

Power Quality Issues of Wind and Solar Energy Systems Integrated into the Grid

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Abstract— This paper emphasis on the integration of wind and solar energy into existing power system, which highlights the technical challenges i.e., power quality issues and non technical challenges. The renewable energy sources have increased significantly due to environmental issues and fossil fuels elevated cost. Integrated power grid is an electric power system formed as a result of the integration of several individual power grids. The individual member systems retain their separate functions, but their operations are supervised by a single control centre. Some of the challenges and issues associated with the grid integration of various renewable energy sources particularly solar photovoltaic and wind energy conversion systems are discussed. Due to the wind speed's uncertain behaviour it is difficult to obtain good quality power, since wind speed fluctuations reflect on the voltage and active power output of the electric machine connected to the wind turbine. Solar penetration also changes the voltage profile and frequency response of the system and affects the transmission and distribution systems of utility grid. The increasing number of renewable energy sources and distributed generators requires new strategies for the operation and management of the electricity grid in order to maintain or even to improve the power-supply reliability and quality. The technical issues for small scale generation and large scale generation; some of the non technical issues has been discussed.

The main objective of the paper is to deal with the technical details involved in the generation of power through wind technology and choice of generators and their social, economic and environmental advantages and disadvantages and their control strategies.

Keywords— power quality issues, grid connected PV systems, grid connected wind energy system

I. INTRODUCTION

Renewable energy sources such as solar, wind, geothermal, biomass etc. are available in plenty in nature and are not replenished. As the share of electricity produced from variable renewable resources grows, so does the need to integrate these resources in a cost-effective manner, i.e., to ensure that total electricity production from all sources including variable renewable generation equals electricity demand in real time. The factors such as rapidly declining costs of electricity produced from renewable energy sources, regulatory and policy obligations and incentives, and moves to reduce pollution from fossil fuel-based power generation, including greenhouse gas emissions. While not all renewable energy sources are variable, two such technologies – wind and solar PV – currently dominate the growth of renewable electricity production. The production from wind and solar PV tries to capture the freely available but varying amount of wind and solar irradiance.

The grid must have standard conditions of supply to ensure that end-use equipment and infrastructure can operate safely and effectively. These conditions are commonly referred to as power quality requirements. They most commonly relate to voltage and frequency regulation, power factor correction and harmonics. In all distribution networks, challenges to maintaining these power quality requirements arise from the technical characteristics and end-user operation of electrical loads. Some loads have significant power demands that increase network current flows pulling down line voltage (such as electric hot water heaters and large air-conditioners). Some have very major power draws on start-up (such as standard induction motors) driving voltage fluctuations. Some loads have significant reactive power needs (again including motors) or create significant harmonics (such as computer power supplies and fluorescent lighting). Power quality at different points of the distribution network at any time is impacted by the aggregate impacts of loads and network equipment in highly complex ways.

Energy is the prime, plus mainly widespread gauge of all kind of exertion by humans as well as environment. Due to brisk boost in the population and average of living, we are faced with energy calamity. Conventional sources of energy, are increasingly depleted. Hence, Non Conventional Energy Sources have emerged as prospective source of energy in India and world at large. Among the various non-conventional energy sources, wind energy is emerging potential major source of energy for growth.

The paper is organized as follows. The Section II introduces the power quality overview. The Section III introduces the power quality issues of wind and solar energy systems integrated into the grid. The Section IV explains the pros and cons. The section V explains conclusion.

II. POWER QUALITY-OVERVIEW

Power quality is defined as “the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment.” All electrical devices are prone to failure or malfunction when exposed to one or more power quality problems. The electrical device might be an electric motor, a transformer, a generator, a computer, a printer, communication equipment, or a household appliance. All of these devices and others react adversely to power quality issues, depending on the severity of problems. A simpler and more concise definition might state: “Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy.” This definition embraces two things that we demand from an electrical device: performance and life expectancy. In light of this definition of power quality, this chapter provides an introduction to the more common power quality terms along with descriptions, causes and consequences of the terms.

A. VOLTAGE SAG (OR DIP)

Description: A decrease of the normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for durations of 0, 5 cycle to 1 minute.

Causes: Faults on the transmission or distribution network (most of the times on parallel feeders). Faults in consumer's installation. Connection of heavy loads and start-up of large motors.

Consequences: Malfunction of information technology equipment, namely microprocessor-based control systems (PCs, PLCs, ASDs, etc) that may lead to a process stoppage. Tripping of contactors and electromechanical relays. Disconnection and loss of efficiency in electric rotating machines.

B. VERY SHORT INTERRUPTIONS

Description: Total interruption of electrical supply for duration from few milliseconds to one or two seconds.

