

Impact of Wind Power Generation on Power System Stability in Deregulated Environment

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ABSTRACT: The deregulation of power systems has brought several new entities in the electricity market place. With the increase in penetration into the utility grid, power quality and dynamic security of might be affected. This paper is concerned with the problems related to system security and stability resulting from the increased proliferation of wind power technology. The paper presents an up-to-date survey on the impact of deregulation on system stability. This paper focuses particularly on the wind power grid connection strength. This is done in relation to wind turbine and generators because of the wide application of wind energy into the system. To maintain the voltage, produce real and reactive power, decrease rotor angle deviation during fault condition and thus leads to improvement in transient stability.

KEYWORDS: Deregulation ,power stability,grid connections

I. INTRODUCTION

Power systems have been in operation since the late 19th century. They were used for powering street lighting, and were soon expanded to include mechanical loads. Originally direct current systems were used to deliver power but these limited the distances that loads could be placed from generation. Because at usable voltage levels the losses and voltage drops were very high and there was no convenient method for voltage transformation. The development of the transformer in the introduction of alternating current systems became standard for power systems. Longer transmission distances became possible and after current frequencies were standardised and interconnection between neighbouring power systems also became possible. Interconnection led to increased security since loads could be supplied by many different generators and higher system efficiency though each generator could be utilised to a larger extent in wind power.

A. CURRENT WIND ENERGY SCENERIOS FOR INCREASING IN POWER PRODUCTION

Wind energy distribution is not uniform across all states in India. Southern and western states have maximum wind capacity installed due to highest wind density and velocity. Tamil Nadu is leading state in terms of wind installations with 33% share in overall wind capacity installed in the country. Wind power plants in Tamil Nadu have generated 82 billion units cumulatively till the year 2013-14.:

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Wind energy installations across states

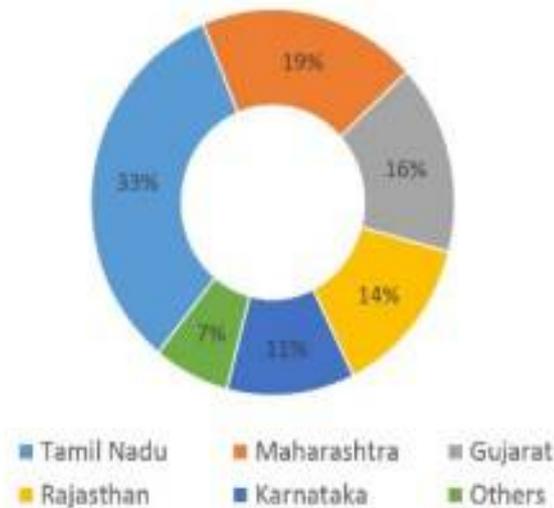


figure 1: This figure shows the wind energy installation across the states.

courtesy:- https://en.wikipedia.org/wiki/Wind_power

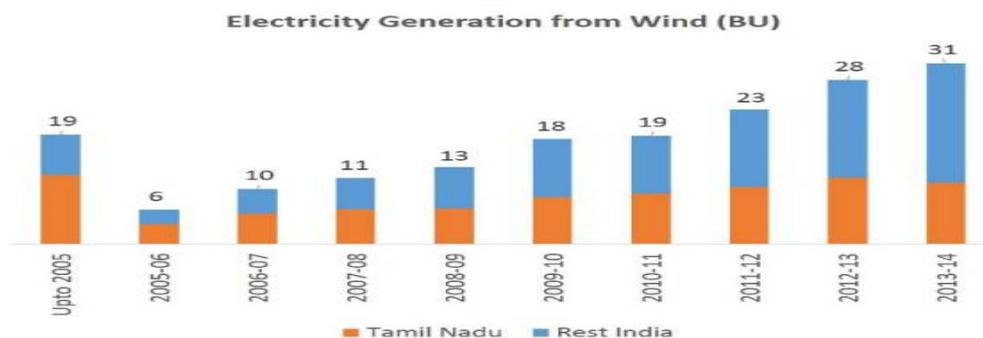


figure 2: The above figure shows Electricity generation in all over india.

courtesy:- https://en.wikipedia.org/wiki/Wind_power

The private sector investment in the wind energy sector is booming with these target set by the government. In addition, Credit Rating Information Services of India Limited (CRISIL) mentioned in its report that the wind energy sector can attract Rs. 1 lakh crore of investment by 2020. This is assuming falling cost of wind energy compared to the grid tariffs. CRISIL expects 4 GW of wind energy capacity addition every year over the next five years.

