A Comparative Study on Impact of Photovoltaic Power System and Distribution Generation System for Maximization of Output Power

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ABSTRACT
Distributed generation (DG) has many uses in commercial and industrial field depends on energy uses such as renewable and non-renewable energy sources. But nowadays it is broadly used with wind and solar power. The main motto behind this is to provide a system which is environmental friendly i.e. greenhouse effect, carbon footprint reduction and limited renewable energy sources which increase the cost of fuels in today's scenario. . In photovoltaic (PV) the fluctuation of real power and reactive power is not easily controlled and results give unstable system. The variation in voltage also gives the tripping of PV unit during disturbance which is a large disadvantage of distribution system.

Keywords:
Distribution generation, voltage fluctuation, Q-Margin

1. INTRODUCTION
Distributed generation (DG) generate electricity from many small energy sources. Most countries generate electricity in large centralised facilities, such as fossil fuels (coal, gas), nuclear power, large solar power plants and hydro power plants. DG allows collection of energy from many sources and may give lower environmental impact and improved security of supply [1, 2].

Integration of DG in the present scenario will helped to us because it is highly durable and reliable system, there is not any extra requirement of transformer and substation to implement the DG, its increase the area of power reliability, it provide the supply in emergency, total apparent power is increase, increase power efficiency and reduce losses which provide total utilization of grid [3, 4].

DG has large area of uses in distribution system; it's not complex and has similar characteristics to an active transmission network. To use a huge amount of benefits from DG it's important to know both positive and negative impact of DG on distribution network. Power efficiency, durability, reliability and stability will help us to improve the future power scenario. The impact of DG on the local voltage level can be significant [5]. The increase in solar power and wind power has led to significant modelling and analyses of the distribution system. Photovoltaic power plants are increase as a renewable source due to its more advantages.

With respect to other electricity generating technology, photovoltaic (PV) are still more expensive. In PVs the fluctuation of real power and reactive power is not easily controlled and results give unstable system [6]. The variation in voltage also gives the tripping of PV unit during disturbance which is a large disadvantage of distribution system. In generating station we use synchronous generator (SG) which is important in security and stability point of view. During any fault or variation the speed governor and AVR/exciter regulate the frequency (active power) and terminal voltage (reactive power) of the SG, so that the stability of network is maintained. The factor which affect mainly is variation in voltage and stability.

Contingency analysis is a key function of security assessment which involves predicting and mitigating potential failure in distribution network [7]. These contingency is measured by interconnection of several system feeder and measure in the form of single and multiple outage and all other failure condition. Some of the internal and external causes are responsible for equipment outages. Internal faults are due to insulation breakdown, over temperature, over voltage operation or other human imperfection. The external causes results from some environmental effect such as clouding, lightning, ice or stormy condition, birds and animal contact or other object which is in direct contact.

2. A STUDY OF QV METHOD
A 16-bus 3-feeder distribution test system as shown in figure 1 is used in this study. The total load on the system is 28.7MW, 17.3MVAr. Two PV generator one at bus 2 and other at bus 3, are connected to the distribution system. The inverter connected PV systems have their own reactive power capability; they are not allowed to operate in voltage control mode to avoid controller interactions. To obtain maximum real power into the system, small PV units are worked at unity power factor. So the study is based on unity power factor.

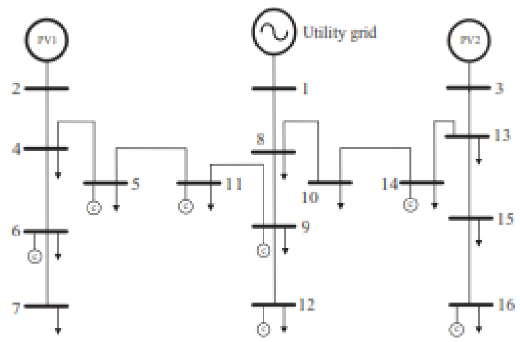

Fig. 1: Single line diagram of 16-bus distribution test system

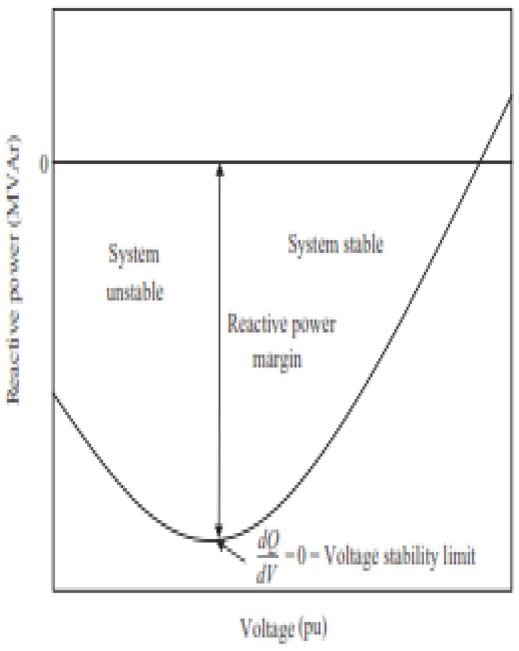

Fig. 2: Typical Reactive Power-Voltage (Q-V) Curve

According to QV method [8], the voltage magnitude (V) increases as the reactive power (Q) injection at the same bus bar is increased, in this condition the system is stable. But if the voltage of any bus decreases and the reactive power is increases at the same the system goes to unstable mode. By this analysis we found the critical point and reactive power margin (Q-margin). If the value of Q-margin is high the system is less reliable to voltage collapse as shown in figure 2 [9].