Causes: Mainly due to the opening and automatic reclosure of protection devices to decommission a faulty section of the network. The main fault causes are insulation failure, lightning and insulator flashover.

Consequences: Tripping of protection devices, loss of information and malfunction of data processing equipment. Stoppage of sensitive equipment, such as ASDs, PCs, PLCs, if they're not prepared to deal with this situation.

C. LONG INTERRUPTIONS

Description: Total interruption of electrical supply for duration greater than 1 to 2 seconds.

Causes: Equipment failure in the power system network, storms and objects (trees, cars, etc) striking lines or poles, fire, human error, bad coordination or failure of protection devices.

Consequences: Stoppage of all equipment.

D. VOLTAGE SPIKE

Description: Very fast variation of the voltage value for durations from a several microseconds to few milliseconds. These variations may reach thousands of volts, even in low voltage.

Causes: Lightning, switching of lines or power factor correction capacitors, disconnection of heavy loads.

Consequences: Destruction of components (particularly electronic components) and of insulation materials, data processing errors or data loss, electromagnetic interference.

E. VOLTAGE SWELL

Consequences: Data loss, flickering of lighting and screens, stoppage or damage of sensitive Description: Momentary increase of the voltage, at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds.

Causes: Start/stop of heavy loads, badly dimensioned power sources, badly regulated transformers (mainly during off-peak hours) equipment, if the voltage values are too high.

F. HARMONIC DISTORTION

Description: Voltage or current waveforms assume non-sinusoidal shape. The waveform corresponds to the sum of different sine-waves with different magnitude and phase, having frequencies that are multiples of power-system frequency.

Causes: Classic sources: electric machines working above the knee of the magnetization curve (magnetic saturation), arc furnaces, welding machines, rectifiers, and DC brush motors. Modern sources: all non-linear loads, such as power electronics equipment including ASDs, switched mode power supplies, data processing equipment, high efficiency lighting.

Consequences: Increased probability in occurrence of resonance, neutral overload in 3-phase systems, overheating of all cables and equipment, loss of efficiency in electric machines, electromagnetic interference with communication systems, errors in measures when using average reading meters, nuisance tripping of thermal protections.

G. VOLTAGE FLUCTUATION

Description: Oscillation of voltage value, amplitude modulated by a signal with frequency of 0 to 30 Hz.

Causes: Arc furnaces, frequent start/stop of electric motors (for instance elevators), oscillating loads.

Consequences: Most consequences are common to under-voltages. The most perceptible consequence is the flickering of

lighting and screens, giving the impression of unsteadiness of visual perception.

H. VOLTAGE UNBALANCE

Description: A voltage variation in a three-phase system in which the three voltage magnitudes or the phase-angle differences between them are not equal.

Causes: Large single-phase loads (induction furnaces, traction loads), incorrect distribution of all single-phase loads by the three phases of the system (this may be also due to a fault).

Consequences: Unbalanced systems imply the existence of a negative sequence that is harmful to all three phase loads. The most affected loads are three-phase induction machines.

III. POWER QUALITY ISSUES OF WIND AND SOLAR ENERGY SYSTEM

INTEGRATED INTO THE GRID

A. GRID CONNECTED PV SYSTEMS

A grid-connected PV (photovoltaic) power system is electricity generating solar PV power system that is connected to the utility grid. A grid-connected PV system consists of solar panels, one or several inverters, a power conditioning unit and grid connection equipment. They range from small residential and commercial rooftop systems to large utility-scale solar power stations. Unlike stand-alone power systems, a grid-connected system rarely includes an integrated battery solution, as they are very expensive. When conditions are right, the grid-connected PV system supplies the excess power, beyond consumption by the connected load, to the utility grid.

