A Review on Policies and Challenges Faced in SolarPhotoVoltaic Technology: Indian Perspective

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***Abstract*—The primary goal of integrating and using renewable power in India is to facilitate economic development. The aim is to increase energy access, enhance energy security and at the same time reduce environmental pollution. Solar PhotoVoltaic technology have the potential to provide the same. It provides solution to the long-pending energy problems being faced by developing nations like India. In this research paper, a review on different policies, regulations and installation challenges faced by SPV have been presented. The paper also assesses specific remedies that could be put to use to prevent any hindrance to SPV installations.**

I. Introduction

Solar energy is seemingly the most viable energy sources when using conversion systems in order to produce electricity be it photovoltaic systems or solar-thermal systems [1]. Integrating solar PV into the electrical network requires accurate control of the system. Proper integration mandates changes in the regulatory framework and consistent policies across all sectors in the country. Looking into the history of efforts (illustrated in Fig.1), taken up in India towards developing non-conventional sources, it is observed that around 1970s, energy security concerns were on the peak.

II. Regulations and Policies for Solar Energy: Indian Power Sector

The need to look for alternate energy fuels, apart from oil was realized, but primarily as rural energy program. Soon, India included renewable energy development as a part of five-year economic plans. It was in 1982, that a department was created within the Ministry of Energy which was called Department of Non-Conventional Energy Sources. Till the 1980s, the huge initial cost of the solar PV systems continued to pose a hindrance to their expansion. Nonetheless, the government continued exploring the renewable potential and in 1992 [2], it upgraded the Department of Non-Conventional Energy Sources to a complete independent ministry later renamed Ministry of New and Renewable Energy (MNRE). Renewable technology primarily refers to wind, solar, biomass, wastes (organic and municipal wastes), small hydro etc.

Despite all the efforts, the renewable share in Indian power sector failed to reach the expected peak, which led to a major regulatory structure change where a comprehensive legislation named "Electricity Act 2003" was passed [3]. The incorporation of renewable purchase obligations, renewable energy certificates, feed-in-tariffs, laid a strong foundation for independent power generation. Not only this, the State Electricity Regulatory Commissions (SERCs) were mandated to promote renewable participation in generation by specifying minimum renewable purchase obligation (RPO) of power. The National Tariff Policy of 2005 stipulates the electricity purchase at preferential tariffs (determined by the SERCs). Although more efforts are needed in order to bring RES to compete with other sources in terms of cost. While the Indian government introduces new regulations and norms, there is a dire need to address certain gaps in the existing policy frameworks.

The development of solar photovoltaic power generation would be a source of waste photovoltaic modules which contain heavy metals, close to 1 to 1.2 million tonnes of waste per year [4], i.e. a lack of circulatory principle is observed. While focussing on capacity and generation enhancement of RES based power, a circular economy principle must be followed i.e. no other form of pollution should be caused in an attempt to use renewable technologies [5].

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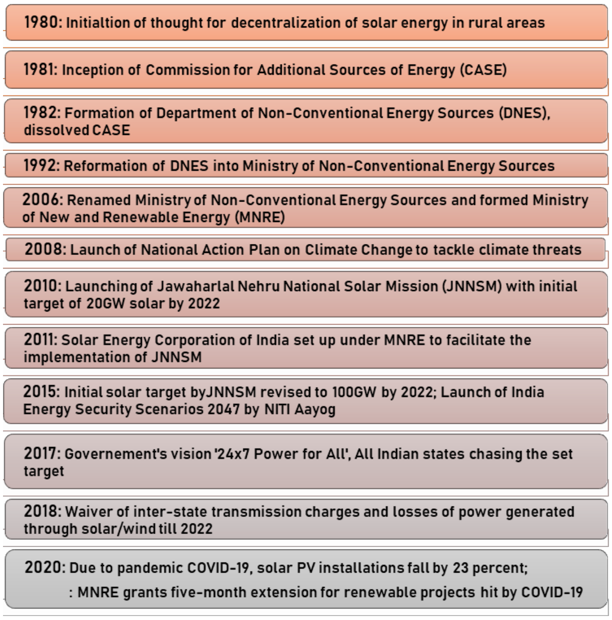

Fig. 1: Solar Energy Milestones in India [6]

Another policy design concern presented in [7], caters to California's residential market and highlights the fact that if solar penetration is encouraged beyond a point, the widespread shift towards generation at consumer end would reduce the demand from utility grid. This could result in lesser demand from the DISCOMs (Distribution Companies) by the customers. As a consequence, the DISCOMs could suffer from overall less demand, leading to recovery of transmission losses from a limited number of customers. This could become a "utility death spiral". A contrary belief states that this may not be as big an issue as the solar rooftop projects could shift help reduce the load demand during peak hours, which would compensate for the additional costs that DISCOMs would have to bear for upgrading their distribution system.

