A Review: Palisades to Extensive Rooftop Solar PV in India

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***Abstract*— In contemporary times, climate change and melting ice caps are the biggest concern among the nations of the world. It's time to switch to alternative sources of energy, solar energy being the most prominent of them. In India, solar panels are being installed by the government in most rural and urban households providing subsidies as far as possible. This paper provides the present situation of solar rooftop installations, factors affecting its implementation and the way forward. While the factors like high solar irradiance, the subsidies by the government and reverse metering are supporting the installations of rooftop solar PVs, there are still obstructions in the extensive installations of rooftop solar PVs discussed in this paper. The high initial cost is one of the major hindrances in the wide-scale installations of rooftop solar PV. Rooftop solar PVs are still being installed at a slow pace, lack of awareness in the citizens being the cause. Awareness among people can be increased through government schemes and plans. Also, if more funds are put into Research & Development, the domestic manufacturing of solar PVs can bring down the cost substantially.**

Keywords: Photovoltaic System, Rooftop PhotoVoltaic, Palisades.

I. Introduction

In the very early days of the 21st century, the government of India along with other progressive nations tended to use renewable sources of energy in place of non-renewable sources of energy due to the myriad benefits of the clean energy [1]. The conventional sources of energy generation using fossil fuels like coal, petroleum and other kinds of depleting natural resources have been in use, moreover it has been predicted that the energy demand will increase by 25% in the upcoming 25 years (*source*: www.oecd.org/greengrowth), and the rate at which fossil fuels are depleting, an energy crisis is on the way [2]. Seeing the amount of rising carbon footprint, it's high time to transition power generation from conventional to renewable sources of energy like wind, solar, hydal, geothermal etc. These alternative sources are necessary to meet the rising demands.

India has 70% of its energy generation from thermal energy, 60% of which in turn is generated from coal. While the energy generation from alternative sources is around 25%. In addition, the coal that is used for thermal energy production is also imported at around 143 MT annually [3]. Without a full proof plan to meet the rising energy demands, India is bound to have an energy crisis. Given below are the various sources of energy generation in fig.1.

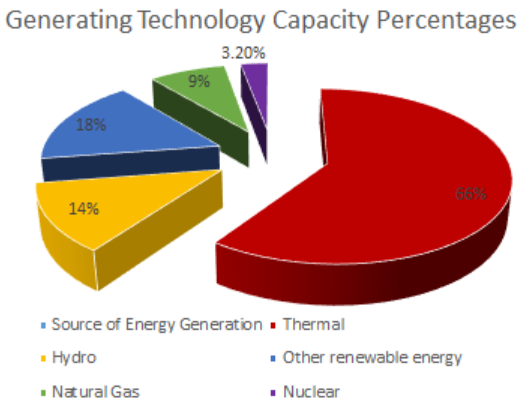

Fig.1: Energy Generation from Various Sources

From the early years of the last decade, generation of energy from solar radiation seems a viable energy production option, taking into account the ample number of lead steps taken by the government for reduction in the price of solar energy generation. As per the data from the Ministry of New and Renewable (MNRE), the magnitude of solar energy generation has seen a swell of 1100 percent, being 2.6 GW in the first quarter of 2014, taking a climb to 30 GW in the second quarter of 2019 [4]. Reverse metering system is an important policy in the promotion of use of solar photovoltaics for generating energy. Fig 2 clearly shows the rising installed capacity of solar photovoltaics in India. The government is not the only key player in the field. Corporates have started to

invest and do the installations of solar panels, including its design, and development. The tariff on solar energy generation is very much comparable to the grid now [5]. The corporate installation leader is Tata power solar, trailing by CleanMax Solar. Around 35 percent of the solar market is captured by the top ten solar installation companies. The last couple of years have seen a plunge of around 33 percent in the solar market. To reach its 100 GW solar energy target by 2022, India needs to promote installation of solar rooftop photovoltaic (PV) systems in commercial and residential areas [6].