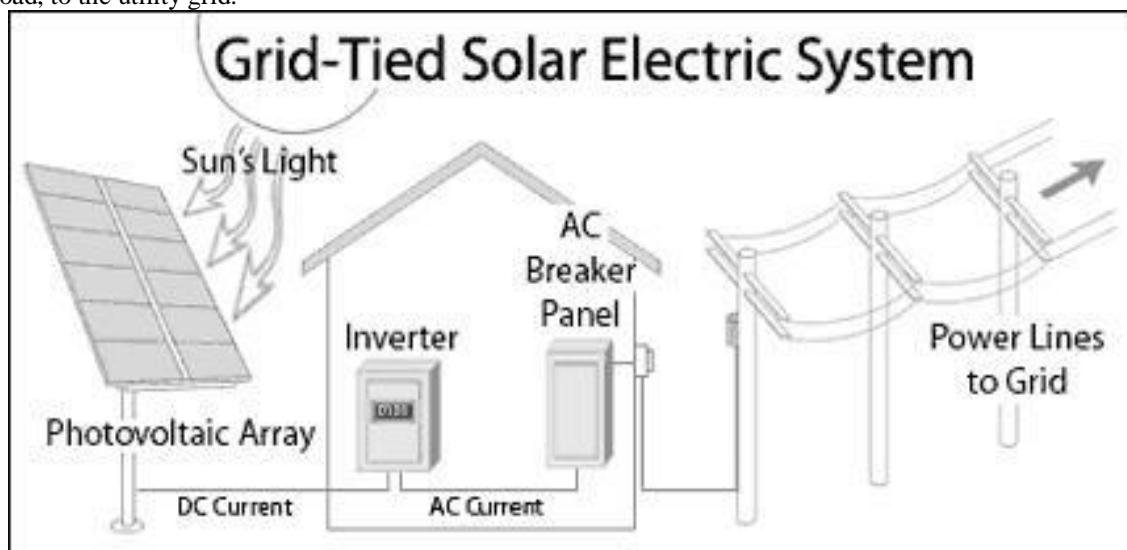


Fig no1 Grid- Tied Solar Electric System

Grid-connected PV which have a capacity on an average 407 MW that can meet the load of major consumers. They can feed excess power to the grid where it is consumed by other users. The feedback is done through a meter to monitor power transferred. Photovoltaic wattage may be less than average consumption, in which case the consumer will continue to purchase grid energy, but a lesser amount than previously. If photovoltaic wattage substantially exceeds average consumption, the energy produced by the panels will be much in excess of the demand. In this case, the excess power can yield revenue by selling it to the grid.

Solar energy gathered by photovoltaic solar panels, intended for delivery to a power grid, must be conditioned, or processed for use, by a grid-connected inverter. An inverter changes the DC input voltage from the PV to AC voltage for the grid. This inverter sits between the solar array and the grid, draws energy from each, and may be a large stand-alone unit or may be a collection of small inverters, each physically attached to individual solar panels. The inverter must monitor grid voltage, waveform, and frequency. One reason for monitoring is if the grid is dead or strays too far out of its nominal specifications, the inverter must not pass along any solar energy. An inverter connected to a malfunctioning power line will automatically disconnect in accordance with safety rules. Another reason for the inverter monitoring the grid is because for normal operation the inverter must synchronize with the grid waveform, and produce a voltage slightly higher than the grid itself, in order for energy to smoothly flow outward from the solar array.

In general, grid-connected PV systems are installed to enhance the performance of the electric network; PV arrays (as well as other distributed generation (DG) units) provide energy at the load side of the distribution network, reducing the feeder active power loading and hence improving the voltage profile. As a result, PV systems can delay the operation time of shunt

capacitors and series voltage regulators, thus increasing their lifetime. PV systems can also reduce the losses in distribution feeders if optimally sized and allocated. PV systems can increase the load carrying capability (LCC), which is the amount of load a power system can handle while satisfying certain reliability criteria, of existing networks. To meet increased demand while satisfying the same reliability criteria, utilities have to increase their generation capacity

However, PV systems can also impose several negative impacts on power networks, especially if their penetration level is high. These impacts are dependent on the size as well as the location of the PV system. PV systems are classified based on their ratings into three distinct categories: (1) Small systems rated at 10 kW or less, (2) intermediate systems rated between 10 kW and 500 kW, and (3) large systems rated above 500 kW. The first two categories are usually installed at the distribution level, as opposed to the last category which is usually installed at the transmission/sub-transmission levels.

The negative impacts of PV systems on electrical networks can be classified as shown in Fig 3.1.2.

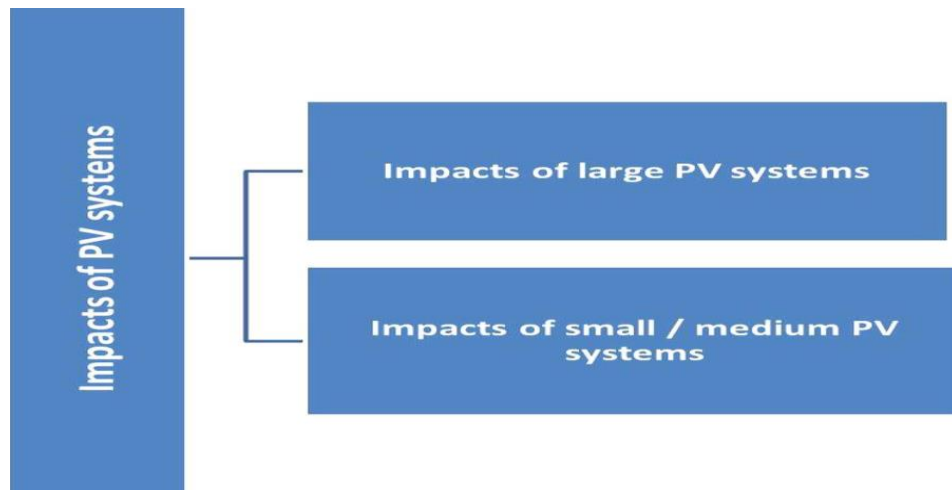


Fig no.2. Impacts of PV systems on electrical networks

The anticipated impacts of large-scale PV systems (above 500 kW) on transmission/sub-transmission networks are as follows

