A survey report on issues of grid connected wind farm

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Abstract—Day by day increasing demand of electricity forces us to invent alternative sources for electricity generation leads to development of renewable energy sources. Among various alternative sources wind is gaining more attention due to its technical maturity and cost effectiveness. Integration of wind farm in grid causes adverse effect on grid leads to poor power quality and threat to power system security. Power quality is one of the key factors in today scenario because modern power electronics devices are very sensitive and poor power quality result in high cost & loss of consumer. This paper focuses on various issues which are responsible for poor power quality of grid

Keywords—wind farm, Harmonics, flicker, power quality, FACTS

I INTRODUCTION

To have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like wind, biomass, hydro, co-generation, etc. In sustainable energy system, energy conservation and the use of renewable source are the key paradigm. Electrical power is expensive to store. Hence, the power produced at the generating station must be consumed by the load. Therefore, there must be a power balance between all the generating plant and the load demand. Any imbalance would affect the frequency of the system which could lead to loss of synchronism in certain cases. The accomplishment of a power balance between the load and the generating plants is more challenging in the case of wind power generation due to its unpredictable nature especially when the generating ratio is high. A system of high wind power integration would expand the reserve capacity due to the variability of the primary resources. A conventional power plant is expected to integrate the renewable energy like wind energy into power system is to make it possible to minimize the environmental Impact on conventional plant. The integration of wind energy into existing power system presents a technical challenges and that requires consideration of voltage regulation, stability, power quality problems. The power quality is an essential customer-focused measure and is greatly affected by the operation of a distribution and transmission network.

The integration of wind parks and other renewable energy conversion systems on weak distribution grids is a major issue for both the utilities planning offices and independent power plants investors, specially having in mind that the individual group/turbine capacity already surpasses 2 MW and wind parks with a capacity in the range of 150. One of the main problems in wind energy generation is the connection to the grid. Injection of wind power into the grid affects the power quality resulting in poor performance of the system. The wind energy system faces frequently fluctuating voltage due to the nature of wind and introduction of harmonics into the system. Injection of the wind power into an electric grid affects the power quality.

II. POWER QUALITY STANDARDS, ISSUES AND IT S CONSEQUENCES

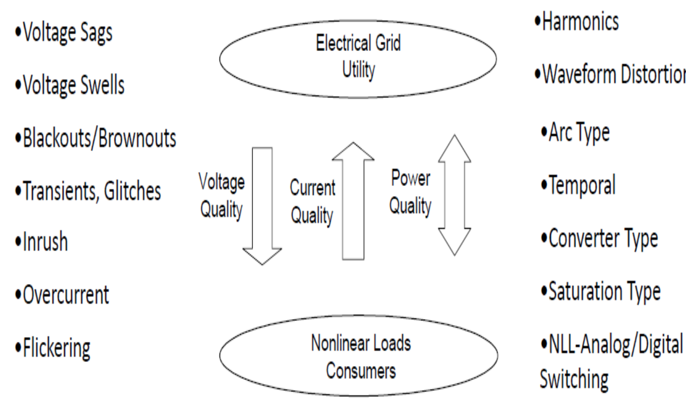
A. International Electro Technical Commission Guidelines

The guidelines are provided for measurement of power quality of wind turbine. The International standards are developed by the working group of Technical Committee-88 of the International Electro-technical Commission (IEC), IEC standard 61400-21, describes the procedure for determining the power quality
Characteristics of the wind turbine

The standard norms are specified.
1) IEC 61400-21: Wind turbine generating system, part-
21. Measurement and Assessment of power quality characteristic of grid connected wind turbine
2) IEC 61400-13: Wind Turbine----measuring procedure in determining the power behavior.
978-13)
3) IEC 61400-3-7 Assessment of emission limit for fluctuating load IEC 61400-12: Wind Turbine Performance. The data sheet with electrical characteristic of wind turbine provides the base for the utility assessment regarding a grid connection

