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Solar Energy in India: Savouring a Dream

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Abstract: ***India has a great potential to tackle energy problems faced, by the use of renewable energy technologies and sources. Most of the countries are blessed with two or more renewable energy resources; India on the other hand has plenty of such resources. The current paper assesses the past growth & future expectation of renewable energy productions and also highlights ways implemented to achieve the dream of 175 GW by 2022 target of renewable energy capacity including wind and biomass. It is difficult not to be dazzled by India's renewable energy ambition and an audacity of ambition to achieve such an amazing dream. In 2014 when India announced the 100 GW target for solar energy, India had 3 GW of solar energy and 33.8 GW of renewable energy capacity. Such ambitions have been central to changing the perception about India's willingness to contribute to the global effort to reduce carbon pollution. The paper emphasizes to summarize the availability, current status, major achievements and future potentials of solar energy options in India. Specific policies revised by the government also highlight purpose of the paper.***

Keywords: Solar energy; Renewable energy policies; Solar Technologies

1. Introduction

Due to growing modernization, urbanization, industrialization, population growth and income levels, the national electricity consumption rate is expected to expand significantly. Today, India's 275 GW of installed electricity generating capacity is significantly higher than 140 GW of peak demand. In fact, India's coal generation capacity alone is higher than its peak demand. At present fossil fuels like coal, oil and natural gas contribute to about 70% of national primary energy needs [1]. Reserves of the fuels are depleting rapidly and the projected depletion times are 103, 33 and 31 years for coal, oil and natural gases respectively [2]. Most of the fossil fuel based plants account for 66 % of energy which comes from coal fired stations. This coal fired stations were build decades ago and which emit heavier pollutants now [3,4]. On a global scale there has been a considerate increase in the global temperature due to increase in concentration of the greenhouse gases (GHG) in the atmosphere. Approximately 960 kg/MWh of CO_2, 6 kg/MWh of SO_2 and 2.6 kg/MWh of NO_2 are the quantities of main pollutant emitted out during generation of electricity from coal fired plants [5]. Although the dreadful effects of NO_2& SO_2 are not as alarming as compared to CO_2 due to their lesser concentration present in surrounding. CO_2 contributes the higher to the greenhouse effect phenomenon due to higher concentration. The upper safe limit of CO_2 concentration is suggested to be 350 ppm so as not to harm the environment and CO_2 level exceeding is supposed to cause severe damage to environment [6]. In May 2016, the global concentration has reached almost 400 ppm and its current growing rate is more than 2ppm/year [7]. The doubling of CO_2 value causes a rise in the global mean temperature of 1.5^0C – 4.5^0C [8]. This rogue depletion of fossil fuel reserve, awareness on carbon footprint and effect of global warming have thus forced a policy of accelerated utilization of renewable energy sources for the electricity production. Chart 1 shows the cumulative installed capacity of solar energy.

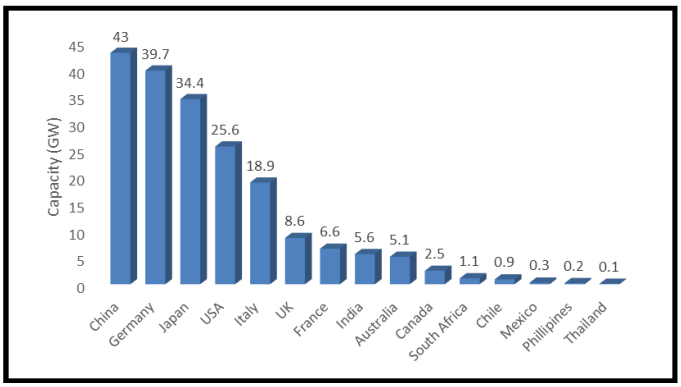

Chart-1. Cumulative solar capacity installed world-wise as of December 31, 2015 [GW] [17]

2. Research

The methodology adopted in preparing this paper is the collection of data based on recent developments and projections of renewable based energy generation in the near future as reported in the latest literatures and energy research articles. Based on the data compiled and analysis of the available data, the continuing development in the field of solar energy over the previous few year is reviewed. The increased projections in the installed capacity of solar energy and further reduced capital cost and new amendment's made in tariff as per new policies are also highlighted in this paper. The further scopes in this field in order to achieve the nations dream are also discussed.