1. Severe power, frequency, and voltage fluctuations

PV arrays' output is unpredictable and is highly dependent on environmental conditions such as temperature and insolation levels as depicted in Fig.no.3 and 4, respectively. Partial shading due to passing clouds, temperature, and insolation random variations are all factors that will affect PV system production, resulting in rapid fluctuations in its output power. In a practical study on a 2 MW solar plant on a distribution feeder, the power output was measured and recorded every 5 min. The measurements showed sudden and severe power fluctuations caused by passing clouds and morning fog. Active power fluctuations result in severe frequency variations in the electrical network, whereas reactive power fluctuations result in substantial voltage fluctuations. These voltage fluctuations may cause nuisance switching of capacitor banks.

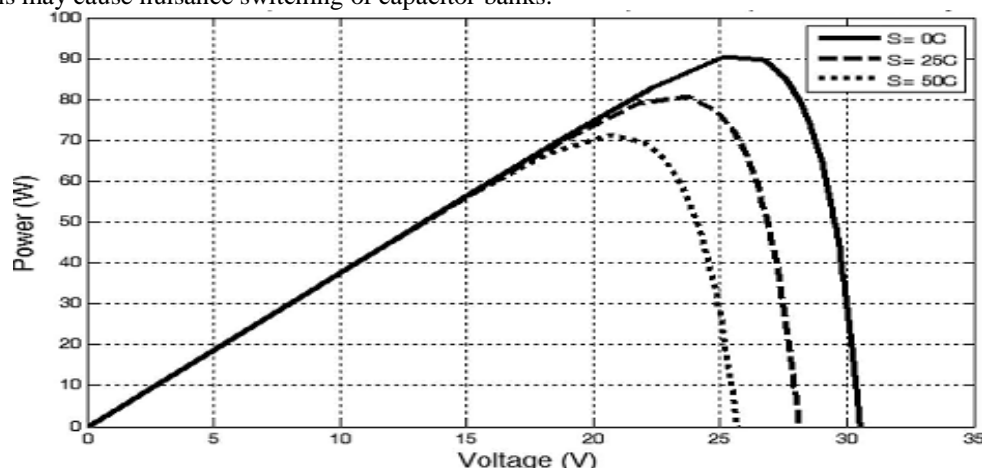


Fig.no.3 Effect of temperature variation on the DC power output of a PV array

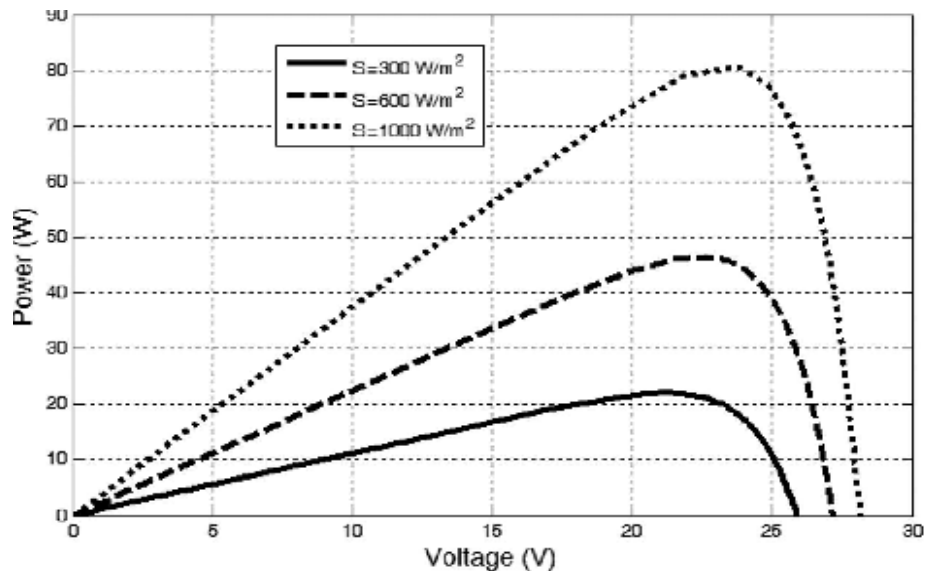


Fig.no.4. Effect of insolation variation on the DC power output of a PV array

2. Increased ancillary services requirements

Since the grid acts as an energy buffer to compensate for any power fluctuations and firm up the output power of PV sources, thus, generating stations' outputs need to be adjusted frequently to cope with the PV power fluctuations, i.e., to dance with the sun. For example, if a cloud blanked out a PV system supplying 1 MW of electricity in 10 s, then the electric grid should be able to inject extra power at a rate of 1 MW/10 s or else voltage and frequency disturbances will occur in the power system. As a result, utilities need to incorporate fast ramping power generation to compensate for these power fluctuations from PV arrays before voltage and frequency variations exceed the allowable limits.