The Government of India has assured to continue accelerated depreciation benefits and generation based incentive (GBI) to wind energy sector to fuel the overall growth of the sector. In addition, the National Wind Energy Mission is in pipeline to accelerate the wind energy sector with more emphasis on offshore wind energy.

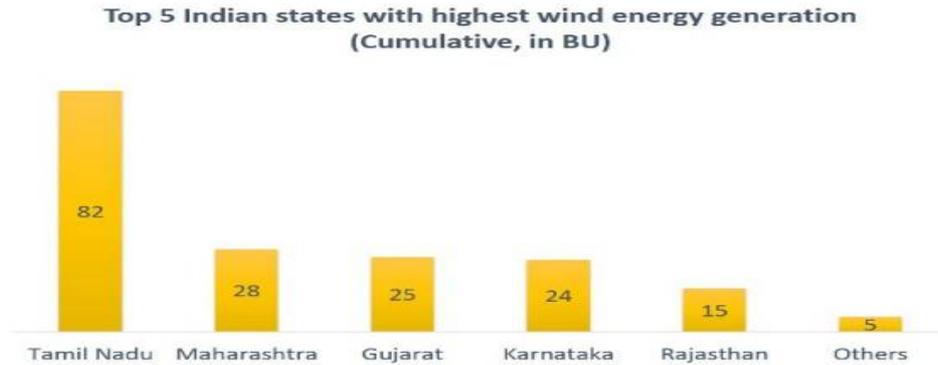


figure 3: The above graphs shows top five states in India with highest wind electricity generation courtesy:-
https://en.wikipedia.org/wiki/Wind_power

Five-year Plan Years	By the End of the 11th Plan Through 2012	By the End of the 13th Plan Through 2022
Wind	17,582	40,000
Small Hydro	3,358	6,500
Biomass	3,218	7,500
Solar	1,003	20,000
Total	25,161	74,000

B. CHALLENGES IN POWER SYSTEM

In all over the world deregulating electricity markets are on the assumption that their result in their more efficient operation. As more electrical power has been generated and consumed the expansion of the electricity grid to transport this electricity from producers to consumers has progressed relatively slowly because of the large costs involved. As a result of this the transmission system is being operated at its limits and in ways for which it was not designed.

Power quality has become increasingly important for grid operators as they required to ensure the stability and reliability of power system. As it is built to help improve reliability levels are now used for energy trading there is increasing in the transfer of power along transmission lines stresses the power system. The system is stressed as many undesirable phenomena arise so these may cause damage to different parts of the system. In order to keep the system operating securely the limits must be placed on power transfers. When it is related with thermal heating the thermal limit which establishes the maximum electrical current that a transmission line or electrical facility can conduct over a specified time period before it sustains permanent damage by overheating or before it violates public safety requirements. Limits on power transfer are also required to keep the power system stable. If the system becomes unstable then the security of the supply of electricity can be compromised.

Power system stability can be categories into three are as:

1. **Rotor angle stability** refers to the ability of synchronous machines in an interconnected power system to remain in synchronism after being subjected to a disturbance. Instability may result in the form of increasing angular swings of some generators, leading to their loss of synchronism with other generators. Even sustained oscillations that are damped slowly

may result in faulty tripping of protection equipment, and undesirable strain on the turbine shafts in power plants. Rotor angle stability divided into two types:

A) **Small-signal rotor angle stability** which refers to the ability of the power system to maintain synchronism under small disturbances. These disturbances are small in the sense that linearization of system equations can be performed to analyse system performance. This type of stability depends on the initial operating state of the system.

