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Technical Issues in Grid Connected Solar Photovoltaic Roof Top system: A Review

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Abstract: ***The worldwide depletion of fossil-fuel resources has necessitated an immediate search for renewable energy sources to satisfy tomorrow's demand. Present expectations for renewable portfolios are modifying power systems by replacing conventional generation with clean energy options such as photovoltaic (PV) systems. Solar energy is a clean, inexhaustible and environmentally sustainable fuel among all green energy choices. For the sustainable growth of electric power, the use of green energy systems such as SPV power plants offers reliable power throughout the day. If the SPV power plant is installed into an interactive grid system, the power during non-solar time is imported from the grid and the surplus energy during solar time is fed into the grid. As a result, in order to meet load demand, grid-connected power system networks are now being deployed, integrating solar and utility grids, where the grid serves as an energy storage facility. In this review article the technical issues associated with grid integrated roof-top PV systems and current scenario of generation of solar power in India is discussed.***
Keywords: Solar energy, Solar Roof Top PV system, Renewable energy sources, Grid Connected system, Technical issues

I. INTRODUCTION

Renewable energy initiatives are primarily developed to address the rising energy needs of rural communities and the promotion of decentralised and hybrid growth in order to curb the growing movement of rural residents to urban areas in search of better living conditions. Due to the exponential rise in energy demand, the exponential decline of earth's fuel supplies, global warming and the harm to existence of traditional energy sources, it is important to transition into renewable energy sources. Promoting and improving renewable green energy sources, such as solar energy generation, wind energy, hydropower, bioenergy and geothermal energy, etc., has drawn the attention of government and private stakeholders to meet the rising need for energy and technology growth for the future [8]. India is endowed with large amounts of solar radiation, a diversity of crops and climatic conditions, large coastal areas and future river systems that offer the best conditions for developing renewable energy. The various Distributed Generations (DGs) which are renewable in nature with a wide spectrum range of few kW and 20 MW are gradually involved and rapidly developing and the interest of researchers and utilities has been seen. Among several renewable energy sources, the DG SPV system is the most cost-effective option for future energy needs [1]. Due to many benefits of solar PV systems, such as the universal availability of solar energy in the world, cost-free, ample, low maintenance. Solar PV DGs collect energy from the sun [1].

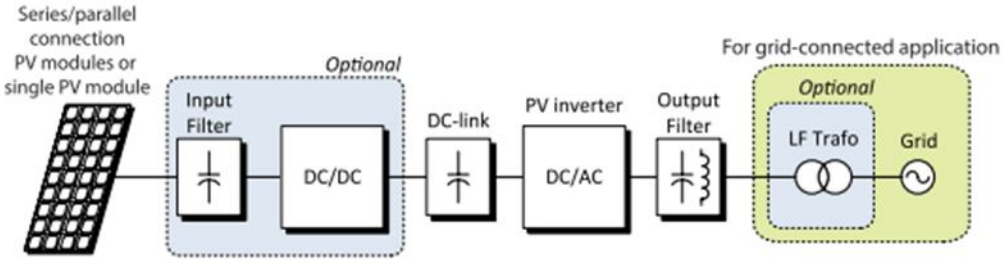

Fig.1: Normal scheme of a grid-connected or standalone PV system application [1]

Certain problems arise due to the integration of large or small systems such as: control of voltage, variation in frequency or power, PQ issues, stability and security issues, synchronisation, grid economy, efficiency, reduction in cost, etc. For each generation of power scales, inverters have been used. It is commonly used to link the PV system to the utility grid [1]. Due to the incorporation of PV systems into the power grid, the inverters should have unfavourable insulation protection, which ensures that the inverters should interrupt the supply of electricity directly when the power grid is under restoration [1]. Grid tied inverters normally are checked for unfavourable insulation conditions at the time of assembly to check the connection and disconnection without any damage to the main grid.

II. TECHNICAL ISSUES IN GRID INTEGRATED POWER SYSTEM NETWORK

All The technical issues are addressed, such as:

A. Low Quality in Power Supply (Due to Generated Harmonics and Frequency and Fluctuations in Voltage)

Power Quality efficiency (PQ) of low voltage grid-tied solar PV system can be seen as an important step towards quality of supply. The installation of a PV system with low PQ disruptions is critical for low voltage customers. One of the most common PQ disruptions in the power system is the current and voltage distortions called harmonics. Complete voltage harmonic distortion (VTHD) and total current harmonic distortion (ITHD) are found under various conditions in the harmonic analysis related to distribution networks. The harmonics content is best defined as total harmonic distortion (THD) and total demand distortion (TDD). It has been found that the measured THD is higher when the energy is absorbed by the loads and the solar irradiance is low. This could lead to a situation in which the low voltage consumer with a PV system could be penalised by the utility. At higher solar irradiance and high load consumption, the THD values of the grid are very low and are within reasonable limits as per the norm. The TDD result of the grid-tied PV device remains at a lower level, regardless of whether it is solar. However, according to the extent of solar PV penetration considered, the VTHD levels observed were within statutory limits, although in several cases the ITHD levels were violated. Several studies found solar PV to be key or only means of injection of harmonics, although the results of non-linear loads are omitted.