The previous situation also necessitates a significant increase in the frequency regulation requirements at higher penetration levels of PV systems. The frequency regulation should increase by 10%. Geographical distribution of PV arrays in a certain region plays an important role in determining the maximum allowable PV penetration in that region; the closer those PV arrays are, the more power fluctuations are expected due to clouds, and the more frequency regulation service is needed to balance out those power fluctuations.

1.3% if the PV system is located at a central station.

6.3% if the PV system is located in 10 km² area.

18.1% if the PV system is located in 100 km² area.

35.8% if the PV system is located in 1000 km² area.

These results indicate that, due to their dispersed nature, small-scale PV systems are not likely to impact frequency regulation requirements and so, these requirements should be determined based on the penetration level of large, centralized PV stations only.

3. Stability problems

PV arrays' output is unpredictable and is highly dependent on environmental conditions. This unpredictability greatly impacts the power system operation as they cannot provide a dispatchable supply that is adjustable to the varying demand, and thus the power system has to deal with not only uncontrollable demand but also uncontrollable generation. As a result, greater load stability problems may occur.

PV arrays do not have any rotating masses; thus, they do not have inertia and their dynamic behavior is completely controlled by the characteristics of the interfacing inverter. As the penetration level of PV increases, more conventional generators are being replaced by PV arrays; thus, the damping ratio of the system increases. As a result, the oscillation in the system decreases. The presence of solar PV generation also can change the mode shape of the inter-area mode for the synchronous generators those are not replaced by PV systems. Some critical synchronous generators should be kept online (even if they are operating beyond their economic operating range) to maintain sufficient damping of the system. During fault conditions in a system with high PV penetration, rotors of some of the conventional generators swing at higher magnitudes.

The study on the impacts of large-scale PVs on voltage stability of sub-transmission systems concluded that PV sizes, locations, and modes of operation have strong impacts on static voltage stability; voltage stability deteriorates due to PV inverters operating in constant power factor mode of operation, whereas PV inverters operating in the voltage regulation mode may improve the system voltage stability.

The anticipated impacts of small/medium PV systems (below 500 kW) on distribution networks are as follows

1. Excessive reverse power flow

In a normal distribution system, the power flow is usually unidirectional from the Medium Voltage (MV) system to the Low Voltage (LV) system. However, at a high penetration level of PV systems, there are instants when the net production is more than the net demand (especially at noon), and as a result, the direction of power flow is reversed, and power flows from the LV side to the MV side. This reverse flow of power results in overloading of the distribution feeders and excessive power losses. Reverse power flow has also been reported to affect the operation of automatic voltage regulators installed along distribution feeders as the settings of such devices need to be changed to accommodate the shift in load centre. Reverse power flow may have adverse effects on online tap changers in distribution transformers especially if they are from the single bridging resistor type.

2. Over voltages along distribution feeders

Reverse power flow leads to over voltages along distribution feeders. Capacitor banks and voltage regulators used to boost voltage slightly can now push the voltage further; above the ac-acceptable limits. Voltage rise on MV networks is often a constraining factor for the widespread adoption of wind turbines. Voltage rise in LV networks may impose a similar constraint on the installation of PV systems. This problem is more likely to occur in electrical networks with high penetration of dispersed PV power generation.

3. Increased difficulty of voltage control

In a power system with embedded generation, voltage control becomes a difficult task due to the existence of more than one supply point. All the voltage regulating devices, i.e., capacitor banks and voltage regulators, are designed to operate in a system with unidirectional power flow.

4. Increased power losses

DG systems reduce system losses as they bring generation closer to the load. This assumption is true until reverse power flow starts to occur. Distribution system losses reach a minimum value at a penetration level of approximately 5%, but as the penetration level increases, the losses also increase and may exceed the no-DG case.

5. Severe phase unbalance

Inverters used in small residential PV installations are mostly single phase inverters. If these inverters are not distributed evenly among different phases, phase unbalance may take place shifting the neutral voltage to unsafe values and increasing the voltage unbalance.