B) **Transient stability** which is concerned with the ability of the power system to maintain synchronism when subjected to a severe disturbance.

2. **Frequency stability** refers to the ability of a power system to maintain steady frequency following a severe system upset which results in a significant imbalance between generation and load. If there is an excess of load, kinetic energy from generators is used to supply the loads, which causes the generators to decelerate and the system frequency to decrease. Similarly if there is a load deficit kinetic energy will build up in the generators causing the frequency to increase.

3. **Voltage stability** refers to the ability of a power system to maintain acceptable voltages at all nodes in the system. A voltage collapse typically occurs when not enough reactive power is being produced to energise the power system components and is often a slow process. A possible outcome of voltage instability is loss of load in an area or tripping of transmission lines and other elements by their protective systems leading to cascading outages.

Voltage stability of power system to maintain voltages at all buses in grid after any disturbance. In the wind power generation voltage control depends on constant speed or variable speed of WPP.

C. WIND POWER AND ITS IMPACT IN DEREGULATED ENVIRONMENT

After the deregulation of the electricity market, where electricity is traded in a competitive way. In a deregulated settings market players have more difficulty to reach to the desirable information and construct their production plans based on that demand, market prices for the electricity and so on are recently in there is a huge level of uncertainty introduced to the power system related to the continuously growing high level integration of renewable power resources like intermittent wind power which is shaping current and future power market and industry. The intermittency behaviour of wind power makes very hard to predict and manage the output energy of the wind farms and therefore considering wind power as uncertain power source. The amount of wind power is continuously increasing in the world and making the planning of conventional production such as hydro power generation even more challenging. These uncertainties in the power system are interesting for many researchers in the field who have shifted from the building of the conventional deterministic models to multi-stage stochastic models for short-term hydropower planning to evaluate impact of uncertainties especially intermittency of wind power.

The renewable energy impact on the power system particularly wind power impact is huge and interests many researchers in the field. All those impacts are mainly depends on the following factors: the penetration level of wind power, the generation mix in the power system and grid size. The impacts of wind power on the power system can be divided into short and long-term effects. The short-term effects are those which last minutes to hours, whereas the long-term effects have yearly timescale. Example of long-term effect can be the contribution of wind power to the system adequacy: its capability to meet peak load situations in a reliable way. Besides wind power impact on the power system can be categorized into local or global effects according to the effect size scale. Although wind power is introducing more uncertainty to the system which creates planning problem for all electricity players in the system which is always important to emphasize and start from the benefits got from wind power. First installed wind power can increase the energy reliability and decrease the risk of energy deficit.

This is concluded in various scientist research analysis such as L. Soder analyses the impact of wind energy on the energy reliability in power system and in M. Amelin analyses the wind power contribution to supply adequacy. The same conclusion However first the intermittency behaviour of the wind power can also decrease the energy reliability in different circumstances and Second wind power can provide voltage control and partially support to primary and secondary control however it can cause power quality problems creating harmonics and voltage flicker. Installed wind farm can reduce congestion problems on transmission lines; can also reduce transmission losses if wind farm is installed close to the heavy consumption areas. For example, consider two-area system where electricity is mainly produced in one area and is consumed in another area. If the wind farm install in the area where the consumption is higher, it will decrease the congestion on transmission line which transfer electricity from the production area to the consumption area. Unfortunately renewable energy like wind and solar are produced where the source is and transferred to the final customer. Therefore sometimes it can even increase the congestion on the lines. In H. Holttinen discusses the impact of hourly wind power variations on the hourly load following reserve requirements. Beside mentioned above characteristics, wind power creates imbalance cost for the wind farm owners when they make in advance contract. This increases market prices which in its turn effects on other players in electricity market. J. Matevosyan develops new imbalance cost minimization method using stochastic programming which generates optimal

wind power production bids for a short term power market. Finally, stochastic behaviour of wind power production has a big impact on the demand for real time balancing power, as well as on market prices.