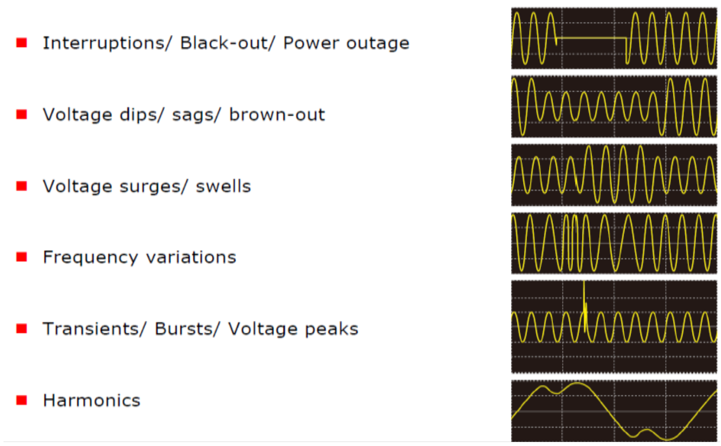
III POWER QUALITY

Power quality problem is any power problem manifested in voltage, current, or frequency deviation that results in failure or malfunctioning of customer equipment. Power quality and reliability cost the industry large amounts due to mainly sags and short-term interruptions. Distorted and unwanted voltage wave forms, too. And the main concern for the consumers of electricity was the reliability of supply. Here we define the reliability as the continuity of supply. The problem of distribution lines is divided into two major categories. Power quality is a two-pronged issue, with electronic equipment playing both villain and victim. Most new electronic equipment, while more efficient than its mechanical predecessors, consumes electricity differently than traditional mechanical appliances First group is power quality, second is power reliability. First group consists of harmonic distortions, impulses and swells. Second group consists of voltage sags and outages. Voltage sags is much more serious and can cause a large amount of damage. If exceeds a few cycle, motors, robots, servo drives and machine tools cannot maintain control of process. Both the reliability and quality of supply are equally important. Power supply quality issues and resulting problems are consequences of the increasing use of solid state switching devices, nonlinear and power electronically switched loads, electronic type loads .the advent and wide spread of high power semiconductor switches at utilization, distribution and transmission leaves have non sinusoidal currents.



IV CAUSES AND CONSEQUENCES OF POWER QUALITY ISSUES

The causes and consequences of power quality problems can be traced to a specific type of electrical disturbance. In most of industry, more than 90% of the electric motor with inverter driven application. Poor power quality causes trouble in receptacle/transmission equipment and electronic equipment malfunctions / Failure. Power quality is a common problem for both electric power suppliers and users. it is not easy to identify whether the cause of poor power supply quality is at the supplier’s system or the user’s system.
Power disturbances can be classified into the following categories.



Power Imbalance

WECS generate electricity when wind speeds exceed a certain minimum and the WECS output depends on these wind speeds. Wind speeds cannot be predicted with high accuracy over daily periods, and the wind often fluctuates from minute to minute and hour to hour. Consequently, electric utility system planners and operators are concerned that variations in the output of WECS may increase the operating costs of the system [9]. This concern arises because the system must maintain a balance between the aggregate demand for electric power and the total power generated by all power plants feeding the system. The variability and the unpredictability of wind power can cause a power imbalance on the grid [7, 8, 10, 11]. Their output power may not be available to meet the demand when needed, while there could be an excess when the demand is low, thereby causing an upset on the grid. [12] reported a loss of 4000MW (58% of capacity) in Germany in December 2004 and a loss of 2000MW (83% of capacity) within 6 six hours in Denmark in January 2005 as a result of large changes in wind power output due to a forecasting error. A penalty cost is often attached to the deviation in the scheduled and actual energy delivered to the grid to cover the

Power outages:

Power outages are total interruptions of electrical supply. Utilities have installed protection equipment that briefly interrupts power to allow time for a disturbance to dissipate.

 Causes: Ice storms; lightning; wind; utility equipment failure.

 Effects: Complete disruption of operation.

Voltage Variation:

The voltage variation results from the wind velocity and generator torque. The voltage variation is directly related to real and reactive Power variations. The voltage variation is classified as under:

• Voltage Sags.
• Voltage Swells.
• Short Interruptions.
• Long duration voltage variation

Variation, flicker, harmonics of voltage causes the malfunction of equipments such as microprocessor based control system, adjustable speed drives, etc. It may leads to tripping of contractor switch, tripping of protection devices, stoppage of sensitive equipments like personal computer, etc and may stop the process and it can damage of sensitive equipments. Thus it degrades the power quality in the grid. Voltage fluctuations are changes or swings in the steady-state voltage above or below the designated input range for a piece of equipment. Fluctuations include both sags and swells.

 Causes: Large equipment start-up or shut down; sudden change in load.

