ASSESSMENT OF POWER QUALITY CHALLENGES UNDER INTEGRATION OF HIGH PENETRATION LEVELS OF WIND ENERGY INTO ELECTRICITY GRID

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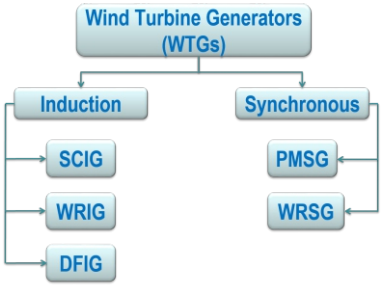
Abstract- Wind energy is an important contributor to the evolution of the smart grid. Integration of large-scale wind energy into the unified electrical grid introduces challenging impacts on the grid performance. Power Quality is one of the most important factors that are affected by such high penetration of wind energy. This paper addresses the impacts of high penetration of wind energy on different power quality aspects such as voltage, frequency. The study involves the assessment of the various voltage stability issues such as voltage flicker, voltage distortion, and voltage transient. Frequency fluctuations and harmonics are also discussed in light of Saudi Arabian Grid Code. Dynamic wind energy system is modeled and simulated using MATLAB software in order to validate the presented analysis.

I. INTRODUCTION

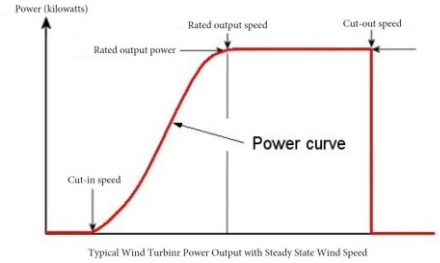
The power quality issues can be viewed with respect to the wind generation, transmission and distribution network, such as voltage variations, frequency variations, harmonics, flickers. It is important to describe a comparison of the power quality for wind power systems based on several generic types of wind generators which include asynchronous (induction) generator and synchronous generator.



II. EFFECTS OF TURBINE SPEED ON POWER QUALITY

For fixed-speed wind turbines, all fluctuations in the wind speed are further transferred as fluctuations in the mechanical torque, hence as fluctuations in the electrical power delivered to the grid. Wind farms with induction generators generate real power and consume reactive power. The over-speed of the induction generator resulted from transient currents drawn by the induction generator from the electrical power system can exceed the stability limit resulting collapse of the system and islanding operation.

For variable-speed wind turbines, It is typically equipped with an induction or synchronous generator. It can increase energy capture, improve power quality, and reduce mechanical stresses on the wind turbine.



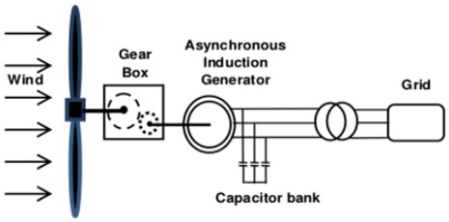
Typical Wind Turbine Power Output with Steady State Wind Speed

Wind turbines use either stall regulated or pitch regulated to avoid the fluctuations on the grid that results from high wind speed.

III. POWER QUALITY ASSESSMENT FOR DIFFERENT TYPES OF WTG SYSTEMS

Squirrel Cage Induction Generator (SCIG) have a steep torque speed characteristic and therefore fluctuations in wind power are transmitted directly to the grid. The connection of the SCIG to the grid should be made gradually in order to limit the in-rush current. Because of the high magnetizing current, the full load power factor becomes relatively low. Too low power factor is

compensated by connecting capacitors in parallel to the generator. In the case of a fault, SCIG's without any reactive power compensation system can lead to voltage instability on the grid. The power extracted from the wind needs to be limited, because otherwise the generator could be overloaded or the pull out torque could be exceeded, leading to rotor speed instability. In this notion, this is done by using pitch angle control.



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