Table 1. Few Prominent issues related to Solar PV due to power quality

Power Quality Metric	Source of Metric
Flickering	Variations of the solar PV generation[3]
Slow change in voltage variations	Power flow variations[3] • Apparent motion of the position of the sun, change in cloud cover[3] Shading effects[3]
Fast voltage variation	High capacity solar PV[3] Tracking systems[3] Intermittency of the power generation due to change in climatic conditions[3]
Over- voltage	Solar generation (or any DG) increases voltage at terminals of the generator[3]
Low order harmonics	Harmonic network impedance affected by solar PV inverters [3] Primary emissions determined by the control algorithm of the inverter[3] Secondary harmonics caused by the background distortion and the input impedance of the inverter[3]

B. Imbalance in Voltage

Based on the IEEE Recommended Practice for the Utility Interface of Photovoltaic Systems, PV inverters would be allowed to connect to the grid under standard network voltage conditions which are between 88-110% of the nominal voltage and shut down above these thresholds. In addition, PVs can work at a power factor greater than 0.85 (lag or lead) when their output is greater than 10% of the rating. Utilities aim to reduce the imbalance index of their network by dividing single-phase loads evenly over all three stages, or also by reconfiguring the network. Probabilistic tests have demonstrated that it is very unusual for residential and small business loads to result in higher voltage mismatch values in the network.

Normally, PVs are placed randomly between residential loads, so it is assumed that overall power generation and positions will vary significantly from one network to another. It is not even shocking, for example, that 80, 50 and 10% of all customers have installed rooftop PVs at each point.

C. Security and Stability Issues

Power Routers are simply devices connected to the grid. With the Energy Router in the house, the "attack surface" for the grid is increasing exponentially, so protection needs to be well planned. Protection includes consideration of (1) intrusion into the Energy Router (host intrusion detection and prevention) and (2) upgrade of the "Over the Air" (OTA) firmware. Embedded systems such as an Energy Routers do not require frequent updates. So, a whitelisting strategy is feasible. In addition, some new Linux kernel features include container based virtual machine features (starting with kernel 2.6.24 in 2007) through namespaces and C-groups [4]. There are several academic papers on cyber security problems for grid-connected PV networks. In studies data integrity assaults on PV-free voltage regulators. The effect of cyber-attacks in Transient reliability of power grids with traditional voltage support systems is studied. The cyber security problems posed by distributed energy resources (DER) are summarised. In provides a way of identification of voltage sensor attacks in Distribution networks of PV units. Despite these reports, hazards and challenges related to PV structures with ancillary facilities have not yet been discussed [4].

III.SOLAR POWER GENERATION: PRESENT SCENARIO

Since the sunlight required to fulfil our energy needs in the future is ample, many scientists are stressing the value of solar energy. Sunlight is considered an alternative source of electricity, such as hydrogen and wind. Solar power has the potential to turn environmentally sustainable electricity into a more flexible, popular and cheaper energy supply. Solar power is widely used in many applications, such as water heating systems, satellite power systems. Solar systems have been strongly attractive options for domestic, business and industrial applications for both stand-alone and grid-connected operations. The average nameplate performance of the standard 72-cell multi-silicon module was approximately 290 watts in 2010. Today, customers can expect at least 345 watts at one tenth of the 2010 price.

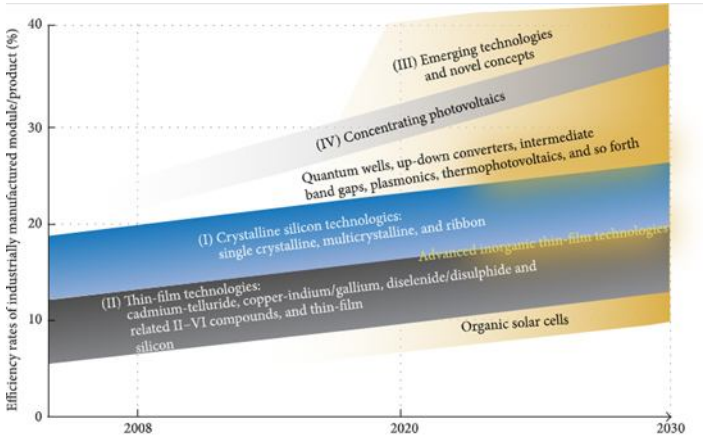

Fig. 2 Evolution of different types of solar photo voltaic cells from 2008-2030

Solar power is a fast-growing industry in India. The country's solar installed capacity as of 31 August 2020 was 35,739 MW. The Indian Government had an initial 20 GW capacity target for 2022, which was four years ahead of schedule. In 2015, the target was increased to 100 GW of solar capacity (including 40 GW of solar roofing) by 2022, targeting an investment of US$ 100 billion [6]. India has set up nearly 42 solar parks to make land accessible to solar plant developers. Rooftop solar power accounts for 2.1 GW, of which 70% is industrial or commercial [6]. In addition to its large-scale grid-connected (SPV) initiative, India is developing off-grid solar power for local energy needs [6]. Solar products have increasingly helped to meet rural needs; by the end of 2015, just below one million solar lanterns have been sold in the country [6].