6. Power quality problems

Power quality issues are one of the major impacts of high PV penetration on distribution net-works; power inverters used to interface PV arrays to power grids are producing harmonic currents; thus, they may increase the total harmonic distortion (THD) of both voltage and currents at the point of common coupling (PCC). Voltage harmonics are within limits if the net-work is stiff enough with low equivalent series impedance. Current harmonics, on the other hand, are produced by high pulse power electronic inverters and usually appear at high orders with small magnitudes. An issue with higher-order current harmonics is that they may trigger resonance in the system at high frequencies. Diversity effect between different current harmonics can also reduce the overall magnitude of those current harmonics. Another power quality concern is the inter-harmonics that appear at low harmonic range (below the 13th harmonic). These inter-harmonics may interact with loads in the vicinity of the inverter. Even harmonics (especially the second harmonics) can possibly add to the unwanted negative sequence currents affecting three phase loads. DC injections as well may accumulate and flow through distribution transformer, leading to a possible damage

7. Increased reactive power requirements

PV inverters normally operate at unity power factor for two reasons. The first reason is that current standards (IEEE 929-2000) do not allow PV inverters to operate in the voltage regulation mode. The second reason is that owners of small residential PV systems in the incentive-programs are rewarded only for their kilowatt-hour yield, not for their kilovolt-ampere hour production. Thus, they prefer to operate their inverters at unity power factor to maximize the active power generated and accordingly, their return. As a result, the active power requirements of existing loads are partially met by PV systems, reducing the active power supply from the utility. However, reactive power requirements are still the same and have to be supplied completely by the utility. A high rate of reactive power supply is not preferred by the utilities because in this case distribution trans-formers will operate at very low power factor (in some cases it can reach 0.6). Transformers' efficiency decreases as their operating power factor decreases, as a result, the overall losses in distribution transformers will increase reducing the overall system efficiency.

8. Electromagnetic interference issues

The high switching frequency of PV inverters may result in electromagnetic interference with neighboring circuits such as capacitor banks, protection devices, converters, and DC links leading to mal-function of these devices.

9. Difficulty of islanding detection

Islanding detection techniques are characterized by the presence of non detection zones defined as the loading conditions for which an islanding detection method would fail to operate in a timely manner, and are thus prone to failure. Moreover, the inclusion of islanding detection devices increases the overall cost of integrating PV systems in electrical networks.

Maximum Allowable Penetration Levels For PV Systems

Penetration limit	Limiting factor
5%	Ramping rates of generators during cloud transients (central station PV)
15%	Ramping rates of generators during cloud transients (distributed PV)
1.3%	Power fluctuations due to clouds transients for central station PV
6.3%	Power fluctuations due to clouds transients if the PV system is distributed in 10 km ² area
18.1%	Power fluctuations due to clouds transients if the PV system is located in 100 km ² area
35.8%	Power fluctuations due to clouds transients if the PV system is distributed in 1000 km ² area
10%	Frequency regulation expansions vs. break-even costs
Minimum feeder loading	Over voltages assuming no load tap changers (LTCs) exist in the MV/LV transformer
40%	Voltage regulation
5%	Minimum distribution system losses
33%	Overvoltages

Table no.1 Summary of Allowable PV Penetration Limits

From the above results, it can be concluded that there is no agreed-upon maximum allowable penetration limit for PV electricity. It can vary from 1.3% up to 40% depending on the limiting factor as well as the size, location, and geographic distribution of PV arrays. A comprehensive techno-economic assessment should be performed for each individual network to determine the maximum allowable PV penetration in such a network. For example, Hydro One—the largest distribution utility in Ontario—requires that distributed generation “to be interconnected to a distribution system circuit line section, including the proposed generator, not to exceed 7% of the annual line section peak load.”

B. GRID CONNECTED WIND ENERGY SYSTEM

Wind generation interface system is connected to grid system with voltages on each side of the impedance shown in Fig.no.3.2.1

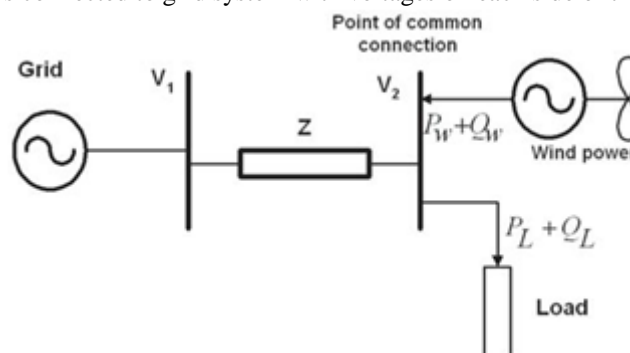


Fig.no.5. Grid connected wind generator interface to power system.

In the power system, the power is transmitted using three phase power that is as symmetrical as possible. The line-to-line voltage is $\sqrt{3}$ times larger than phase voltage and total three phase power is constant. The voltage drop over the impedance can be written as in (1)

$$V_1 - V_2 = \sqrt{3} IZ \quad (1)$$

Where V_1 -rms voltage, z - impedance of transmission line, transformer in the feeding grid.