A careful study on solar energy resources based electricity potential is done and latest data related to solar, is discussed in this section. India is the fourth largest importer of oil and the 15th largest importer of petroleum products and Liquefied Natural Gas (LPG) [9]. The upsurge use in the indigenous renewable sources is expected to diminish India's dependence on affluent imported fossil fuel. Far-reaching survey of developments and issues related with different solar technologies are studied in the following subsections.

2.1 Solar Power

With the advent of newer and newer technologies in the field of Photovoltaic (PV) and Concentrated Solar Power (CSP) plants, the electricity production using solar energy is growing rapidly in almost every part of the world. The total annual solar radiation which falls on earth is more than 7500 times of what the total world consumes which is estimated to be 450 EJ (exajoule). The annual solar radiation reaching the earth's surface, approximately 3,400,000 EJ, is in order of magnitude greater than all the estimated non-renewable energy resources including fossil fuels and nuclear. India undeniably receives about 4-7 Kwh of solar radiation per square meter per day with 300 sunny days in a year [10]. India is all set to become the fourth largest solar market globally in 2016 behind only China, USA and Japan.

2.2 SolarEnergy

The India's economy is expected to be almost twice over the next 20 years, with growth rate on an average of about 3.4 % p.a. Growth which is a factor is usually driven by increase in productivity (i.e. GDP/person), which account for almost three quarters of the growth.Much of expected growth in the global economy is driven by the major emerging economies, with China and India accounting for half of the increase in the utilization of energy. Thus it is crucial that India make efforts for satisfying this growing demand. The growth in world energy demands comes from fast-growing emerging economies like china and India and the energy demands within the OECD (Organisation for Economic Co-operation & Development) barely grows. India duly has the potential to overtake China in terms of largest growing market for energy [11]. The main reasons for increase in global energy demand is that a significant part of Indian population remains without modern and reliable energy despite a rapid extension of the reach of power system in the recent years, around 240 million people in India lack access to electricity.
As on December 2016, solar, wind, biomass and small hydropower contribute to about 16 percent of the total installed capacity for electricity.As per national solar mission,26 SPV projects of aggregate 330 MW capacity have been sanctioned. Under the 100 SPV power plants, 78 projects of 98 MW are set [12].Under the 750 MW VGF scheme, large scale ground mounted solar PV projects with cumulative capacity of 490 MW have been commissioned under commercial operation [13]. Amendment is done in the scheme for setting up of 1000 MW of Grid connected Solar PV power projects by CPSUs and Govt. organizations under various Central/State Schemes/Self use/3rd Party sale/Merchant sale with Viability Gap Funding (VGF) under Phase-II of JNNSM [14].MNRE had allocated 1037.26 MW capacity to 16 CPSUs/Govt. Organizations within the sanctioned funds of Rs.1000 Crore for this scheme.
Under the grid connected solar PV power projects (3000 MW) by NTPC and other PSU's tenders for 3000 MW capacity projects allotted to states of Andhra Pradesh,Rajasthan, Uttar Pradesh, Karnataka, Telangana have been issued by NTPC.

