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Grid Integration of PV System: Issues, Challenges and Opportunities

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***Abstract*—The constant increase in electricity demand, as well as the depletion of fossil resources, has prompted research into alternate energy sources. Solar photovoltaic (PV) systems are gaining popularity in the renewable energy area due to their size, installation, and ability to operate both off and on the grid. As a result, solar roof tops with grid integration are gaining popularity in India. Many FACT devices must be interfaced with power electronics converters in order to integrate such renewable energy sources with the grid. Power quality requirements such as voltage imbalance, voltage regulation, power factor, harmonics, and others have become more significant since the development of power electronics switching devices. Overall, the distributed generation option increases power quality concerns when integrated with the grid. This paper focuses on opportunities, challenges and issues related to the grid integration of solar PV systems**.

***Index Terms*— Solar PV, Micro grid, FACT devices, Power quality**.

I. INTRODUCTION

PV power generation is growing in India, despite the fact that solar photovoltaic cell generation is expensive due to the initial capital costs. As part of the National Solar Mission, the Government of India provides many incentives for solar power plants and also supports the policy regulatory structure in many states. The main advantages of solar grid integration are increased grid efficiency, stability and less transmission & distribution losses, etc. As a result, solar installations are carried out after a thorough survey to ensure that all necessary and sufficient parameters are fulfilled. The integration of a solar PV system with the grid, on the other hand, has always been difficult. The process of power transmission from renewable energy sources to the grid is known as renewable energy grid integration.

The demand for energy in developing countries is growing at a rate of 5% each year. The geography of India makes it an excellent choice for solar energy harvesting. India's energy demand is expected to surge in the coming years due to its enormous population and economic activities [1]. India, as a rapidly developing nation, is currently undergoing transformation in solar market . As of December 2020, the country's total solar installed capacity was estimated to be 38.5 GW. In India, the National Solar Mission and policies have been declared, with the goal of achieving 100GW of installed solar capacity. This sector mostly consists of major solar projects and even larger solar utilities that produce power in a central location and deliver it to the grid. In comparison to other leading solar countries, India's rooftop solar systems are substantially lower in comparison with overall solar installations. [2].

In recent years, the government has introduced several of the laws and programs aimed at increasing the

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adoption of solar photovoltaic systems. Solar street lights and solar rooftops are now being installed in greater numbers as a result of these efforts.

PV energy systems are thus fast growing and contributing significantly in most regions and power system. Around 99% of the installed capacity is accounted for by Grid linked PV systems throughout the world. The battery less grid-connected PV is cost efficient and almost maintenance-free. For grid-connected PV, batteries are not needed as the power produced is uploaded to the grid for direct transmission, distribution and consumption. This eases the pressure on other sources that supply the grid with electricity. The output ratio of the grid-connected PV system is calculated. The integration of PV system with grid introduces small quantity of harmonics [3].

The solar PV energy generation is uncontrolled as it depends on solar radiations. Hence the power generation is intermittent and inconsistent. This forces further challenges in PV integration with grid.

II. PV - GRID INTERFACE ISSUES

A. Power Quality

The power quality is most important aspect of the power system. The power quality standards are defined for various power quality parameters like voltage distortion, sag & swell, flicker, transient, unbalance, interruptions, harmonics, power factor etc. by IEEE and many standardizing authorities [5, 6, 7]. It is to be noted that the power quality parameters shall be within 5%.

B. Power Fluctuations

The intermittent nature of solar radiations causes interruptions in grid interfacing. Interruptions and power fluctuations causes malfunctioning of protective switchgears, poor voltage regulation, reverse power flow and hampered power quality in distribution systems. The power fluctuations can be reduced with the help of battery storage and stabilizers. Power interruptions and fluctuations further places limit on reliability and profitability of consumers. This also hampers the productivity and quality [8].

C. Variations in Energy Generation

Apart from interruptions, solar PV installations give variable power generation. The magnitude of variance is significant in case of large solar installations. This places limits on demand – supply proportions [9].

D. Frequency Control

The frequency of the power system is determined by the balance between the load and the output power. With frequency decreases in large interconnected networks, output power rises and vice versa. The first frequency control line is the local governor, supplying the system with "reserve power flow". Frequency controller and synchronizing techniques with PID control and other control algorithms are used for frequency governing.

E. Speed of variations

Not of the magnitude, but the speed of variation in power generation occurs in solar PV systems. Small rate of variation is easily tolerated in grid system but larger rate of variation in power generation results in fast power fluctuations [9].

F. Forecasting

PV generation is making rapid inroads in electricity grids with rapid growth. Variability and uncertainty being the key challenges, the output power generation is subjected to variance. Forecasting helps the power management for grid system planning to ensure reliability and consistency. For PV forecasting statistical, physical and hybrid approaches are in practice [10, 11].

G. Location

Depending on location, the availability of solar radiation can vary. There is significantly more solar radiation in some locations than in other places. This will mean that the production of solar energy relies on those areas where systems need to be installed [12]. The sizing and placement of PV panels needs to be optimized for large installations to have maximum impact on the grid [13].

H. Installation Cost

Being pollution free, solar PV installation needs to be encouraged. High setup cost gives setback for solar installations. For solar PV systems to become competitive with fossil fuels, we must either increase their

efficiency or significantly reduce the manufacturing cost. Many researches are in progress to shift PV panel manufacturing from silicon PV to thin film for cost cutting [14, 15].

I. Safety and Security

The solar installation requires safety procedures to be followed during installation which includes safety of workers as well as solar panels. The safety consideration at design stage includes- safeguarding from hazards of working with electricity, firefighting safety, signs & labeling on equipments. At installation level safety procedures are related to use of personal protective equipments (PPE kits), handling of power tools, following assembly and installation guidelines and location awareness.

III. Challenges in Grid Integration

The energy producing companies are facing challenges in grid integration of PV power pants which includes

A. Voltage Violation

The PV access bus is clearly influenced by changes in solar capacity and location, and distributed photovoltaic generation has a significant impact on it. The voltage will change as solar capacity increases, especially when the load demand is low and the photovoltaic output is high. The influence on PCC voltage will rise as the electrical distance decreases. Changes in insolation under partial shade generate output power variations, which ultimately alter system voltage [17].

B. Increased Demand Ramping

As the PV installation capacity increases, the problem of ramping becomes more apparent resulting in rising power grid issues. At present, the PVs are permitted to inject their entire generated power into the network without violating the network operating limits. However, to curb PV power fluctuations, the utility might either request the PV owners to smoothen PV power output or limit PV generation.

3.3 Simultaneous Tripping and Re-closing

Auto reclosing is a phenomenon in which the breaker tries to reconnect the line between two points with the delay or without delay at the time of the fault. The simultaneous tripping and reclosing may be observed in PV based distributed energy system due to the intermittent nature of PV systems.

IV. Opportunities

Adoption of solar photovoltaic (PV) is on the rise due to a decrease in costs for development of utility-scale solar systems as well as their operations. Despite the decrease in costs, the ability of solar systems to ensure utilities reduce their carbon footprints has driven the growth in their adoption. Solar PV plants allow utility companies to line up with environmental regulations and at the same ensure that their grid systems are stable.

V. Conclusion

The PV integration with grid is challenging. The implementation shall be supported with prior surveys, calculations and design for best possible solution for grid interface. It is to be noted that the best use of government policies and schemes for deeper penetration of the solar PV system is possible with cost efficient installation. For maintaining the power quality standards prescribed by standardizing authorities, power conditioning equipments like active filters and compensation devices are required to be deployed.

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