Wind Power Impacts On Power System By Following are:

Local Global Short -term 1.wind farms can provide voltage support depending on the design (seconds to minutes)
2.wind power can cause power quality problems creating harmonics and voltage flicker 1.increasing need for the real time balancing power imbalance (minutes to hours), 2.can also partially contribute to primary or secondary control.

Long -term 1.wind farm can decrease/increase congestion on the transmission line, 2.can reduce/increase transmission losses, 1.wind power will contribute to the system adequacy, 2.wind farms can create a need for additional investment to enhance a transmission line 3.if conventional unit is replaced by wind farm additional need for reserve power will be needed.

As an environmentally friendly energy source wind power has got prevalent public support, and accordingly wind power integration to the power system is growing significantly. The risk related to keep short term power balance (avoiding frequency deviations) can increase radically and planning of the frequency control reserves (instantaneous, fast and slow) becomes more challenging because of the output uncertainty of the wind power due to its intermittency behaviour. Due to the fluctuations in the wind power, the need for balancing power will increase, which in its turn will increase the market prices. The following graph shows the regulated and deregulated states with their capacity.

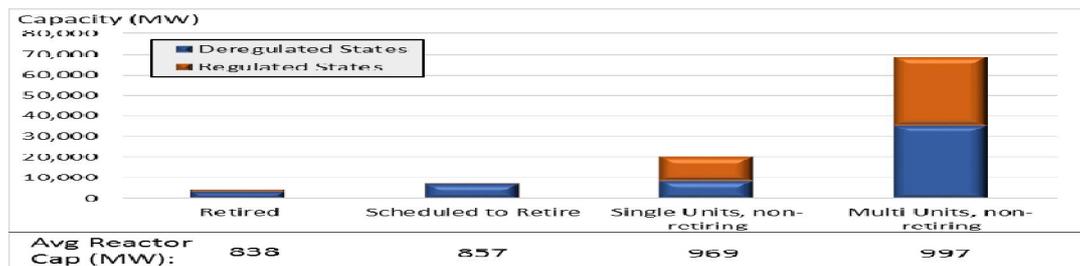


Figure1: Above figure shows capacity and average reactor capacity (MW) in different states

courtesy:- https://en.wikipedia.org/wiki/Wind_power

II. Challenges Of Grid Quality Of Wind Power On Power System in Deregulated Environment

Ii(1) Wind Power Impacts On Grid In Deregulated Environment

In an area where weak grid conditions with growing wind energy penetration power quality will become the main factor for installation of WPPs. The power generating from WPP are so fluctuating hence its impact on plant will be so different. This wind power produces local impact on power system are:

- a) Node Voltage and Voltage Control
- b) Fault current contribution to faults and protection schemes
- c) Active power and Reactive power
- d) Voltage quality as:
 - a. slow voltage variations
 - b. Voltage transients
 - c. Voltage tips.
 - d. Voltage sags
 - e. Voltage swells
 - f. Voltage unbalance
 - g. Waveform distortion (harmonics)

Ii(2) Major Parameters Affecting Grid Power Quality

Generally connecting loads to an electric grid will reduce the voltage while connecting power producing units like WPPs will increase the voltage level. In both cases there shall be impact on network. The major parameters that affect the power quality are:

- A) Local impacts are:
 - a) Branch flow and node voltages.
 - b) Fault current contribution.
 - c) voltage quality.
- B) System wide impacts:
 - a) Reactive power.
 - b) Dynamics and stability.
 - c) System balancing are frequency variations and Islanding.

ii(3)Challenges Of Wind Power On Power System Stability In A Grid

When a power system maintains a state of equilibrium during normal operating condition or returns to acceptable state of equilibrium after being subjected to a disturbance, then the system is said to be stable. A disturbance could be disconnection of generators, load, lines, transformers or a fault.. The stability that considers large disturbances is referred to as transient stability, and small signal stability is one that considers small system disturbances . Small signal stability problems occur when there is an insufficient damping of system oscillations as a result of changes in the operating parameters of a power system Frequency stability is related to dynamics that influence system frequency in the range of 10s of a minute . Voltage instability is characterized by a steady decrease of voltage in one or several buses of the power system causing a system collapse as a result of the protective equipment. Voltage collapse results from the inability of a power system to maintain balance between the demand and supply of reactive power within the system network .