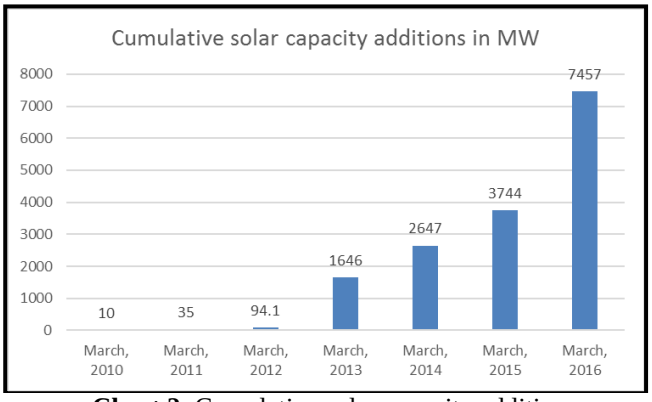

Chart 2: Cumulative solar capacity addition
(source: Ministry of New & Renewable energy)

Project of setting up 15000 MW of grid connected solar PV power plants through NTPC under National Solar mission is under implementation.Under Grid Interactive Rooftop PV, 3044 MWp of rooftop system have been sanctioned/approved [15]. Fig.1 shows the upcoming sanctioned projects in pipeline, with new and new projects being commissioned.

3. Economics of Solar Power Generation

The cost of power procurement by distribution companies from the power generation contracts, largely fossil fuel projects have risen due to the increased cost of fuels, transportation, maintenance spares and labours have risen.In solar, a variety of Indian projects have adopted crystalline silicon technology and the average efficiency achieved is up to 16-17 %. The thin film technologies of cadmium-telluride and copper-indium-gallium-selenide, with 14-15 % efficiency are used. The ongoing research is expected to continuously increase the efficiency in the coming years.The performance of the solar power plants, irrespective of the technology used is higher than the average PLF's observed in Southern Europe. It is interesting to note that in chart 3 and chart 4 PLF's between these two prominent technologies do not differ remarkably and that the performance of C-Si is better [16]. While likely in such case the growth in roof-top solar power plant is much more desirable because the economics involved in solar roof-top projects is considerably low. The economics of solar rooftop is very simple. Despite needing initial huge funds, but once with the set up and installation, the numbers add up very easy with respect to money and carbon credits too. The table no. 1 gives a detail analysis for setting up a 100 kWP rooftop grid. The most important factor that is worth noting the payback period & Returns on Investment (ROI). With the introduction of net metering policy, it has given a broader push to roof top projects. A common incentive is tax credit or tax exemption for investment in renewable energy. India offers a 10 yrs. corporate income tax holiday besides an accelerated depreciation of 80 % for solar and wind installations [16].