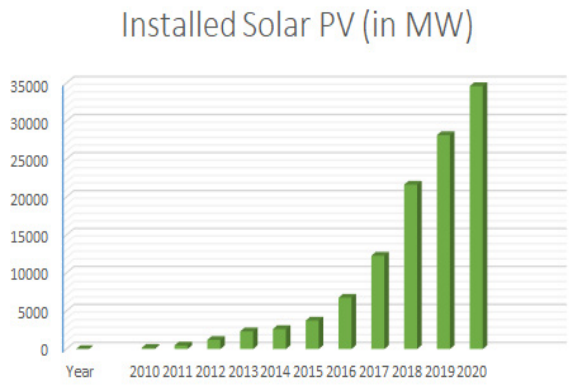

Fig. 2: Installed Solar PV Capacity in India

The rate of energy generation from solar resources is still very lagging compared to the other alternative energy generation sources, leaving aside being at par. The adoption of decentralized models such as placement of solar photovoltaics (PV) systems on rooftops of households, industries and other office buildings are needed to accelerate the energy generation from solar photovoltaics (PV) [8] . India being at the verge of the most populous nation, the conventional sources of energy generation need a helping hand, and solar photovoltaics is the best bet. Nations like Germany, Japan and the USA have successfully implemented energy generation from solar photovoltaics and their tariffs on solar energy generation is at par with the grid [9].

The maintenance cost of solar panels is way less compared to other non conventional sources of energy generation like the hydel or the windmills.Thus solar photovoltaics rooftop is the alternate option of clean energy generation and the bang of the buck [10]. Since India is still a developing nation, the level of awareness of many residents is still very low for the decentralized rooftop solar photovoltaics system. The Indian government has rolled out many schemes and plans for the wide adoption of rooftop solar photovoltaics, setting examples like its installation on public places like the railway stations and airports, and thus made it part of the initiatives like the Make in India [11].

The sole objective of this review is to put light on the contemporary scenario in the field of energy generation through the rooftop solar photovoltaics, the palisades and the way forward. This paper will help understand the vast resources the nation has, will help the people willing enough to unlock the full solar potential and tap on this myriad source of clean energy [12].

II. India's Potential Solar Energy

The location of India in the subtropical belt is an edge to harness solar energy throughout the year. There is a huge potential for solar energy to be developed as the alternative source of energy. Government being well aware about the solar energy potential India has, it has set up the SOLAR ENERGY CORPORATION OF INDIA (SECI), through the MNRE to be responsible for generation, purchasing, forecasting and manufacturing, producing, exporting, importing, exchanging and trading in energy generated and the products involved in the country and around the world [13,14].

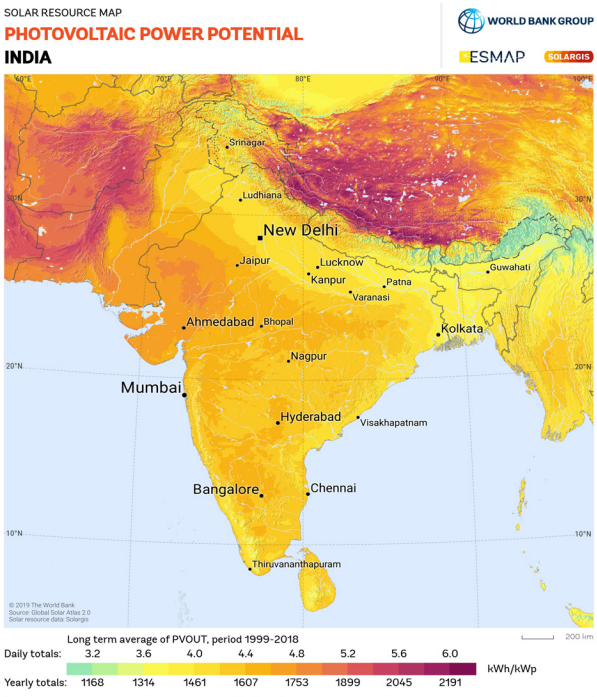

Fig. 3: Solar Irradiance Potential of India (Source:SECI)

As shown in figure 3, the map shows the solar irradiance potential of India. With the fourth largest solar energy generating capacity in the world, and the third largest producer of solar energy in Asia, India is climbing it's way to the global leader in solar energy generation. Also, this is only around 38 percent of the full non renewable energy being employed. The country will also be the proud host of the world's biggest solar energy generating unit, which is being set up in Thar.