Before the advent of wind power plants, power systems mainly consisted of synchronous generators for electricity production. The behaviour and control of these generators following a disturbance are well understood by the utility operators due to their experiences there of 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 powersystem. 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.

The power electronics devices provide the reactive power to the grid in the case of variable speed generators. Excitation system and voltage source static var compensators such as STATCOM have been used to increase the stability margin thereby improving the ride through capability of the generator

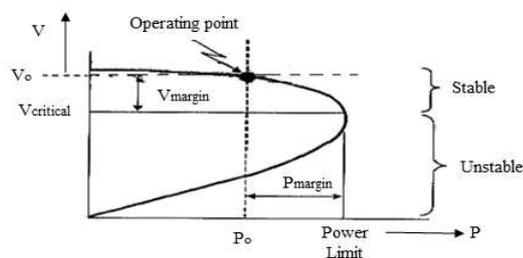
III. IMPACT OF WIND TURBINE ON POWER SYSTEM VOLTAGE STABILITY IN DEREGULATED ENVIRONMENT

III(1)Voltage Stability In Deregulated Environment

Voltage stability is the ability of a power system to maintain steady acceptable voltages at all buses in the system under normal operating conditions and after being subjected to a disturbance. Instability occurs in the form of a progressive fall in voltage in some buses. A possible result of voltage instability is a loss of load in an area. The factors contributing to voltage stability are the generator reactive power limits, load characteristics, the characteristics of the reactive power compensation devices and the action of voltage control devices. Contingencies such as unexpected line outages in stressed system may often result in voltage instability which may lead to voltage collapse. Unavailability of sufficient reactive power sources to maintain normal voltage profiles at heavily loaded buses are the prime reasons for the voltage instability. Although the voltage instability is a localized problem, its impact on the system can be wide spread as it depends on the relationship between transmitted active power, injected reactive power and receiving end voltage.

III(1)(i) PV Curve

The relationship between transferred power (P) and the voltage (V) can be illustrated by the PV curve. Figure 3.2.1 shows a typical PV curve. PV curves are used to analyze the voltage stability. The curve shows how the voltage falls as the demand increases. At the “knee” of the PV curve, the voltage drops rapidly with an increase in load demand. Load flow solutions do not converge beyond this point, which indicates that the system has become unstable. This point is called the critical point. The critical point of the PV curve defines the maximum demand that can be served (the ‘Power Limit’) for a particular power factor and the associated critical voltage. The upper part of the PV curve is considered to be stable whilst the lower part is considered to be unstable. Consequently normal operation is restricted to the upper part of the curve alone.



courtesy:- www.indianwindpower.com

Figure 3.2.1 shows a typical PV curve

III(1)(ii) Loading Margin

The loading margin is the difference between the present operating point of the system and knee (critical loading) point of the PV curve. It represents the additional power that may be transferred to the load that is located in a node or in a load zone so that power system initially found in a stable zone moves to the final state that corresponds to the voltage stability. Loading margin is usually calculated starting from the current operating point and assuming small load increments, for which a new load flow calculation is performed until the nose of the P-V curve is reached. For load flow calculations, it is necessary to represent the input of active and reactive power, P and Q. Wind turbines with induction generators must be represented with an induction machine, with the active power P set to the momentary value. Based on the machine impedance, the load flow program will then calculate the reactive power consumption Q corresponding to the terminal voltage. Variable speed wind turbines however have reactive power controllability. Therefore, the most suitable representation is a fixed PQ representation or if the wind turbine is set to voltage control, a PV representation.

