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ANALYSIS OF IMPACT OF WIND TURBINE ON ELECTRICAL GRID NETWORK

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***Abstract* – the analyze of the impact of wind turbine on weak electrical grid network and a number of proposal for wind turbine project development was shown.**

***Key words* – wind turbine, electrical grid, wind power penetration, weak grid conditions.**

Problem formulation. The relationship of transmission system operator with all users of the transmission system (generators, customers, etc.) is set out in grid codes. The objectives of the grid codes are to secure efficiency and reliability of power generation and transmission, to regulate the rights and responsibilities of the entities acting in the electricity sector.

In the past there were usually no wind power connected to power system or the percentage of wind power penetration was extremely small compared to total power production. Therefore connection requirements for the wind farms were originally not included in the grid codes [1].

Most wind turbines are connected to the electric power grid. Wind turbines arc not only a new kind of power plant that transform wind energy into electricity, they also have other traits that power companies, utilities and grid operators are not used to. Wind speed is constantly changing, in a way that is hard to predict, and so the power production will vary. Wind turbines are comparatively small and are usually connected to the distribution grid, while large conventional power plants are connected to the transmission grid, with much higher voltage levels [2].

Recent research analysis. As the wind speed is often fluctuating, small imbalances are likely to degrade the power quality especially in weak grids where WPPs are connected. But large imbalances due to faults, loss of generation, etc. can threaten the stability of the grid. Even during the normal operation of the WPPs the quality of the power produced is continuously varying due to the effects of wind turbulence, wind shear, tower shadow and the operation of control systems (transformer tap-

changing, capacitor switching, etc). These effects lead to periodic power pulsations in the power output [3].

Power quality also relates to different characteristics of the electric power system to which the WPPs are connected:

Technical performance: It includes voltage quality, frequency stability, absence of harmonics, transient stability and other parameters.

Power system reliability: It requires high availability with zero or least interruption [3].

Wind turbines are quite small power plants that should be sited where winds are strong. Therefore they are often located at the periphery of the grid, where the grid is weak. One or a few turbines can always be connected directly to the distribution grid.

The grid operator can handle the variations of power produced by wind turbines in the same way as variations in load (power consumption). When the wind speed decreases the power from other power plants, for example hydropower, will be increased. As long as the share of wind power is below 10 per cent of the total power production this is no problem [2].

Wind power is intermittent by hourly, daily, monthly and annual variations, resulting in fluctuating power being supplied to the grid and hence leading to operational problems. This situation is more acute especially if the grids are weak and the portions of such fluctuating sources are more than certain limits (generally 25%) [3].

When wind power penetration (wind turbines' share of power production) first reaches a level of 10 per cent, the grid and power system may need to be adapted.

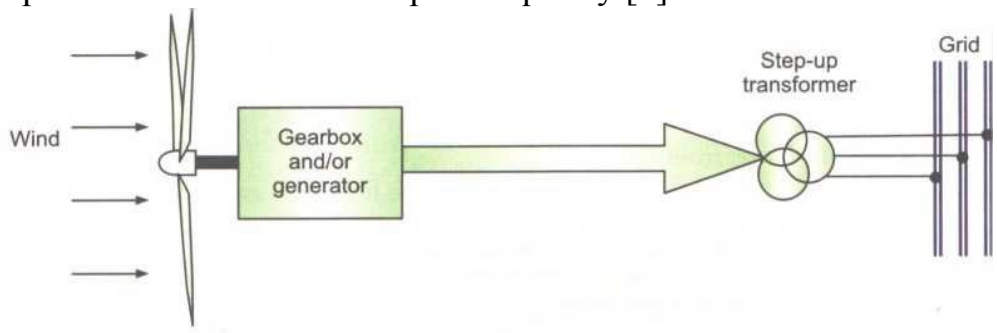
But it is no problem to use a much larger share of wind power in the power system than for the local minimum load. Power systems have good power regulation capacities to keep supply and demand in balance; this is done every minute of the year, with or without wind power, and there are always power plants with reserve capacity in the system [2].

Article purpose formulation. To analyze the impact of wind turbine on electrical grid network, especially if the grids are weak and the portions of such fluctuating sources are more than certain limits.

Hard core. One of the ways to tide over this problem is to connect a large number of WPPs at the point of interconnection (POI) or point of common coupling (PCC). Due to the spread in the operating point and averaging effect, the variations in power supply at the POI will be lower than those with a single WPP. Another alternative is to configure the WPPs as an integrated energy system for operation in conjunction with other renewable energy sources, traditional energy sources and/or storage elements (like the wind-diesel, wind-SPV- diesel and wind-pumped hydro

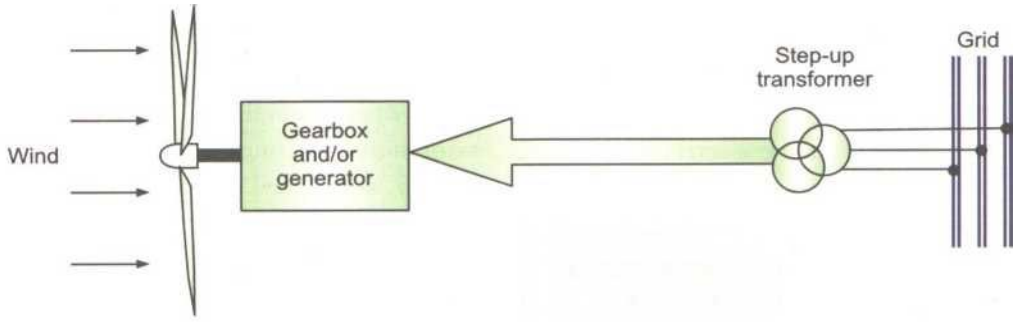
systems). By proper sizing of the various elements and selection of control logic, a near constant output power can be achieved. Another strategy could be to operate this integrated energy system either in a grid-connected mode or in a stand-alone mode [3].

