An overview on: Solar Power in India

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Abstract- The demand for energy is growing day by day in the whole world. The Conventional energy sources like coal and petroleum are limited. Renewable energy resources will play an important role in the future. India is situated in sunny belt India is endowed with vast solar energy potential. Government of India had launched Jawaharlal Nehru National Solar Mission (JNNSM) in 2009. The target was to start Grid connected Solar Projects of 20 GW by 2022. In May 2015 government increases the target to 100GW by 2022. 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. The paper also focuses on the technical and economical barriers and challenges for development and utilization of solar energy technology. The paper reviews existing government act and regulatory policies to support solar energy development in India. Indicating how these policies are helping in achieving their goals. Finally, a review based on of the future target of solar energy supply has been presented.

Keywords-Non-Conventional Sources, Solar Power, Renewable Energy, Indian Policies.

I. INTRODUCTION

Electricity is very important for any country for urbanization, industrialization, economic growth and improvement of living standard of society**.** India is ranked fifth in the electricity generation in the world [1]. 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) [2-4]. 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 $N0_x$, CO_x and SO_x gases which is ingenious to health and environment. 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].

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]. Solar energy technology is very important tool which can lowers worldwide carbon emissions. The cost of solar energy technologies are rapid declining in the recent past years and it is showing potential for continuous declines in the near future. Currently, the installed capacity of solar energy projects in India is about 4.22 GW. India is planning to produce 100 GW of solar power by 2022.

In this paper we will discuss about current status of solar projects in India and feature planning of Indian government on the solar projects. We will also discuss the government new policy and barriers on the solar technology.

II. SOLAR POWER IN INDIA

TABLE .I. THE ELECTRICITY SECTOR REQUIREMENT AND AVAILABILITY IN INDIA ON MARCH 2015[2]

A. Overview of 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

Source: MOP, GOI.

Solar power can be generated by direct photovoltaic's (PV) or indirect by solar thermal power. In photovoltaic power plant a solar cell or photovoltaic cell (PV) is used which is a device that converts light into electric power using the photoelectric effect. The PV cell is a solid-state device consists of thin layers of Semiconductor materials that produce electricity when exposed to light. Photovoltaic power generation consist of solar panels having a number of solar cells containing some photovoltaic materials. Materials presently used for photovoltaic are mono-crystalline silicon, poly-crystalline silicon, cadmium telluride and copper indium selenide/sulfide [8]. The International Energy Agency has classified the photovoltaic applications into four categories namely off-grid domestic, off-grid nondomestic, grid connected distributed and grid

connected centralized [7]. In a Concentrating Solar Power (CSP) plant the heat is collected by lenses or mirrors and transformed to mechanical energy through a steam turbine and then into electricity [9]. Wide ranges of technologies CSP plant are present; the most developed are parabolic trough, solar power tower, concentrating linear Fresnel reflector and sterling dish. The various techniques are used to track the sun and focus light [8].In this paper we will discuss both type plants in India.

B. Solar Power in India

India lies in the sunny belt of the world. India is endowed with vast solar energy potential. Most parts of India get 300 days of sunshine a year [11]. About 5,000 trillion kWh per year energy is incident over Indian land area with most area receiving 4-7 kWh per sq. meter per day [10]. Hence, both technology solar thermal and solar photovoltaic's can effectively provide huge capability for solar in India. Solar also provides the ability to generate power on a distributed basis. Assuming 10% conversion efficiency for PV modules it is three orders of magnitude greater than the likely electricity demand for India on the year 2015 [13]. Figure 1 shows solar radiation data map of India. It can be observed that highest annual global radiation is received in Rajasthan and northern Gujarat.