At the load ability limit or tip of the nose curve, the system Jacobian of the power flow equations will become singular as the slope of the nose curve become infinite. Thus the traditional Newton- Raphson (NR) method of obtaining the load flow solution will break down. In this case, a modification of the Newton- Raphson method known as the continuation power flow method is employed. The continuation power flow method employs an additional equation and unknown into the basic power flow equations. The additional equation is chosen specifically to ensure that the augmented Jacobian is no longer singular at the load ability limit.

III(1)(iii) Power System Voltage Stability In The Presence Of Wind Turbine Generators

When the penetration of wind generation is high, it is important to keep WTGs on line as much as possible during grid disturbances as per grid code requirements. Therefore, there is a significant interest in investigating the dynamic performance and characteristics of the system under high penetration of wind generation. This section investigates the effects of wind turbines on power system voltage stability. In transmission networks and distribution grids, node voltage and reactive power are correlated and therefore node voltages can be controlled by adjusting the reactive power generation or consumption of generators. Fixed speed wind turbines have SCIG that always consume reactive power and consequently, it is present practice to provide capacitor banks at each wind turbine. A variable-speed wind turbine with a voltage controller effectively performs voltage control task. Unfortunately, this does not come for free. The

variable-speed wind turbines require power electronic converters with a rating that is higher than the rating for operation at unity power factor.

IV. POWER SYSTEM TRANSIENT STABILITY IN THE PRESENCE OF WIND TURBINE GENERATORS IN DEREGULATED ENVIRONMENT

IV(1) Transient Stability In Deregulated Environment

The deregulated environment has presented the new entities by a variety of problems in the planning and operation. There is need to assess the impact of Independent Power Producers (IPP), Non-Utility Generators (NUG) and Distributed Generators (DG) on system operation and stability. These entities seek transmission access and in many cases cause congestion and overloading of equipment. These in turn are primary causes of problems in system reliability and security. The recent electricity blackouts that happened in many countries during 2003-2004 are partly attributed to the restructuring of the power industry. Many of the utilities involved were trading large quantities of power with other entities over congested and overloaded transmission lines. Local outages and events caused widespread blackouts across national and transnational boundaries. It is impractical to achieve complete immunity to blackouts and there is a need to strike a balance between economy and security. Good design and operating practices could significantly minimize the occurrence and impact of widespread outages.

Therefore there is a necessity of the following issues to enlighten of the deregulation of the power system:

- a) Reliability criteria.
- b) On-line security assessment.
- c) Robust stability controls.
- d) Coordinated emergency controls.
- e) Real-time system monitoring and control.
- f) Wide-spread use of distributed generation.

These events showed that there is an urgent need to provide rigorous analysis and tools of system security to determine operating limits under the new operating environment. In the new power system conditions are extremely unpredictable and the volume of the transactions that have to be examined may be huge. Also the intra-area and inter area transactions have increased resulting in frequently changing operating points and load flow patterns that may cause stability problems. The traditional approach to deploying preventive controls based on off-line analysis studies may not be satisfactory. Tools are necessary for such as on-line stability and voltage stability assessment. Therefore the stability analysis of modern power systems becomes more critical, demanding and difficult. This chapter provides an overview of issues related to system transient stability in a deregulated environment

Power system transient stability phenomena are associated with the operation of synchronous machines in parallel and become important with long-distance high power transmissions. Analysis of transient stability of power systems involves analyzing the dynamic response of the system to large disturbances. There are sudden disturbances such as sudden change of load, switching operation, loss of generation and fault. Following such disturbances in power system, rotor angular differences, rotor speeds, and power transfer undergo fast changes whose magnitudes are dependent upon the severity of disturbances. For a large disturbance, changes in angular differences may be so large as to cause the machine to fall out of step. This type of instability is known as transient instability. Transient stability is a fast phenomenon, usually occurring within one second for a generator close to the cause of disturbance. Transient stability is the ability of a power system to maintain synchronous operation of the machines when subjected to large disturbances. Stability depends on both the initial operating state and the severity of the disturbance. Generally, the loss of synchronism develops in a very few seconds after the occurrence of disturbance. During a fault, electrical power from the nearby generators is reduced drastically. In some cases, the system may be stable even with sustained fault; whereas in other cases system will be stable only if the fault is cleared with sufficient rapidity. Whether the system is stable on the occurrence of a fault depends not only on the system itself, but also on the type of fault, location of fault, fault clearing time and the method of fault clearing.