2.1 Impact of High PV Penetration:

The penetration level of PV ($\%PV_{penetration}$) is given by

$$\%PV_{Penetration}= [P_{PV}/P_{Load}]x100 \qquad (1)$$

Where P_{PV} is total power delivered by PV generators and P_{Load} is peak load demand. As the penetration level of PV increases, static voltage stability of system increases.

3. CHARACTERISTICS OF PV SOLAR CELL

The solar generation can use PV flat plate collectors and produce fluctuation of power generation with a sudden loss of apparent power output with partial PV array clouding, the major power fluctuation results at the output of the PV solar facility due to blocking of complete array string if one module is shaded [10]. Some data of power output from utility scale PV solar farms are presented below. It is clear that these type of power variation on large scale can produce several power quality and power fluctuating problems.

Recently a US utility installed large 2MW utility scale power plants on ware house roofs [11]. The power output from such a 2MW utility scale PV power plant, which was monitored over several months and characteristics of a day is presented in figure 3. The main reason of large power fluctuation is due to storm, fog or clouding which is overall loss of stability, power quality, low capacitor factors and power fluctuation etc. The complete operating experience will provide the better use of PV solar energy into a balancing and regulated generation.

If we try tour best then large penetration of distributed PV solar generation can be used. Overload on highly loaded distribution feeder and release capacity on these feeders and substation transformer.

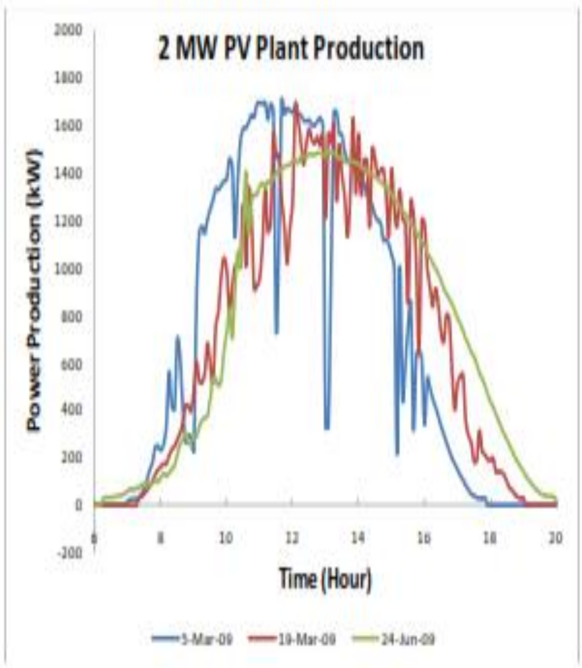

Fig. 3: 2MW PV Solar generation profiles during 3 days in southern California.

A company named Petra Solar has deal in a new renewable energy technology that generates power through PV solar modules on utility, street light that can hold one or more PV module such as rooftops which have not cover any extra space. Petra Solar's SunWave™ photovoltaic (PV) systems not only feed distributed renewable energy into the electric grid, but also introduced a smarter grid connection with associated communications, remote sensing, grid management and control.

These Smart Grid features improve grid operation efficiency with very limited grid impacts due to the highly distributed nature of the generation and intelligent inverter control. The grid-tie distributed nature of the SunWave™ systems also reduces the cost of interconnecting PV on the utility grids. The AC module with micro-inverters furthermore increase the energy harvesting compared to a string inverter design by approximately 20 - 30% as independently measured by Berkeley [12].

4. VOLTAGE FLUCTUATION

Voltage rise induced by PV generation was presented in the National Renewable Energy Laboratory (NREL) report [13]. A study is shown the result of fluctuation of voltage. Where a PV panels which is all 720 kWp are located on the top of two neighbouring buildings generally called central station mode. Cloud coverage of the entire system is likely to happen in this geographical area. If the cloud is coming in the region the voltage of the PV module is decreases and if the cloud is leave the module will increase the voltage.

4.1 Voltage Drop Analysis

Voltage drop occurs when PV power swings from a high level to a lower level within a short duration. This represents the instance when cloud moves into the area of the solar power site. In order to capture the worst case for this instance the loading level is simulated at its maximum. The study states that the slack bus voltage at substation 7 is set to 0.972 pu, which was the lowest recorded voltage measured on CB2111 at 10am from the network data information. There are three options for PV installation – Substation 11 high voltage side, Substation 11 Transformer 1 and Transformer 2 low voltage side. Since Transformer 1 has a lower voltage ratio, its voltage drop will not be as serious as that of Transformer 2 if solar cells are installed on the low voltage side. Therefore, PV connection to the low voltage side of Transformer 1 is not considered.

4.2 Voltage Rise Analysis

For voltage rise situation, the network is carrying minimum load which is a condition set for this simulation to reflect the worst case scenario for voltage rise. The sun radiation is simulated to increase from $70/m^2$ to $1000/m^2$ within 20 seconds to reflect the scenario when clouds leave the PV site. The voltage at substation 7 the slack bus was set to 1.02 pu. This was the highest recorded voltage measured at 3pm on CB2111 at substation 7. For the similar reasoning in voltage drop analysis, two connection options for the PV system are studied – the low voltage side and high voltage side of transformer 1 at substation 11.

5. CONCLUSION

Although DG has several potential benefits, the connection of it in the existing distribution network will increase the fault level of the system. The study shows that loss of multiple PV generators, overloading and line outages from a distribution network can be a risk for the system stability. System planners must ensure that minimum margin can be maintained at all times to operate the system reliably under abnormal conditions. This paper has presented some of the challenges and benefits of integrating large-scale distributed PV power plants. To mitigate the negative aspects, highly distributed PV generation with Smart Grid features are proposed and implemented.

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