

Future Scope and Potential of Solar Energy in India An Overview

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Abstract: 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, 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 on 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 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 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 fulfil 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 on the development of renewable energy resources. In the renewable energy resources, solar energy plays 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, 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 centre-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 endeavour 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 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 by reserves of coal .The thermal power station emit 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 fuels-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].

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.

Revised Version Manuscript Received on April 26, 2017.

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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. It has an average of 250–300 clear sunny days and 2300–3200 hours of sun shine 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	Phase-II	Phase-III
	2010-13	2013-17	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

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

Government of India is trying to improve the share of energy generation from the solar energy and launched Jawaharlal Nehru Solar Mission. Under First Phase of 200 Jawaharlal Nehru National Solar Mission (JNNSM). The Prime Minister has emphasised 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 favourable 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 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 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, 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 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 borne, 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 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 a 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 gigawatts (GW) to 100 GW by 2019. It adopts a 3-Phase approach from 2010 to 2022.

Table: III. JNNSM Capacity Addition Target

Growth of Solar Power in India			
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

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.

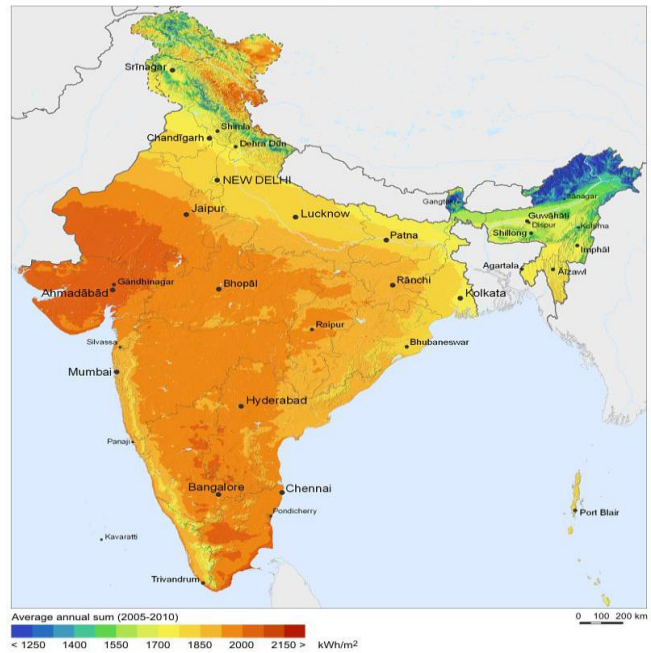


Fig.1. Solar Resource Map of India

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 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.

IV. SOLAR PARK

Ministry of New and renewable Energy (MNRE) has drawn a scheme to set up 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 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), central public sector enterprises under MNRE, has been implementing various schemes to develop solar sector in the country.



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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.

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:

Table IV. Setting Up of Solar Parks

S No.	State	Capacity of Solar Park (approx)	Land Famous at
1	Gujarat	750 MW Taluka- Vav, Distt. Banaskantha	750 MW Taluka- Vav, Distt.Banaskantha
2	Madhya Pradesh	750 MW +750 MW	Rewa-Distt
3	Telangana	1000 MW	Mehboob Nagar- Distt.Anantpur
4	Andhra Pradesh	2500 MW	Distt: Kadapa and Kurnool
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, Near Guwahati, Meghalaya
8	Jammu & Kashmir	7500 MW	Leh and Kargil
9	Punjab	1000 MW +1000 MW	District-wise land identified
10	Rajasthan i. Bhadla Phase-II	700 MW	District - Bhadla and Jaisalmer
	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	Odhisa	1000 MW	Location yet to be identified
	Total	22,100 MW	

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V. FUTURE GROWTH OF SOLAR IN INDIA

The solar industry's structure will rapidly evolve as solar reaches grid parity with conventional power up to 2018. Solar will be seen more as a viable energy source, not just as an alternative to other renewable sources but also to a significant proportion of conventional grid power. The testing and refinement of off-grid and rooftop solar models in the seed phase will help lead to the explosive growth of this segment in the growth phase. Global prices for photovoltaic (PV) modules are dropping, reducing the overall cost of generating solar power.