IV.CONCLUSION

Modern energy sources have a detrimental environmental impact and are thus not suitable for the economy of the world. Now is the time to move towards non-traditional sources. This paper presents the different practical and nontechnical issues in the interconnection of rooftop solar PV DG to the power grid. Power quality difficulties resulting in high integration of solar PV rooftops in power distribution network. The current situation of solar power production in India has also been discussed in this article.

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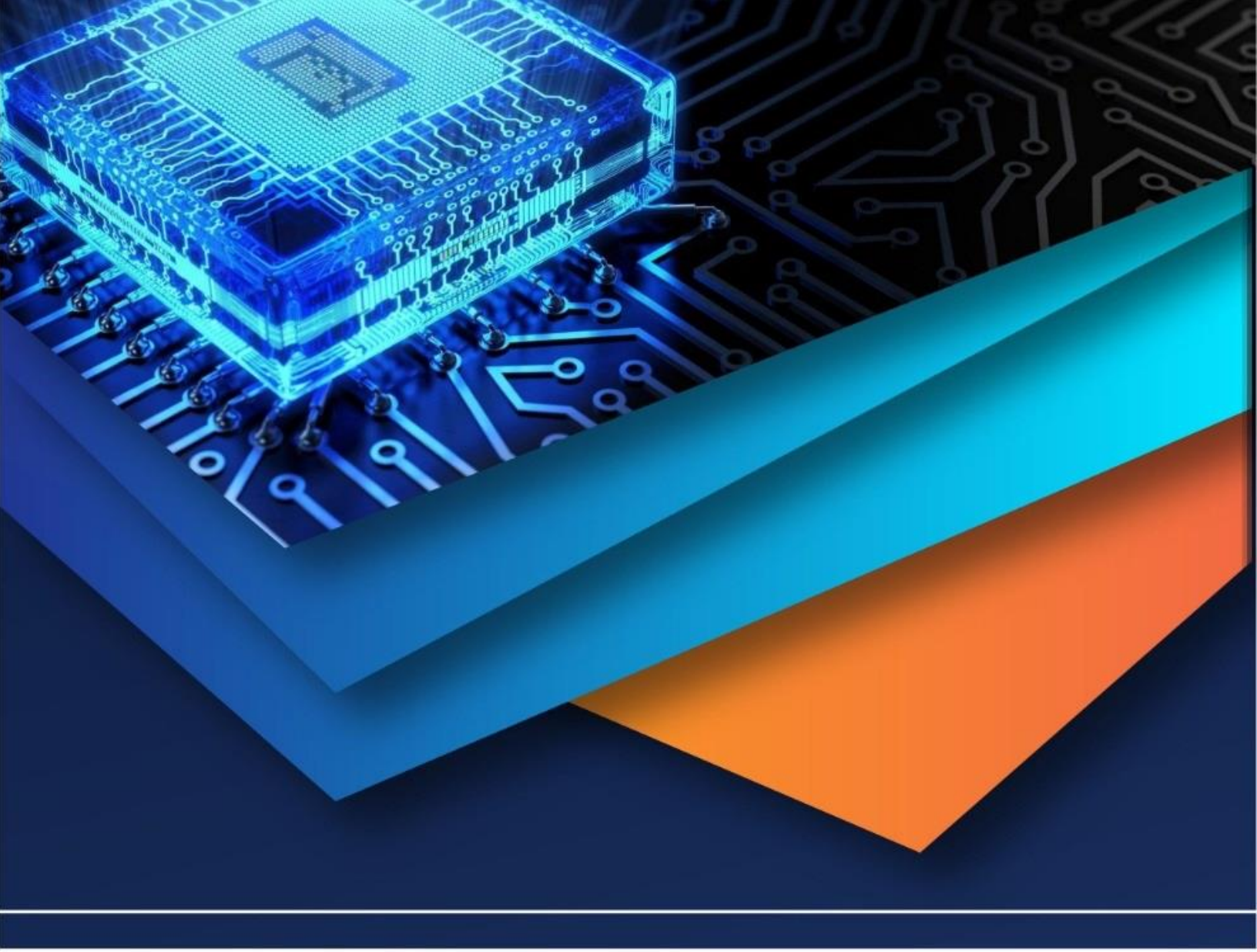

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