III. Challenges Faced in SPV Installation

In a typical rooftop PV system, the electricity generating PV panels are mounted on the rooftop of a commercial or residential structure. PV modules, solar inverters etc. are included in such systems. The residential building rooftop mounted system typically have a range of 5-20 kW, those on commercial buildings are around 100 kW approx.

In order to build large scale solar parks, which are being setup at a fast pace world-over, large amount of land is required, which is usually located in the outer remote areas of a city. This instils the need to invest more in building the transmission lines which could be the reason for more transmission losses. Huge land is inevitable required for setting up of a mega solar project. As compared to other RES, PV requires more land since the overall radiation energy per unit area is quite meagre, is uncertain and is variable with time. The primary constraint is that the maximum energy availability which ranges from about 1000 to 2200 kWh/m2/yr [8], an average value for Indian climatic conditions. Around 5 to 6 acres of land is required for generating one mega-watt of electricity. Solar projects like Rewa Ultra Mega solar power are built over 4000 acres of land with installed capacity of 750MW, another solar park Kurnool Ultra Mega solar park is spread over 5684 acres of land [8]. The importance of proper PV siting and network optimization is often neglected while planning rural microgrid networks. Choosing an optimal location is vital because non optimal locations could result in an increased power loss and reduced reliability level. The study conducted in [9] aims to address the gap in planning of PV microgrids meant for rural electrification purpose.

Penetration of solar PV development primarily for utility scale solar energy has increased interest among researchers in understanding the environmental interaction with the solar energy development. One of the major challenges in the utility scale solar energy projects is the issue of generation intermittency and efficient usage of land. On a broader scale, solar PV systems could either be categorized as distributed scale or at a utility scale. The distributed systems here refer to the solar PV systems meant to serve a small scale, localized energy demand and could be stand-alone systems [10]. In this work, the focus is laid on the grid-integrated PV systems i.e., the utility scale solar energy systems. Such systems are large and necessitate large flat space and thus there is a dire need to create a trade-off between development and sustainability of the natural environment. The overall footprint of a solar system encompasses all the areas that are directly transformed due to the installation of the solar PV system [11].

One of the major issues that needs to be addressed in order to promote high PV penetration is the impact that these panels have on the power quality. PV panels could potentially cause current & voltage imbalance, harmonic distortion and also unwanted voltage rise [12]. The rise in penetration of photovoltaics in Low Voltage (LV) grid is a bit alarming for the distributed network operators. There is a resilience in allowing more PV proliferation due to the negative effects like increase losses, issues in protection, transformer rating issues and reverse power flow etc. This could be a potential threat to the traditional LV grid. Thus, it necessitates the accounting of uncertain variables and implementation of stochastic assessment techniques needed for the analysis of power quality. The need for novel stochastic techniques, thus, cannot be ignored, for this would ensure low computational costs as well. Through this work, the researchers intend to bring to light not only the outstanding technical issues but also review the potential solutions to each of these problems

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which hamper higher PV penetration. Voltage Imbalances: One of the most researched and major affected parameters while including solar PV plants into the system is the voltage imbalance. Higher PV penetration may cause either under or over voltage issues in the system buses or nodes [13]. An in-depth analysis of the impact of high PV penetration on the voltage imbalance is conducted in [14].

There could be environmental issues associated with solar integration. A lot of factors influence the output of the solar PV panel, ranging from geographical location to which technology is used to tap solar power. Since large solar parks require a large amount of land, this could potentially cause land degradation and loss of habitat [15]. The total land requirement for solar farms could vary from four to eight acres per megawatt. The manufacturing of PV cells involves many hazardous chemicals like sulfuric acid, hydrochloric acid, acetone, etc. The workers too may get affected by exposure to silicon dust [15].

IV. Conclusion

The potential solution to the land requirement lies in efficiently utilizing the available land i.e., by maximizing the energy yield from the land being utilized. This would also help recover the cost of the land and would nonetheless mitigate atmospheric CO2 levels, by reducing emissions. The lands where energy transformations happen, in a way increase the carbon uptake or potentially lead to afforestation. Thus, incorporation of sustainable practices would further obviate any adverse effects that may affect the environment due to the large land usage. A lot of power quality issues arise due to SPV integration with the main grid. The authors in this work conclude and review various methods and techniques that could be implemented to prevent the same. With the optmized planning and power electronic converters, it is possible to manage the challeneges faced in SPV installation. This would reduce the burden on the utility grid for genrating mor power and hence reduce the overall demand-supply energy gap faced by developing nations.

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