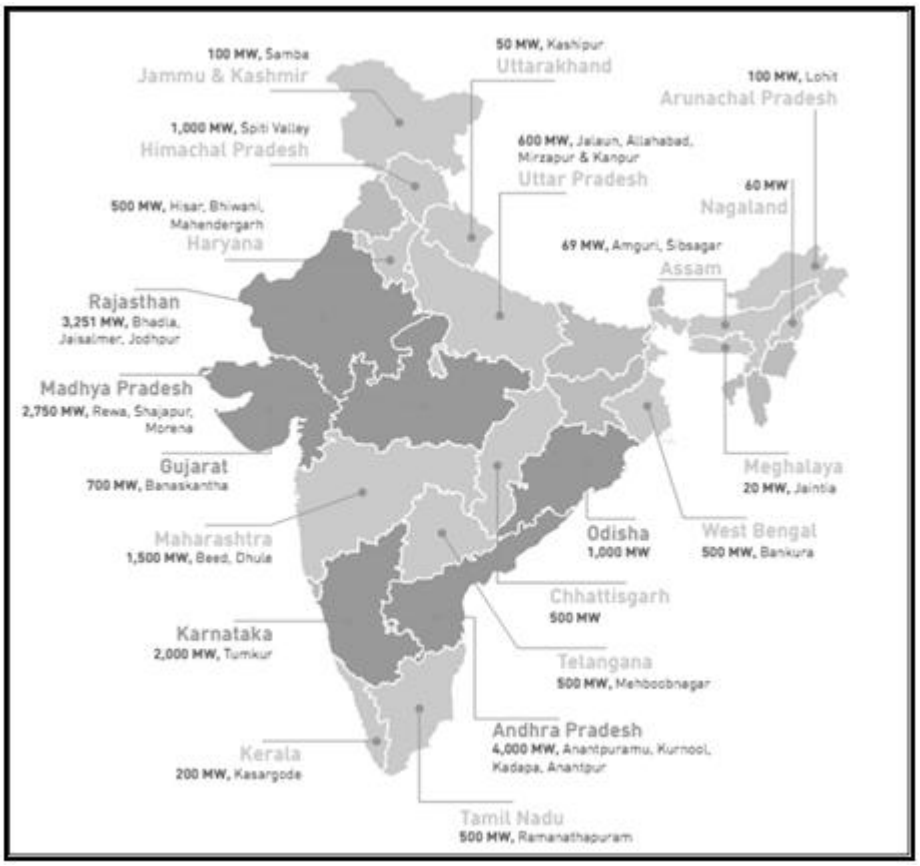

Figure 1: Upcoming commisioned plants state wise (Source: List of approved solar parks in India, MNRE)

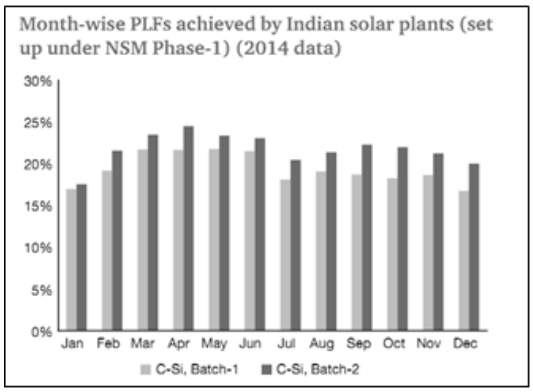

Chart 3: PLF's achieved month-wise data for different C-Si batches (Source: MNRE)

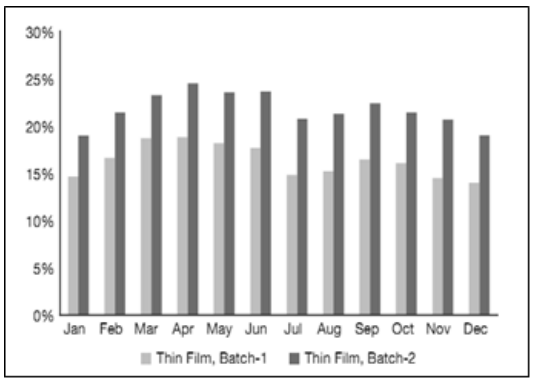

Chart 4: PLF's achieved month-wise data for different Thin Film batches (Source: MNRE)

Table 1: Cost Economics of 100 Kwp (MNRE)

Sr. No.	*Parameter*	*Value*
1	Capacity (kWp)	100
2	Cost (in Rs)	Rs. 70 Lakh
3	Equity by developer (20%) + borrowing from other sources	Rs.14 lakh + 21 lakh from other sources.
4	World bank loan to developer (50%)	Rs. 35 lakh
5	Electricity generation per year	1.50 lakh unit
6	Revenue generation per year @Rs. 7.04 per unit	Rs. 10.54 lakh
7	Revenue generation per month	Rs. 88,000/-
8	Simple Payback period	6.62 yrs
9	EMI for world bank (8%, 15 yr, 35 lakh)	Rs. 33,447/-
10	EMI for balance 50% equity (12%, 15 yr, Rs. 35 lakh)	Rs. 42,000/-
11	Total EMI payment by developer	Rs. 75,447/-
12	Net saving per month to developer	Rs. 12,553/-