At the point of common connection (PCC), wind farm and local load is also connected. The short circuit power SK , in wind connection is shown in (2)

$$SK = V_1^2 / Z \quad (2)$$

The change in wind power production will cause changes in the current through the impedance Z . These current changes cause the changes in the voltage V_2 . In practice, connections with network with short circuit ratio < 2.5 are avoided, as this give rise to voltage fluctuations, called as weak grid.

The impedance $Z = R + jX$ at the fundamental frequency. Generally the impedance in presence of harmonics become as shown in (3)

$$Z(h) = R + jhXL \quad (3)$$

Where h is the harmonic order, the inductive reactance changes linearly with frequency.

The combination of wind power production and load are represented as $P + jQ$, where P is the active power and Q is the reactive power. The reactive power is depend on the phase shift between voltage and current, such as shown in (4)

$$\theta = \tan^{-1} (Q/P) \quad (4)$$

The reactive power in the wind has an impact on voltage V_2 , The impact is also depend on local load and on the feeding grid impedance.

Power Issues And Its Consequences

A. Voltage Variation

The voltage variation mainly results from the wind velocity and generator torque. The voltage variation is directly related to real and reactive power variations. The wind generating system equipped with an asynchronous generator consumes the reactive power and can cause additional negative problem for the grid. Switching the wind turbine generator ON and OFF also varies the voltages. The voltage variation is commonly classified as short duration and long duration voltage variation.

(a) Voltage Sag /Voltage Dips

It is the decreased of the nominal voltage level between 10% to 90% of the nominal rms voltage, at the power frequency, for the duration of 0.5 cycle to 1min.

Causes—Start-up of wind turbines, Fault on the transmission/ distribution network, Fault in consumer installation, connection of heavy loads, start up of large motors.

Consequences—Malfunction of equipments namely microprocessor based control system, programmable logic controller, adjustable speed drives, that may lead to a process stoppage, tripping of contractors, relays trip for voltage sensitive load and loss of efficiency in electric machine.

(b) Voltage Swell

It is momentary increase of voltage at power frequency, with duration of more than one cycle and typically less than few seconds.

Causes—Start/stop of heavy loads, fault on the system, badly regulated transformer during off peak hours.

Consequences-Flickering of light and screen, Damage of sensitive equipments.

(c) Short Interruptions

It is total interruption of electrical supply for a duration from few milliseconds to one or two seconds.

Causes—Mainly due to the opening and automatic re-closure of protection devices.

Consequences—Tripping of protection devices, stoppage of sensitive equipments like personal computer, programmable logic control system.

(d) Long Duration Voltage Variation

It is total interruption of electrical supply for a duration greater than 1-2 seconds.

Causes- Equipment failure in power system, failure of protection equipments.

B. Flicker

Voltage flicker describes dynamic variations in the network voltages caused by wind turbine or by varying loads. Thus the power fluctuation from wind turbine occurs during continuous operation. The amplitude of voltage fluctuation depends on grid strength, network impedance, phase-angle and power factor of the wind turbines. It is defined as a fluctuation of voltage in a frequency 10-35 Hz. The IEC 61400-4-15 specifies a flicker meter that can be used to measure flicker directly. The flicker coefficient gives a normalized dimensionless measure of flicker, independent of network situation and independent of short circuit apparent power of the grid. It gives ratio of short circuit power and generated rated apparent power, which is necessary to achieve a long term flicker level. (Plt) , as the given equation (5).

$$C(\Psi K, V_a) = Plt (S_k / S_n) \quad (5)$$

Where, C(Yk, Va)-flicker coefficient depends on grid impedance angle Yk and the average wind velocity Va.

SK - Short-circuit power of grid at point of common coupling.

Sn- Apparent power of wind turbine at rated power.

P It- Long term flicker emission.

The flicker standards are generally used to characterize the transient voltage variations .The short flicker is evaluated over a 10 min period and long term flicker is evaluated over 2 hours period.

Causes: Fluctuation of active and reactive power of wind turbine, i.e. yaw error, wind shear, wind turbulence or fluctuation in control system, switching operations in wind turbine. In fixed speed wind turbine each time a rotor blade passes through the tower, the power output of the turbine reduces .This effect cause's periodical power fluctuation with a frequency of about 1 Hz, where as in variable speed turbine power fluctuation are smoothed .Flickers are produced by arc furnace, arc lamps, capacitor switching.

Consequences—Degradation of power quality, damage to sensitive equipments.

C. Harmonics

It results from the operation of power electronic converters. The harmonic voltage and current should be limited to the acceptable level at the point of wind turbine connection to the network. The emission of harmonic current during the continuous operation of wind turbine with power converter has to be stated.

