developing a solar farm cluster called the solar city on a 10,000 acre land at Kadiri in Anantapur district. Solar city is expected to attract investments worth Rs. 3000 crore in the first phase. Four firms (Sun bore, Lance Solar, AES Solar and Titan Energy) have signed a memorandum of understanding with the State to set up their units there. These companies will be the anchor units in the solar city and have a combined capacity of 2000 MW. Karnataka Power Corporation Ltd. has implemented two projects– each of 3 MW power capacities and has awarded the third project of same capacity recently. The solar plants, located in Kola and Chickadee districts, have been implemented under the Arunodaya scheme for ensuring assured power supply to rural areas, especially irrigation pump sets [2, 4, 7 9]. These PV power plants are intended as tail-end support/powering of irrigation pumps Jawaharlal Nehru National Solar Mission (JNNSM) is one of the major global initiatives in promotion of solar energy technologies, announced by the Government of India under National Action Plan on Climate Change. It has set an ambitious target of deploying 20,000 MW of Grid-connected Solar Power & 2000MW of off-grid Solar Power by the year 2022. Ministry of New & Renewable Energy (MNRE) intends to raise its targets under the National Solar Mission from 20 Giga-watts (GW) to 100 GW by 2019. It adopts a 3- Phase approach from 2010 to 2022. Table.III. shows the current installed capacity of the solar power state wise [15].

Table.III. JNNSM capacity addition target

State	MW as of 31-Mar-2015	MW as of 31-Mar-2016	MW as of 30-Sep-2016
Rajasthan	942.10	1,269.93	1,294.60
Punjab	185.27	405.06	571.20
Uttar Pradesh	71.26	143.50	143.50
Uttarakhand	5.00	41.15	41.15
Haryana	12.80	15.39	15.39
Delhi	5.47	14.28	23.87
Jammu and Kashmir			1.00
Chandigarh	4.50	6.81	6.81
Himachal Pradesh			0.20
Northern Region			2,097.72
Gujarat	1,000.05	1,119.17	1,136.32
Maharashtra	360.75	385.76	385.76
Chhattisgarh	7.60	93.58	128.46
Madhya Pradesh	558.58	776.37	810.37
Daman & Diu	0.00	4.00	4.00
Western Region			2,097.72
Tamil Nadu	142.58	1,061.82	1,555.41
Andhra Pradesh	137.85	572.97	947.05
Telangana	167.05	527.84	961.79
Kerala	0.03	13.05	13.05
Karnataka	77.22	145.46	289.13
Puducherry	0.20	0.20	0.03
Southern Region			3,766.46
Bihar	0.00	5.10	90.10
Odisha	31.76	66.92	66.92
Jharkhand	16.00	16.19	16.19
West Bengal	7.21	7.77	11.77
Eastern Region			184.98
Tripura	5.00	5.00	5.00
Arunachal Pradesh	0.03	0.27	0.27
Mizoram			0.10
North Eastern Region			5.37
Andaman & Nicobar	5.10	5.10	5.10
Lakshadweep	0.75	0.75	0.75
Others	0.00	58.31	100.92
Total	3,743.97	6,762.85	8,626.18

The growth of Solar Power in India

a) Solar Resource Map of India

Most parts of India receive good solar radiation 4- 7 kWh/sq. m/day. In the solar energy sector, some large projects have been proposed, and a 35,000 km² (14,000 sq mi) area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW. Aggressive bids under the Jawaharlal Nehru National Solar Mission (JNNSM) have produced grid-connect megawatt (MW) sized plants generating even less than 15 US cents per kilowatt-hour (kWh), among the lowest in the world[13-14].