4. Upcoming Solar Technologies

Like any other rapidly developing sector, solar energy is also seen to develop with great speed. With the generation cost coming down from Rs. 17 /kWh to Rs. 7 /kWh in just three years and panels efficiency going up from 14 % to 17 % and above, it is clear that we have achieved a steep growth as far as technological advances is concerned. This is a most buzzing topic right now because of the intense competition with tariffs coming down and is expected to go down up to Rs. 4.34-5.00/kWh [17]. Gallium Arsenide can give efficiencies thrice that of normal PV cells, by using triple

junction layers, even though high cost remains an obstacle. Cadmium Telluride thin film cells are believed to be the cheapest to manufacture with the lowest carbon footprint and shortest payback period. However, obstacle such as highly unstable nature of CdTe while manufacturing and its toxicity still needs to be overcome. Solar roadways are among the other example of solar applications. Commercially tested first in Netherlands, solar roadways can solve the problems of land acquisition and provide power from photovoltaic roads. Smart solar roadways technology developed by a couple in USA takes the technology further. Floating solar plants are an application which makes use of floating mounting structures, the advantages are saved expenditure on land purchase, cooling of panels leading to a higher output and longer life, reduction in evaporation on water bodies such as lakes. Space based solar is an application in the line of most impossible technology but still exists. It is a technological dream and most companies are working on it. The idea of sending solar plants in space and sending the capture energy to earth by microwaves is behind the concept. A Japanese company (Shimizu corp.) has also designed and proposed a model of a lunar belt, meaning a belt of solar panels around the circumference of moon.

5. Energy Policies & Acts

The prime importance of setting energy policies in order to achieve the require goal is to increase the share of RES in India. The policies and framework are decided by government [18].

5.1 Electricity Act (EA), 2003

The Electricity act is mainly designed to promote renewable energy by ensuring grid connectivity & sale. It aims at overcoming the shortage of energy and access of electricity to the maximum. It is also functioned to supply reliable and quality power in efficient manner at a very reasonable rate. According to section 61, it is stated that the SERC determines the tariff for the promotion of RE [18]. Similarly, under section 86, they decide fix minimum % energy purchase from RE sources for the state. Foreign Direct Investment (FDI) up to 100 % is permitted under the automatic route for renewable energy generation and distribution projects subject to provisions under this act.

5.2 National Electricity Policy (NEP), 2005:

- The national electricity policy promotes the private participation of maximum partner in RE. it formulates strategies to bring about active participation of private sector more and more in this field.
- The NEP is responsible for constantly updating from time to time National electricity policy and Tariff Policy, in consultation with state and government authority in order to bring about optimal utilization of coal, natural gas, nuclear power etc. it also aims at capital cost reduction in RE through competition. The act promotes the generation of electricity through cogeneration and renewable sources too.

5.3 National Tariff Policy (2006):

This policy abides and mandates to fix a minimum purchase of obligatory energy consumption by the states from renewable energy sources and giving special tariff.

6. Initiatives & Outreach

Government has taken variety of new projects in continuation with the initiatives launched in the previous years:

6.1 Green Energy Corridor

A Green Energy Corridor has been setup in order to ensure the evacuation of renewable energy. The initiative has been taken by Power Grid Corporation of India Limited (PGCIL) seeking loan assistance of US 1000$ from Asian Development Bank. The loan would be utilized in funding various transmission projects like HVDC Bipole link between Western Region and southern region of up to 6000 MW and between western region and southern region of up to 2000 MW. It also aims to invest in Real time monitoring/measuring scheme.

6.2 Renewable Purchase Obligation

While it can mainly be observed that Renewable Purchase Obligations (RPO) are better effective methods to bring about a change. While RPO requires distribution license, captive power consumers and open access to purchase or generate certain percentage of total energy requirement from appropriate renewable sources, it should be made stringent on a state i.e. it should adhere to the particular amount of generation and failure to do so should result in hefty amounts of penalty. And while the state specific solar and non-solar targets be increased considerably, even if it means to bring about newer schemes and incentives to the table. The absence of strict enforcements has led to non-compliance with the targets. Most of the state are not in position to enforce these regulations on distribution entities. The RPO regulations strictly imply that if an obligated entity fails to comply with the targets, it has to purchase Renewable Energy certificates (REC) at forbearance rate as shown in Table 2 decided by CERC [18].