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The potential of solar energy generation depends on the climate of the country, irradiance and monsoons being the major influencers. Therefore, the potential varies throughout the year. In the month of January, the irradiance is low in the northern part of the country, while the southern part receives enough irradiance, around 3 - 4.5 kWh/m^2/day to be useful for energy production. In the month of February, the major part of the country receives irradiance in the range of around 5kWh/m^2 while the western and the easter parts of the country still receive irradiance in the 3 to 4 kWh/m^2/day range. As the summer season sets in from the month of April onwards, the entire country gets an irradiance in the range of 5-7.5 kWh/m^2/day. In this phase, the ice laden himalayas receive a minimum of 4.7 kWh/m^2/day of solar irradiance [15].

As the monsoon fades, the potential of solar irradiance also comes to an average of around 3.9 kWh/m^2/day. This decreased irradiance does not affect northern India. The northern part still has an effective irradiance of 5 - 7.5 kWh/m^2/day. After the monsoon, the winter season is set to be for three months. During those months, the irradiance is around 4.5 kWh/m^2/day [16].

III. PV Solar Rooftop Situation in India

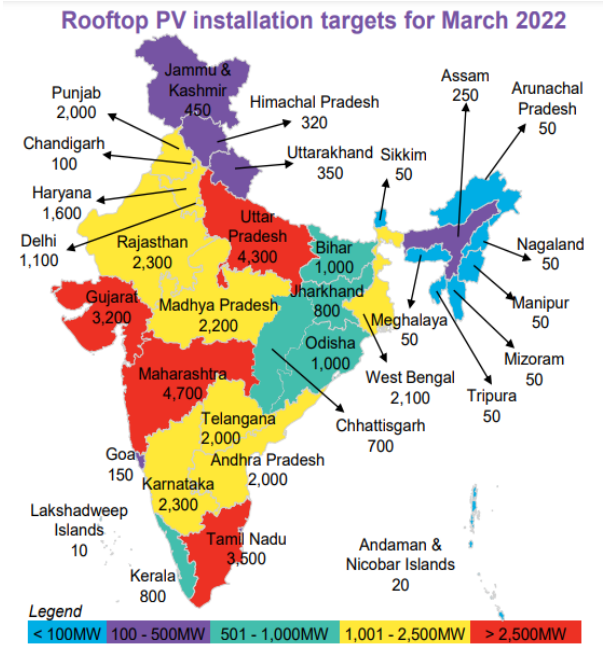

Fig. 4: India's Predicted Rooftop Solar PV Distribution
Source: Bloomberg New Energy Finance

According to Mercom India, the total installed generation capacity was 374.4 GW as of November, 2020. The rooftop solar power is only 2.1 GW, that too 70% of which is commercial or industrial. This makes it very evident that rooftop solar photovoltaics has an enormous potential of growth and must be enhanced to meet domestic energy security [17].

Table 1. List of Major Solar Parks in India

S.No.	Solar Power Park
1	Bhadla Solar Park, Rajasthan
2	Pavagada Solar Park, Karnataka
3	Kurnool Ultra Mega Solar Park, Andhra Pradesh
4	NP Kunta, Andhra Pradesh
5	Rewa Ultra Mega Solar, Madhya Pradesh
6	Charanka Solar Park, Gujarat
7	Kamuthi Solar Power Project, Tamil Nadu
8	Ananthapuramu – II, Andhra Pradesh
9	Galiveedu solar park, Andhra Pradesh
10	Mandsaur Solar Farm, Madhya Pradesh

For the rural and remote areas, solar panels are the best bet. They are capable of energy generation even without connection to the grid. And if the grid is present anyways, reverse metering is the saviour. Individual rooftop solar panels can be installed on houses, thus generating sufficient energy for the needs. The Pradhan Mantri Ujjwala Yojna focuses on lightning up even the remotest of the locations, where there's no other source of electricity. Solar panels can be distributed in those areas. These solar panels provided to the households are enough to meet their energy requirements [18].

To meet the ever growing demand of energy, rather than setting up big solar parks, individual rooftop models are a more feasible and better option for energy generation in India. As per the data from Ministry of Housing and Urban Affairs, India has 34.47 % of yearly urbanization growth rate. Thus, the solar rooftop pv systems may provide an advantage for bringing down the high energy demands in cities from the mains during the peak hours of the day. But the installed capacity of the rooftop solar photovoltaics is minimal in the urban areas, especially in the domestic buildings [19].