In India, this led to a steep decline in the winning bids for JNNSM projects. With average prices of 15 to 17 cents per kilowatt hour (kWh), solar costs in India are already among the world's lowest. Given overcapacity in the module industry, prices will likely continue falling over the next four years before levelling off. Since 2018, the cost of solar power could be as much as 20% lower than that of the most expensive grid-connected conventional energy suppliers. The capacity of those suppliers alone, nearly 8 GW in conventional terms, corresponds to solar equivalent generation capacity potential of 25 to 30 GW. Due to implementation challenges, however, it's unlikely that all of this potential will be realized by 2018. Grid parity will be an inflection point, leading to two major shifts in the solar market. First, thanks to favourable project economics, grid-connected capacity will rise at a much faster rate than before, and second, regulations and policy measures will be refined to promote off-grid generation. According to one estimates, the combination of electricity demand growth, fossil fuel cost and availability challenges, and supportive environmental regulations could increase solar power capacity to more than 50 GW by 2022. The market will see a significant change after 2016. Lower solar costs combined with rising prices of grid power will convince off takers (including distribution companies, private firms using open access, and firms putting up their own captive capacity) that solar power is economically viable. This shift will signal the start of the growth phase, during which grid-connected solar capacity will rise rapidly to about 35 GW by 2020 as developers build capacity to meet both RPO requirements and demand from off takers seeking cost-efficient alternatives to conventional power.



VI. SOLAR ENERGY DEVELOPMENT IN DIFFERENT STATES

The Gujarat solar policy initiated a process of the states formulating their own policy frameworks independent of the federal guidelines. The renewable purchase obligations for state distribution companies, a demand-driven scheme, further accelerated the formulation of solar policies at the state level. These policies exist independent of each other as well as the NSM. Other states like Karnataka, Andhra Pradesh and Rajasthan have followed suit in developing solar power development programs. Rajasthan has implemented land banks as well to make land acquisition easier. As more states plan to meet their solar power obligations, new policies are expected to be offered, creating as very vibrant set of markets across the subcontinent.

A. Gujarat Solar Power Policy -2009

Gujarat is the first state to launch its own solar policy in 2009. The Gujarat solar policy was in place a year before the NSM was announced. The initial target is to achieve 500 MW of installed capacity by the end of this period. Gujarat Energy Development Agency (GEDA) and Gujarat Power Corporation Limited (GPCL) have been appointed as nodal agencies for the facilitation and implementation of the policy. Gujarat Solar Power Policy is the only policy, which has awarded projects with a fixed Fit, on a first-come-first serve basis. This has resulted in the allocation of a number of projects to in-experienced or unknown developers. After the NSM policy was formalized in December 2009, developers moved away from Gujarat towards the NSM. In the first phase of the Gujarat policy, only 396.5 MW worth of PPAs were signed out of 716 MW allotments, leading to a conversion rate of 55% (PPAs signed as a percentage of projects allotted). The tremendous interest from developers for NSM led to the competitive bidding for projects and a subsequent fall in tariffs. The fall in the NSM tariff below the levelized tariff in Gujarat suddenly made the Gujarat policy very attractive again to developers. Further, a significantly higher feed-in-tariff in the first 12 years in Gujarat matches investor's timelines, as they would look to cover the cost of debt during this period. To ensure developer commitment, Gujarat's solar policy for the second phase has been amended to include a deposit that would be encased, if the developers fail to sign the PPAs. Larger available project sizes and the relative ease of land acquisition has led to larger developers getting serious about the Gujarat policy and signing PPAs and starting the implementation of projects. Gujarat has significantly improved the credibility of its solar program from the first to the second phase.