D. Wind Turbine Location In The Power System

The way of connecting the wind generating system into the power system highly influences the power quality. As a rule, the impact on power quality at the consumers terminal is located close to the load is higher, than connected far away from the load. When the wind generating system is connected to a medium voltage transmission line, the distance between the wind generating station and point of common coupling is small, such system are economical as compared to other location. Thus the operation and its influence on power system depends on the structure of the adjoining power network.

E. Self Excitation Of Wind Turbine Generating System

The self excitation of wind turbine generating system (WTGS) with an asynchronous generator takes place after disconnection of WTGS with local load. The risk of self excitation arises especially when WTGS is equipped with compensating capacitor. The capacitor connected to induction generator provides reactive power compensation. However the voltage and frequency are determined by the balancing of the system. The disadvantages of self excitation are the safety aspect and balance between real and reactive power.

Causes—If the sensitive equipment is connected to the generator during the self excitation, the equipment may be a subject to over load, under voltage and over frequency operation.

C. NON-TECHNICAL ISSUES

Lack of technical skilled man power.

Less availability of transmission line to accommodate RES.

RES technologies are excluded from the competition by giving them priority to dispatch which discourage the installation of new power plant for reserve purpose.

IV. PROS AND CONS

A. ADVANTAGES

➤ Grid Connected PV Systems:

Systems such as Net Metering and Feed-in Tariff which are offered by some system operators, can offset a customer's electricity usage costs

Grid-connected PV systems are comparatively easier to install as they do not require a battery system.

Grid interconnection of photovoltaic (PV) power generation systems has the advantage of effective utilization of generated power because there are no storage losses involved.

A photovoltaic power system is carbon negative over its lifespan, as any energy produced over and above that to build the panel initially offsets the need for burning fossil fuels. Even though the sun doesn't always shine, any installation gives a reasonably predictable average reduction in carbon consumption.

➤ Grid Connected Wind Energy System

Cost Effective: The main purpose of connecting the wind power to the grid is to reduce the cost of energy required to do the work so. This connection can generate the electricity at very low cost as it is derived from wind so; there is no cost on the wind as compared to other grid utilities. It can also helps to reduce the electricity bills and also effect the consumption required for production.

Reduce Expense: It is very useful in reducing the cost of electricity and provides electricity to the users at a very reasonable price that all can afford it.

Increase Yield: By connecting the grid with the wind, power we can increase the productivity of electricity to that extent that we can sold it out to other utilities.

Large Coverage: One of the most important advantages of the wind power and grid connection is that it can provide the coverage of electricity almost in every area; weather it is applied on the area having high wind power or the area having the low wind power says 10 mph per year. It can produce the electricity with the same efficiency in the low wind coverage area.

Save Energy and Reduce Pollution: This connection is also helpful in saving the energy in the form of fuel consumption. It can use the gasoline as fuel generator as compared to other forms of fuels such as diesel. It is also helpful in reducing the environmental pollution because it can reduce the emission of radiations that are of different nuclear reactions as it is derived from wind source.

B. DISADVANTAGES

➤ Grid Connected PV System:

Grid-connected PV can cause issues with voltage regulation. The traditional grid operates under the assumption of one-way, or radial, flow. But electricity injected into the grid increases voltage, and can drive levels outside the acceptable bandwidth of $\pm 5\%$.

Grid-connected PV can compromise power quality. PV's intermittent nature means rapid changes in voltage. This not only wears out voltage regulators due to frequent adjusting, but also can result in voltage flicker. Connecting to the grid poses many protection-related challenges.

➤ **Grid Connected Wind Energy System:**

The requirement of reactive power for voltage support is one the key issues related to wind power generation.

Turbine power electronic design and controller optimization.

Problems of wind farms connected into series compensated systems.

Power quality issues including voltage flicker.

Starting and synchronizing of wind farms to the grid.

Sub synchronous resonance issues due to interaction of the electric network and the complex shaft/gear system of the wind turbine

V. CONCLUSIONS

1. PV solar systems are expected to be one of the most growing sources of electricity in the next decades has numerous negative impacts on electrical networks.
2. There is no agreed-upon maximum allowable penetration limit for PV electricity in a certain network as it depends on the network's characteristics as well as types, locations, and geographical distribution of PV arrays within the network.
3. Cloud transients and the mandatory increase in frequency regulation services are usually the bottleneck against the widespread adoption of PV electricity.
4. It is not exaggeratory to say that electrical power systems under the current circumstances are not yet ready to accommodate the anticipated increase in PV penetration.
5. Deregulation of utilities, distributed generations have increase the power quality problem.
6. Awareness of end user for interruption, switching transients.
7. Globalization of industry around the world.

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