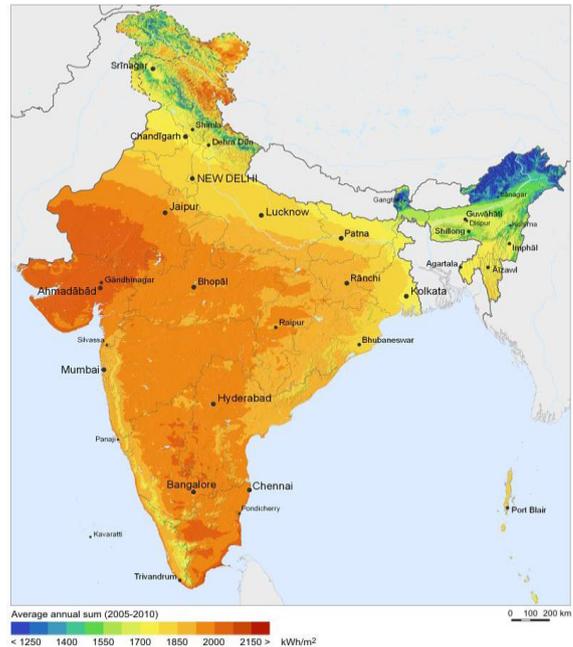


Fig.1. Solar Resource Map of India

b) National Wind Energy Mission

In order to exploit the available wind potential in the country expeditiously, there is a need to address the issues and barriers in a focused manner. The Government, therefore, proposes to launch the National Wind Energy Mission which aims to achieve 60,000 MW of utility-scale wind installations in the country by the end of the 13th five-year plan (end of 2022). According to Ministry of Statistics and Programme Implementation Government of India report Energy Statistics 2015. The total potential for renewable power generation in the country as on 31.03.14 is estimated at 147615 MW. This includes wind power potential of 102772 MW (69.6%), SHP (small-hydro power) potential of 19749 MW (13.38%), Biomass power potential of 17,538 MW (11.88%) and 5000 MW (3.39%) from bagasse-based cogeneration in sugar mills[13].

IV. Solar Park

Ministry of New and Renewable Energy (MNRE) has drawn a scheme to set up a number of solar parks across various states in the country, each with a capacity of Solar Projects generally above 500 MW. The Scheme proposes to provide financial support by Government of India to establish solar parks with an aim to facilitate the creation of infrastructure necessary for setting up new solar power projects in terms of allocation of land, transmission and evacuation lines, access roads, availability of water and others, in a focused manner. Solar Energy Corporation of India (SECI), a central public sector

enterprise under MNRE, has been implementing various schemes to develop the solar sector in the country [10-13]. As per the policy, these solar parks will be developed in collaboration with the State Governments. The implementation agency would be Solar Energy Corporation of India (SECI) on behalf of Government of India (GOI). SECI will handle funds to be made available under the scheme on behalf of GOI. The states shall designate a nodal agency for implementation of the solar park [11-12].

a) Setting Up of Solar Parks

Ministry of New & Renewable Energy (MNRE) has initiated a scheme for setting up of 25 Solar Parks, each with the capacity of 500 MW and above, to be developed in next 5 years in various States. Minister further stated that the estimated cost for development of solar park would be around Rs.0.95 Cr./MW. States which have sent written request for setting up Solar Power Park/Ultra Mega Solar Power Projects are given below [10-15]. Table.IV. shows Setting up of Solar Parks.

Table.IV. Setting Up of Solar Parks

S No.	State	Capacity of Solar Park (approx)	Land Famous at
1	Gujarat	750 MW	750 MW Taluka-Vav, Distt.-Banaskantha
2	Madhya Pradesh	750 MW +750 MW	Rewa-Distt
3	Telangana	1000 MW	Mehboob Nagar-Distt.
4	Andhra Pradesh	2500 MW	Anantpur-Distt, Kadapa andKurnool
5	Karnataka	1000 MW	Mulwar, Bijapur (near Kargi)
6	Uttar Pradesh	600 MW	District-Jalaun, Sonbhadra, and Allahabad
7	Meghalaya	50 MW	University of Science and Technology, 9thMile, Near Guwahati, Meghalaya
8	Jammu & Kashmir	7500 MW	Leh and Kargil
9	Punjab	1000 MW +1000 MW	District-wise land identified
10	Rajasthan	700 MW	District - Bhadla and Jaisalmer
	i. Bhadla Phase-II	1000 MW	
	ii. Bhadla Phase-III	1000 MW	
	iii. Jaisalmer ParkPhase-I	1000 MW	
	iv. Jaisalmer ParkPhase-II	1000 MW	
11	Tamil Nadu	500 MW	Location yet to be identified
12	Odhisra	1000 MW	Location yet to be identified
Total		22,100 MW	