Transient stability analysis involves some mechanical properties of the machines in the system. After every disturbance, the machines must adjust the relative angles of their rotors to meet the condition of the power transfer involved. The problem is mechanical as well as electrical in nature. output electrical power and moment of inertia

respectively of the machine. The above equation is called swing equation. Swing equation can be written for each machine of the system. Solution of swing equation will show how the rotor angles vary with respect to time following a disturbance called the swing curve of the machine. Once the swing curve is plotted, the stability of the system can be assessed. Swing curve provide information regarding the stability of the system. They show any tendency to oscillate and/or increase beyond the point of return. If increases continuously with time, the system is unstable. Whereas, if starts decreasing after reaching a maximum value it is inferred that the system will remain stable.

IV(2) TRANSIENT STABILITY ASSESSMENT

Transient stability assessment (TSA) is part of dynamic security assessment of power systems which involves the evaluation of the ability of a power system to maintain synchronism under severe but credible contingencies. For transient stability assessment of large power systems, time-domain simulation is done. In time-domain simulation, two approaches are available, i.e., backward Euler and trapezoidal rule, which are implicit-stable algorithms and solve together called simultaneous implicit (SI) method.

In transient stability studies, calculation of critical fault clearing time and computation of rotor angle deviation are used for assessing the performance of the power system.

IV(2)(i) Critical Clearing Time

Generating units may lose synchronism with the power system following a large disturbance and be disconnected by their own protection systems if a fault persists on the power system beyond a critical period. The CCT is the maximum time interval by which the fault must be cleared in order to preserve the system stability. The critical period will depend on number of factors:

- a) The nature of the fault (e.g. a solid three phase bus fault or a line to ground fault midway on a transmission circuit);
- b) The location of the fault with respect to the generation; and;
- c) The capability and characteristics of the generating unit.
- d) The calculation of the critical clearing time for a generating unit for a particular fault is determined by carrying out a set of simulations in time domain in which the fault is allowed to persist on the power system for increasing amounts of time before being removed.

IV(2)(ii) Rotor Angle Deviation

Transient stability mainly depends on the balance between real power generation and demand. The rotor angle of a generator depends on the balance between the electromagnetic torque due to the generator electrical power output and mechanical torque due to the input mechanical power through a prime mover. Remaining in synchronism means that all the generators electromagnetic torque is exactly balanced by the mechanical torque. If in some generator the balance between electromagnetic and mechanical torque is disturbed, due to disturbances in the system, then this will lead to oscillations in the rotor angle. Beyond certain point, the increase in the angular separation will result in decrease of power transfer. This increases the angular separation further and also may lead to instability and synchronous generators fall out of synchronism. Hence, the transient stability can be assessed by assuming the rotor angle deviation following a fault.

IV(2)(iii) Rotor Speed Oscillation

Rotor speed oscillation can also be utilized to assess the system stability under various operating conditions. The following indicators are used to quantify the rotor speed oscillations of the large generators.

The maximum rotor speed deviation is defined as the maximum rotor speed value achieved during the transient phenomenon. The oscillation duration is defined as the time interval between the application of the fault and the moment after which the rotor speed stays within a bandwidth of 10 p.u. during a time interval longer than 2.5 seconds.

IV(3) TRANSIENT STABILITY IN THE PRESENCE OF WIND TURBINE GENERATORS

Wind turbines use squirrel cage induction generators or generators that are grid coupled via power electronic converters. These generator types interact with the power system differently. The impact of the generators on the transient stability of power system is investigated in this chapter.