IV. Palisades to the Rooftop Solar Photovoltaics in India

The Ministry of New And Renewable Energy, Government of India [7] has in its findings the various factors in the way of tapping the huge solar energy generation potential India has [20]. Power Distributing companies (DISCOMs) are an important factor in the implementation of the government's scheme to widely install solar panels. On approaching the DISCOMs, one can get the solar panel installed on one's rooftop. After investigating, the obstructions in the way of rooftop solar photovoltaics can be majorly drawn into following in India : social, financial and administrative [21].

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1. *Policy and Administrative Factors:* The absence of suitable policy and administration is one of the major reasons which is slowing down the large scale installation of rooftop solar photovoltaics. Amongst policy and regulatory barriers, the keys issues are as follows:
   a. long term planning
   b. clarity in policy guidelines
   c. bankability of ppa
   d. inclusion of hybridization policy for solar thermal technology

   The reverse metering system is not yet implemented smoothly across all the states of the country, making it one of the obstructions. Despite a provision being made in favour of reverse metering, the actual implementation on the ground is far from reality.
2. *Economic Factors:* The initial installation cost involved in the installation of rooftop solar photovoltaics is high. The other equipment involved with the solar energy generation include batteries and inverters which further increase the installation cost. Then there should be a provision for energy storage. These things make the cost higher. Also, the area required to install solar panels is large, if installed on rooftops, cover a substantial chunk of the roof floorThereby increasing the cost and also the installation area [22].These high upfront costs can not be borne by all individuals. So here comes the major role of government, by providing subsidies and also certain incentives, the government can promote rooftop solar photovoltaics installation. Although there are some government schemes providing the same, a lot is yet to be done.

   On an average, a typical commercial building requires around 150 to 200 kilowatts. For installing such a capacity of solar power generation, the cost would range from Rupees 97 lakhs to 1crore 30 lakhs, assuming Rupees 65000/kW. Such a huge expense, not for main business is rarely spent in the commercial sectors [23] .Since the rooftop solar photovoltaics are not immensely popular in the country, and banks still see them as a new project, they are reluctant to fund projects based on them. With the increased perceived risks, the interest rates are very high at around 12.5 percent.
3. *Social Factors:* The consumers do not see the solar rooftop photovoltaics as a reliable technology for energy generation, as it is still a new tech. The expected lifetime returns and the performance of the solar panels over a long time is not known to the consumers yet. So being skeptical about the installation of rooftop solar photovoltaics is very normal. Apart from all these, the companies in the field of rooftop solar panel installations are relatively new. This leads to trust issues between the consumers and the companies [24].

   A major chunk of the country's population is still not aware about rooftop solar photovoltaics and the need for alternative sources of clean energy. Population of the rural areas especially have this misconception that installing rooftop solar photovoltaics will heat up the roof on which it is installed, since they assume that it converts the sun's thermal energy to electrical energy. The government can cross this obstruction through raising awareness among the people, and organizing various campaigns to make people more responsible and understanding about their duties towards the environment.

V. Conclusion

İn this paper, discussed the potential of solar energy, PV rooftop situation in India and Palisades to the rooftop solar photovoltaics in India.To harness this huge potential solar energy, it is also one of the leading nations to come up with schemes of subsidies and also reverse metering. The reverse metering makes the installation of rooftop solar photovoltaics attractive, but more schemes and initiatives are required like subsiding the installation charges and the reducing the tariff for people getting solar rooftop photovoltaics installed. The budget on R&D must be increased to make the manufacturing costs low, thereby reducing the cost of solar panels. Once the installation charges are reduced, the economical obstructions can be crossed. But only the incentives and subsidies are not the way forward. Schemes like Vocal for local and Make in India are an opportunity for India to promote and develop indegenious solar panels, thereby boosting not only the economy, but also promoting rooftop solar photovoltaics installation. Education needs to be prioritised, which will lead to increased awareness and skilled manpower, which in turn will take India from the list of major solar panel importers to the list of top exporters. In the near future, the aware people will readily get rooftop solar photovoltaics installed, and reduce the nation's carbon footprint.

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