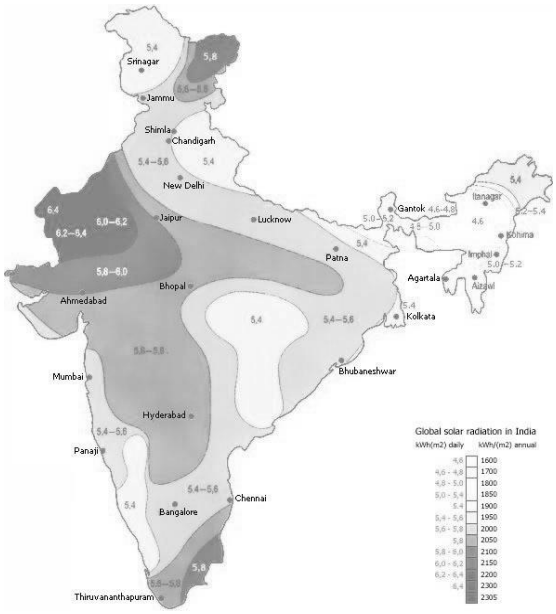

Fig.1. Solar radiation of India (Source: Solar Energy in India**,** Solar Energy Association, Tamil Nadu)

C. Current status of solar energy in India

India is ranked 11th in solar power generation in the world as on Jan. 2014 [3]. Government funded solar energy in India only accounted for about 6.4MW/yr of power as of 2005.In 2010 capacity of 25.1MW was added and 468.3MW in 2011. In 2012 the capacity increase more than two times and become 1205 MW. During 2013 capacity added by 1114MW and during 2014 capacity added by 313MW [5]. In August 2015, the installed grid connected solar power capacity is 4.22 GW. The price of solar energy has come down from Rs. 17.90 per unit in 2010 to about Rs. 7 per unit in 2015.It is expected that with technology improvement and market competition solar power will reach grid parity by 2017-18 [14]. The Grid parity means the cost of electricity generated from alternative energy becomes equal or less than the cost of purchasing power from the grid [1, 15]. Grid parity is very important term in the solar system and preferably photovoltaic panel. The Charanka Solar Park, at current installed capacity of 224 MW is the largest Solar Park in Asia, was commissioned on April 19, 2012[18]. Some solar power plant of India is shown in the Table-2. In India, Rajasthan has the largest share of solar power generation of 28.4% and Gujarat share is 24.4% as on September 2015[17].Table-3 shows current solar power capacity in different state of India.

TABLE.II. SOME SOLAR PLANTS OF INDIA

Name of plant	Peak power in mw	Commission year
Charanka Solar Park, Charanka Village, Patan, Gujarat [18]	224	April 2012
Welspun Solar MP project, Neemuch, Madhya Pradesh [19]	151	March 2013
Mahagenco Solar Project, Maharashtra [20]	130	March 2013
Rajgarh Solar PV (NTPC),Rajghar Madhya Pradesh [21]	50	March 2014
Welspun Energy Rajasthan Solar Project ,Phalodhi, Rajasthan [19]	50	March 2013
Talcher Kaniha Solar PV (NTPC), Odisha [21]	10	March 2014
Unchahar Solar PV(NTPC), Unchahar, Utter Pradesh [21]	10	March 2014

TABLE.III. CURRENT SOLAR POWER CAPACITY IN SOME STATE AS ON SEPTEMBER 2015 [17]

S. NO.	State Or U.T	Capacity in MW
1	Andhra Pradesh	279.44
2	Arunachal Pradesh	0.265
3	Chhattisgarh	73.18
4	Gujarat	1000.05
5	Haryana	12.8
6	Jharkhand	16
7	Karnataka	104.22
8	Kerala	12.025
9	Madhya Pradesh	673.58
10	Maharashtra	378.7
11	Orissa	56.92
12	Punjab	200.32
13	Rajasthan	1199.7

14	Tamil Nadu	157.98
15	Telangana	72.25
16	Tripura	5
17	Uttar Pradesh	71.26
18	Uttarakhand	5
19	West Bengal	7.21
20	Andaman & Nicobar	5.1
21	Delhi	6.712
22	Lakshadweep	0.75
23	Puducherry	0.025
24	Chandigarh	5.041
25	Daman & Diu	2.5
26	Others	0.79
Total		4346.818

Source: MNRE, GOI

III. BARRIERS & CHALLENGES ON SOLAR ENERGY IN INDIA

Various barriers and challenges on solar energy in India have been pointed below.