IV(3)(i) Fixed Speed Wind Turbine Generators

Fixed speed wind turbines use a directly grid coupled squirrel cage induction generator to convert mechanical energy into electrical power. Owing to the different operating speeds of the wind turbine rotor and generator, a gearbox is connected to match the speeds. In fixed speed SCIG, the terminal voltage drops after the occurrence of a fault. Because of this only a small amount of electrical power can be fed into the grid, as the generated electrical power is proportional to the terminal voltage. However, the wind continues to supply mechanical power. Due to the imbalance between supplied mechanical power and generated electrical power, the generator speeds up. Once the fault is cleared, the SCIG draws large amount of reactive power from the grid because of its high rotational speed. Because of this reactive power consumption, it can happen that terminal voltage recovers quickly.

IV(3)(ii) Variable Speed Wind Turbine Generators

The dynamic behaviour of variable-speed wind turbines is fundamentally different from that of fixed-speed wind turbines. Variable speed wind turbines use a power electronic converter to decouple mechanical frequency and electrical grid frequency. This decoupling takes place not only during normal operation but also during and after disturbances. In contrast to the case for directly grid coupled generators, for variable speed wind turbines there are various degrees of freedom to switch then ease to normal operation after the fault clearance. They are not governed by the intrinsic behaviour of the generator. It would be possible to generate extra reactive power when the voltage starts to increase again in order to accelerate voltage restoration.

IV(3)(iii) Geared Drive Wind Turbine Generators

The reactive-power capability of DFIG presents similarities to the CSG capability. It depends on the active-power generated, the slip and the limitations due to stator and rotor maximum-currents as well as the maximum rotor voltage. The asynchronous active power flows can aid in maintaining the rotor angle stability of the system. However, the manner in which wind generation injects reactive power into the system can be critical in maintaining angular stability of the synchronous units. Utilizing wind generation to control voltage and reactive power in the system can ease their active power burden on synchronous generators, and minimize angular separation in the system following a contingency event and can provide a significant level of support which will become increasingly important in future power systems.

The implementation of appropriate control strategies in DFIGs, particularly the implementation of terminal voltage control, can lessen the reactive power requirements of CSGs and help mitigate large rotor angle swings and aid conventional generation in damping the oscillatory signal following a loss of generation event.

IV(3)(iv) Direct Drive Wind Turbine Generators

With full decoupling capability between the converters of direct drive structure, in case of grid disturbance, the GSC is controlled so that it can support the voltage recovery by supplying necessary reactive power to maintain the transient stability.

During a severe contingency, the rotor angle between the machines increases rapidly and may fall out of synchronism. DDSG with controllers could support the voltage by injecting reactive power on the line when the voltage is lower than the reference voltage. By increasing the VAR output to the required value after fault clearing, the transient stability can be enhanced. However, the transient stability can be enhanced further by temporarily increasing the voltage above the regulation reference for the duration of the first acceleration period of the machine. The voltage increased above its nominal value will increase the electric power transmitted and thus will increase also the deceleration of the machine.

The decoupling of mechanical rotor frequency and electrical grid frequency in variable speed wind turbines also affects the response of variable-speed wind turbines to changes in grid frequency. If the grid frequency changes because of a mismatch between generation and load, the mechanical frequency of a variable-speed wind turbine does not change. Thus, no energy is stored in or withdrawn from the rotating mass and drawn from or supplied to the system.

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The controllers of the power electronic converters in variable speed system compensate changes in grid frequency and the mechanical rotor frequency is not affected.

V. CONCLUSION

The need for grid adaptations depends on load variations and capacity to import and export power from grid. The wind is never be same anywhere as wind speed is different in different in geographical conditions. As the wind energy penetration increases more demand will be placed on WPPs for more output, better voltage control, better reactive control ,dynamic support, lesser harmonics response. The WPPs meet that basic requirement proper regulatory commission volume of electrical power generated by WPP become bigger and bigger and wind farms grow longer larger and larger to feed power to grid.

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