B. India's First Solar Park

On December 29th 2010, India's first solar park was inaugurated at Charanaka in Patan district of northern Gujarat. So far, land has been allotted in the solar park for projects worth 176MW to 16 companies from the first and second phases. The total capacity of the solar park is 500MW with 30,000 sq. m per MW land allotted to Solar Thermal and 20,000 sq. m per MW of land allotted to PV projects. The solar park has been financed with over Rs. 12 billion by financial institutions like the International Finance Corporation (IFC), the Asian Development Bank

(ADB) and the Infrastructure Development Finance Corporation (IDFC). The park tackles land procurement, water availability and grid connectivity issues and offers a "single-window" clearance process. Sixteen companies, including Sun-Edison Energy India (25MW), Alex Astral Power (25MW), Roha Energy (25MW), GMR Gujarat Solar (25MW), Kiran Energy (20MW), Emami Cement (10MW) and Azure Power (5MW) have been allotted projects worth a total of 176MW in the park. They have all signed PPAs with the state government.

C. Karnataka Solar Power Policy (2011-16)

Karnataka, a south-western state of India, announced its solar policy on July 1, 2011. Under the solar policy 2011-16, the Karnataka Government proposes to promote solar power as part of renewable energy generation policy in the state.

1. It targets 350 MW worth of projects till 2016.
2. 200 MW is to be developed for direct sale to the distribution companies in the state (40 MW to be added each year)
3. 100 MW under REC Mechanism
4. 50 MW for bundling of power with thermal power from outside the state at rates to be determined by the State Government subject to approval of KERC.

The minimum capacity of solar PV projects is 3 MW and maximum capacity of 10 MW, while for Solar Thermal the minimum is 5MW with no cap on maximum. The quantum of power to be procured by ESCOMs from solar resources under purchase obligation is 0.25% of the total consumption and the shortfall in procurement of solar energy by the ESCOMs can be made good by purchase of solar specific RECs. Though the state has come up with its own policy, it will continue to support programs like the NSM. The state has set a combined target of 126 MW of solar power to be developed by 2013-14 through NSM and its own solar policy.

D. Rajasthan Solar Power Policy - 2011

On April 19th 2011, Government of Rajasthan issued Rajasthan Solar Energy Policy, 2011 to promote solar-energy in the state. The policy aims to help Rajasthan, develop as a global hub of solar power for 10000-12000 MW capacity over the next 10 to 12 years to meet energy requirements of Rajasthan and other states of India.

1. It targets a minimum of 550MW of grid connected solar power in Phase 1 (up to 2013).
2. Projects will be awarded through a process of competitive bidding.
3. PV projects will be worth 300MW, out of which 100MW are reserved for project developers and 200MW for panel manufacturers.
4. The minimum and maximum sizes for PV projects are 5MW and 10MW.
5. Module manufacturers that set up their manufacturing plant in Rajasthan can bid for either 10MW or 20MW worth of PV projects based on their manufacturing capacity.
6. A further 50MW will be allocated for rooftop PV (1MW each) and other small solar power plants.

7. The DISCOMS in Rajasthan will provide PPAs for the projects. In addition, projects worth 100MW (50MW PV and 50MW CSP) are targeted for bundled solar power.

In such projects, the developer can sell conventional power and solar power in a ratio of 4:1 at the weighted average tariff to the distribution utilities in Rajasthan. Varied project sizes will attract small as well as large developers looking to invest in projects of different scale.

VII. CONCLUSION

In this paper, we have discussed that India is very much unbalanced in electricity production. Production is less and consumption is very much high. 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 unlimited source of energy and our country also provide 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 use renewable energy as much as at a place of conventional energy sources. Indian policies have created investment friendly market in the country for entire range of activities announced under the Mission. India centric R&D and local manufacturing is necessary to reduce the cost of achieving Solar Targets.

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