Table 2: Prices decided by REC

Sr. No.	Price of REC's notified by CERC		
	Type of REC	Floor Price (INR/MWh)	Forbearance rate (INR/MWh)
1	Solar	9,300	13,400
2	Non-Solar	1500	3300

Source- REC registry of India

6.3 Net Metering Policy

The ministry through its consistent follow up has resulted into notification on net metering policy for various states to encourage roof top plants. Due to net metering it would be of tremendous ease to achieve the target of 40 GW rooftop grid connected solar projects. So far, 20 States namely Andhra Pradesh, Chhattisgarh, Delhi, Gujarat, Haryana,

Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Manipur, Punjab, Puducherry, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand and West Bengal have come out with Solar Policy supporting grid connected rooftop systems [19]. A net meter is a bidirectional meter that measures flow of electricity in both the directions. Customers are allowed to send surplus amount of power generated from their rooftop solar plants back to the distribution company. For net metering to be applicable, the solar PV plant capacity should not exceed the sanction load of the customer.

6.4 Solar Rooftops

All major sectors i.e. Railways, Airports, Hospitals, Educational Institutions, Government buildings of central/state/PSU are being targeted besides private sectors. Ministry have even tied with ISRO for Geo tagging of all the rooftops.

6.5 Raising of Bonds

Ministry of Finance approved raising Rs. 4000 Crore bonds for renewable energy sector by IREDA during 2016-17.

6.6 Skill Development

Surya Mitra scheme has been launched for creating employable technicians in solar photovoltaics technology by March 2020.

6.7 Solar Tariffs attaining Grid Parity

Solar tariffs have fallen to an unprecedented low of Rs. 3.15/unit during the auction for the 250 MW ultra-mega solar park in Andhra Pradesh. This trend is continuing and moving towards grid parity. On the policy front, the Solar Parks Policy and UDAY scheme have been hailed largely as a success but the broader sector policy reform through amendments in the Electricity Act 2003 is still awaiting parliamentary approval. Going forward, ensuring grid robustness and investment/lending appetite at aggressive tariff levels will be the two main challenges. Policy interventions to address these challenges together with demand growth measures will be key to sustainable growth of the sector [17].

7. Challenges

With the newer and newer policies being introduced, there arises a likely question as to if the policies will be implemented to their full potential or not.

One major disappointment continues to be the roof top solar market where 40 GW target for 2022 seems like a very remote prospect. The market needs a more focussed policy support to ensure effective net-metering implementation and attraction of more financial investors. [17]. The government of India through Ministry of New and Renewable Energy [MNRE] is promoting the adoption of renewable energy resources by offering various incentives such as generation-based incentives (GBI's), Capital and Interest Subsidies, Viability Gap Funding (VGF), Concessional Finance, fiscal incentives etc., but this policy need to have a far outreach [20]. There should be a long term policy, large scale deployment goals, aggressive R&D and the domestic production of critical raw materials, components and products. [21]. All scheduled banks including renewable energy in the category of priority sector, in addition to existing categories make significant inroads for renewable energy [22]

8. Conclusions

In this Paper, authors have studied the solar energy status and discussed about cost of generation and estimated growth. The authors have arrived to conclusion that fast track growth in the field of solar energy sector and other renewable energy sectors is required in order to meet the high needs of energy and global standards and to achieve a better environment to live in. India is amongst the country which has a dedicated organization "Ministry of New and Renewable Energy" rendered completely to the development of Renewable Energy in India. Thus India has a full potential to succeed. In order to increase the utilization of RES, government should promote research and development and provide support and subsidies to install RES based plants. It is no longer an impossible mission to achieve the bigger goal of installing 100 GW solar system in the country, if the formulated policies and acts as well as the initiatives decided are properly implemented in the country.

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