 Effects: Data errors; memory loss; equipment shutdown; flickering lights; motors stalling/stopping

Harmonics

Harmonics can be injected both at the generation and the consumer end. At the consumer end, harmonics are caused by non linear loads such as television, personal computers, compact fluorescent lamps, and so forth. At the generation level, sources of harmonics include the Flexible Alternating Current Transmission System (FACTS) such as reactive power compensators and power electronics devices. Others include adjustable speed drives, generator speed controls, HVDC installations, and underground and submarine cable installations. Most of these are found in the power conditioning devices of integrating WECS into the grid. They could cause distortion to the voltage and current waveform. Also, the power electronic converters in use by the variable speed WECS such as DFIG are sources of harmonic. Harmonics increase line losses and cause excessive heating of equipment which decreases their lifetime. Sub-harmonics could cause flickers that result in an uncomfortable visual effect on the eyes, imbalance and core saturation of transformers and thermal aging of induction motors. IEEE 519-1992 is a standard that sets the requirements and imposes limits for the harmonic measurement of different order harmonics and the total harmonic distortion (THD). The limits for system voltage distortion are 5% for THD and 3% for any individual harmonics as stipulated by IEEE 519-1992. IEC 61400-21 requires harmonic testing and certification of variable speed wind turbines before grid connection since power electronic converters are utilized to achieve grid integration.

Flickers

Flickers are the periodic voltage frequency variations typically between 0.5 and 25Hz that cause annoyance from the incandescent bulb. Flicker annoyance is severe at a frequency of 8.8Hz.The international electrochemical commission (IEC) standard 61000-4-15 describes the measurement of flicker given the instantaneous flicker level (IFl) as well as the probability short term (Pst) measure for a time span of 10 min, and the probability long term (Plt) measured for an average of 2 hours. For flicker free voltage, Pst = 0. A Pst=1 indicates that the flicker pollution has reached the tolerable limit of an average person. The flicker level for a medium-voltage grid is specified by 0.35(Pst) and 0.25(Plt). The wind generators sometimes produce oscillatory output power, which could cause flickers in the power system network. The fluctuation caused by the tower shadow and turbulence effect in wind may cause flickers. IEC 61400-21 furnishes the measurement procedure to calculate the flicker impact of wind turbines. According to this standard, the voltage fluctuation by the wind turbine is divided into two components: the continuous operation and the switching operation. Voltage fluctuations due to continuous operations result from the variation of active and reactive power due to the fluctuation in wind speeds (3p effect in fixed speed wind turbines), whereas variable speed wind turbines have the ability to absorb the 3p effect by mean of a small change in their rotor speed. Switching operations are caused by fast changes of power from one level to another which could be due to generator cut-in, cut-out and switching between wind generators

The effects of flickers are generally not severe in variable speed wind turbines unlike in fixed speed wind turbines. This is because the variable speed wind turbines have the ability to provide speed controls to damp the fluctuations of the aerodynamic torque emanating from switching operations or changes in wind speed therefore mitigating flickers. Both the continuous operation flicker coefficient and the flicker emission due to the switching operations of the wind turbines are provided based on the network impedance phase angle and 10-minute average wind speed. This information is based on tests carried out on wind turbines by the manufacturer and will help in ensuring compliance with the acceptable standards before connecting them to the grid. In power quality campaigns, some of the parameters which characterize power quality are the steady state voltage variations and the flickers present in both continuous and switching operations.

V CHALLENGES OF WIND POWER ON POWER SYSTEM STABILITY

Before the advent of wind power plants, power systems mainly consisted of synchronous generators for electricity production. The behavior and control of these generators following a disturbance are well understood by the utility operators due to their experiences thereof over the years. The advent of wind power introduces induction generators into the power system for electricity generation because they are cheap, robust and support variable speed operations. At the earlier stage of wind power integration, there was little concern about its influence on the overall stability of a power. With the increasing trend of wind power integration, it may begin to have a significant influence on the power system transient stability margin. The induction generators mostly employed in wind power applications operate asynchronously and are characterized by poor reactive power control capability. A surge in the input torque of a generator and a voltage dip beyond the threshold limit at the point of common connection (PCC) can lead into poor feeder regulation which can eventually cause voltage collapse as a result of reactive power demand from the grid.

Fixed speed induction generators are provided with reactive power compensator to cater for the large reactive power demand from the network. The power electronics devices provide the reactive power to the grid in the case of variable speed generators. Critical clearing method has been widely adopted for transient stability studies

VI CONCLUSION

In response to the energy needs and environmental concerns, electricity from wind generators is considered as one of the future solutions. Wind energy is a renewable source of energy but integration of wind farm in grid introduces new factor of uncertainty. Integration of wind farm causes voltage dip, power imbalance and harmonics causes adverse effect on system security and power quality of grid.

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