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 the cases, there shall be two kinds of impacts on the network. Figure 1and Figure 2 provide an overall picture of some of the major parameters that affect the power quality [3].



- Node voltages and voltage control
- Fault current contribution
- Active power and reactive power
- Flicker
- Unbalance currents
- Harmonics

Fig. 1. Impact of connecting WPPs to the grid



- Short-circuit faults
- Transient interruptions
- Voltage sags or swells
- Unbalanced voltages
- Frequency variations

Fig. 2. Impact of grid disturbances on the WPPs

Fig. 3 provides an overview of how the WPPs connected to the

electrical grid affect the electrical power quality within the ambit of both these types of impacts.

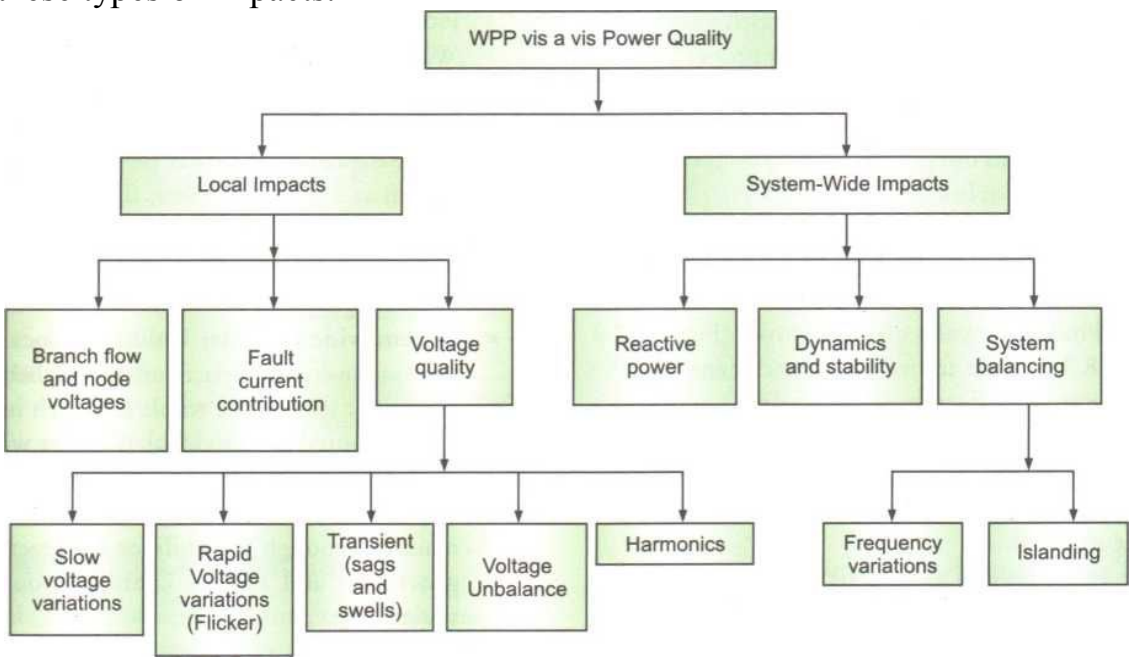


Fig. 3. Major Parameters of WPPs Affecting Grid Power Quality

In areas where weak grid conditions prevail with growing wind energy penetration, power quality will become one of the main factors for installation of WPPs. Unlike conventional generating plants, the power from the WPPs is highly fluctuating (due to changing wind speeds), hence its impact on the grid will also be different. Since WPPs are located in rural areas, the power fed by them into the electric distribution network could lead to some local impacts which need to be addressed [3].

Depending on the capacity of the WPP and wind farms, the wind power penetration has not only affects the local impacts, but also the system-wide impacts. The causes of system-wide impacts cannot be localised, but they are a consequence of wind power that cannot be directly related to individual WPPs or wind farms. Nevertheless, they are strongly related to the WPP penetration level in the grid as a whole. The systems-wide impacts affect:

Reactive power

Dynamics and stability

System balancing: frequency control and dispatch of power from the remaining conventional units [3].

Conclusions. The higher the wind power penetration, the larger the impact of wind power quality at the local level and system wide level. Thus, the requirements on the ramping capabilities of the WPPs must be in order to match the remaining demand curve and to keep the fluctuations of the system's frequency, caused by unbalances between generation and load,

within acceptable limits. Therefore, proper planning and estimation should be done, particularly in weak grids and wherever the wind power penetration level is quite high, or expected to be high in the future, because of the differences in, for example, conventional generation portfolio, wind regime, demand curve and network topology between the various power systems [3].

Grid integration of wind turbines should take into account the grid properties at the point of installation, topology of the machines to be installed, reactive power compensation schemes to be employed and a basic understanding of the local impacts of the turbines at the point of connection. System wide impacts become significant at higher penetrations of wind turbines into the grid.

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АНАЛІЗ ВПЛИВУ ВІТРОВИХ ТУРБІН НА ЕЛЕКТРИЧНУ МЕРЕЖУ

О. В. Лисенко, І. П. Назаренко

***Анотація* – представлений аналіз впливу вітрових турбін на електричничі мережі з малою пропускною здатністю та запропоновано рекомендації щодо їх використання при розробці нових проектів.**

АНАЛИЗ ВЛИЯНИЯ ВЕТРОВЫХ ТУРБИН НА ЭЛЕКТРИЧЕСКУЮ СЕТЬ

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***Аннотация* – представлен анализ влияния ветровых турбин на електричничі сети с малой пропускной способностью и предложены рекомендации по их использованию при разработке новых проектов.**