Solar Energy Corporation of India (SECI), a central public sector enterprise under MNRE, has been implementing various schemes to progress solar sector in the country. As per the policy, these solar parks will be developed in collaboration with the State Governments. The implementation agency would be Solar Energy Corporation of India (SECI) on behalf of Government of India (GOI). SECI will handle funds to be made available under the scheme on behalf of GOI. The states shall designate a nodal agency for implementation of the solar park. The Arrangement proposes to afford financial support by Government of India to establish solar parks with an aim to facilitate the creation of infrastructure necessary for setting up new solar power projects in terms of allocation of land, transmission and evacuation lines, admittance roads, obtainability of water and others, in a focused manner.

V. CONCLUSION

In this paper discuss the study of solar energy in India. India has very much unbalanced in electricity production. Production is less and consumption is very much. Solar power is a very good option in India to increase power production. This is also very good for our environmental protection and economic development. Solar power is an unlimited source of energy and our country also provide a suitable climate for this energy but we need some better idea to increase efficiency and decrease production cost. Our government launches some schemes for production of solar power and achieves some successes but we need education and publicity in society for these schemes so that people take some initiative for using renewable energy as much as at a place of conventional energy sources. Indian policies have created investment-friendly market in the country for an entire range of activities announced under the Mission. India centric R&D and local manufacturing are necessary to reduce the cost of achieving Solar Targets.

REFERENCES

- [1] Kapoor K, Pandey KK, Jain AK and Nandan A, "Evolution of solar energy in India: A review" Renewable and Sustainable Energy Reviews, 40(2014)475–487.
- [2] Veeraboina P and Ratnam GY, "Analysis of the opportunities and challenges of the solar water heating system (SWHS) in India: Estimates from the energy audit surveys & review" Renewable and Sustainable Energy Reviews, 16 (2012) 668– 676.
- [3] Load Generation and Balance Report, Central Electricity Authority, Ministry of Power, Government of India, 2015–16.
- [4] Renewable Energy in India: Growth and Targets, Ministry of New and Renewable Energy (MNRE), Government of India, May 2015.
- [5] Power Sector at a Glance all India, Ministry of Power, Government of India, on 8 Oct. 2015 [Online]. Available <http://powermin.nic.in/power-sector-glance-all-india>
- [6] Savita Lolla and Somnath Baidya Roy, "Wind and Solar Resources in India", Energy Procedia, vol. 70, pp 187-192, 2015.
- [7] Ashok Upadhyay and Arnab Chowdhury, "Solar Energy Fundamentals and Challenges in Indian restructured

power sector”, International Journal of Scientific and Research Publications, vol. 4, issue 10, pp 1-13, Oct. 2014.

- [8] Pandey S, Singh VS, Gnagwar NP and Vijayvergia MM, “Determinants of success for promoting solar energy in Rajasthan, India” Renewable and Sustainable Energy Reviews 16 (2012) 3593– 3598.
- [9] Sharma NK, Tiwari PK, and Sood YR, “Solar energy in India: Strategies, policies, perspectives and future potential” Renewable and Sustainable Energy Reviews 16 (2012) 933–941.
- [10] Ministry of New and Renewable Energy source (MNRE), <http://www.mnre.gov.in/achievements.htm>; 2015.
- [11] <http://www.solarindiaonline.com/solar-india.html#present>.
- [12] Akshay Urja. Newsletter of the Ministry of New and Renewable Energy, Government of India 2010;4 (November–December (2–3)).
- [13] Jawaharlal Nehru National Solar Mission (MNRE) Website of Ministry of New & Renewable Energy, Government of India, <http://mnre.gov.in/>; 2015.
- [14] <http://www.eai.in/ref/ae/sol/sol.html>
- [15] http://en.wikipedia.org/wiki/Solar_power_Indi.