- The main disadvantage of solar energy is its unavailability. The weather conditions are major factor on availability of solar radiation. So, we can't say in a particular time the energy from solar will be available to us or not.
- Land is also a secret reserve in India and as per capital availability is low. Large land area is required, which sometimes is not feasible. The amount of land required for utility-scale solar power plants is currently approximately $1km^2$ for every 20–60MW generation.
- 100 GW of solar would mean about 10.5% share for solar power in total generation of power in India. Such large share of intermittent sources requires huge investments in the power grid infrastructure for transmission smart supply and demand management.
- To achieve a capacity of 60 GW for utility scale projects by 2022, there would be a requirement of about $40 billion. The government currently expects a big share of this to come from international sources. But an international fund for solar projects in India is very less [22].
- Storage problem is also very serious. Suppose if the demand of power is not so high then the electricity produced by the solar plant will have to be stored somewhere to supply when demanded. This increases the cost of the project.

IV. INDIAN GOVERNMENT INCENTIVES AND SUPPORT

B. Government Acts and Policies

Government of India has come out with Acts and Policies to support renewable Energy.

- The Electricity Act 2003 has promotes electricity generation from co-generation and renewable energy sources. This Act accelerated the process of renewable energy development in the country. The guidelines for competitive procurement have been framed under Section 63 of the Electricity Act 2003 it states:

"The Appropriate Commission shall adopt the tariff if such tariff has been determined through transparent process of bidding in accordance with the guidelines issued by the Central Government" [23].

- The National Electricity Policy 2005 stipulates that the share of electricity from non- conventional resources would need to be increased such purchase by distribution companies shall be through competitive process [7].
- According to Tariff Policy 2006 states the Appropriate Commission shall decide a minimum percentage for purchase of energy from non-conventional source according the availability of resources in that region and its impact on retail tariffs [24, 25].

C. Solar Mission

Jawaharlal Nehru National Solar Mission (JNNSM) was launched in 11 Jan. 2009 with the target for Grid Connected Solar Projects of 20,000 MW by 2022[26, 27]. The Mission had adopted a three-phase approach. First four year (2009-13) had marked as Phase-I. The remaining 4 years of the twelfth Plan (2013–17) had been marked as Phase-II and the thirteenth Plan (2017–22) will be Phase-III of the project .The aim of this project was to add 1,000 MW of grid solar power by 2013, and another 3,000 MW by 2017[29]. The target for 2017 may be higher based on the availability of international funds and technology transfer [28].

But in June 2015 The Union Cabinet of India gave approval for stepping up of India's solar power capacity goal under the Jawaharlal Nehru National Solar Mission (JNNSM) by five times, reaching 100 GW by 2022. The target will comprise of 40 GW rooftop and 57 GW through large and medium scale grid connected solar power plants [14]. By this step of government India will become one of the greatest countries of the world in solar energy power generation. That new solar target of 100 GW is expected to abate over 170 million tones of CO_2 over its life cycle. The total investment will be around Rs. 6,00,000 cr. (@ Rs.6 cr. per MW at present rate) for 100GW power generation [14]. Table-4 shows the targets of power generation in different years.

TABLE.IV. TARGET OF POWER GENERATION IN JNMSM BY 2022[30]

Year	Rooftop type solar power project (MW)	Ground Mounted type solar power project (MW)	Total (MW)

2015-16	200	1,800	2,000
2016-17	4,800	7,200	12,000
2017-18	5,000	10,000	15,000
2018-19	6,000	10,000	16,000
2019-20	7,000	10,000	17,000
2020-21	8,000	9,500	17,500
2021-22	9,000	8,500	17,500
Total	40,000	57,000	97,000

Source: MNRE, GOI

D. Government Support

The Government of India is providing Rs. 15,050 cr. subsidy to promote solar capacity addition in the country [14]. This capital subsidy will be provided for solar projects in many cities and towns. Solar power projects with investment of about Rs. 90,000 cr. would be developed using bundling method with thermal power [14]. Further, investment will come from large Public Sector Undertakings (PSU) and Independent Power Producers (IPPs). Many states Government have also come out with state solar policies to promote solar energy technology.

V. CONCLUSION

In this paper, we have discussed about the current status of solar energy in India. The Ministry of non-convection energy resources, government of India is trying to increases the power capacity and achieve the target of 100GW by 2022. This discussion shows that the status of solar energy is satisfactory in India but some extra effort is required for betterment of solar source. In spite of reduction of the cost of solar power, it is expensive source of power compared with conventional sources. It is very important to support and subsidize the solar power till it can compete with the conventional sources. The step of Indian government to increases the target is a very good to become India as one of the most solar powered countries in the world. Such types of steps will be required in the future.

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