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Integration of Wind Energy into Electricity Systems: Technical Challenges and Actual Solutions

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Abstract

Wind energy is the current "star" in the field of renewable energy for electrical production. Still, the power generated by wind turbines over time is characteristically uneven due to the unpredictable nature of their primary source of power. This only increases the problems inherent to the integration of a great number of wind turbines into power networks, making their contribution rather difficult to manage (regulating voltage and frequency, wind-farm operation, etc.) The integration of wind power in the power system is now an issue in order to optimize the utilization of the resource and in order to continue the high rate of installation of wind generating capacity, which is necessary in order to achieve the goals of sustainability and security of supply. This paper presents the main technical challenges that are associated with the integration of wind power into power systems. These challenges include effects of wind power on the power system, the power system operating cost, power quality and power imbalances (stability of grid). In addition, the paper presents the solutions will be offered to improve the management of wind power generation and increase its penetration in the overall electrical energy production.

Keywords: Wind energy, energy storage, compressed air, hybrid systems, diesel engine, wind-diesel, turbocharging, turbo charger.

1. Introduction

The wind power production is decentralized in the regions with high average wind speeds. This is different to the conventional production units of large capacity, connected to the high-voltage grids, whose location and power have been planned. These types of production are centrally controlled to

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participate in the control of the frequency and voltage of grid. The fundamental characteristic of the decentralized production is to be lead in most cases by other factors than the electricity demand. For example, the weather conditions for which performed wind turbines. These factors cause uncertainties on the geographical location, the dynamics of the development, the levels and times of the production activity. Theses consequences influence the development, the management and the exploitation of power systems. These last ones must be ready on one hand, absorbing the decentralized production when it is active, and on the other hand, delivering the replacement power when the production is inactive.

Because it's unpredictable in the short term, the wind power is beneficial only in particular situations when there is a good correlation between the production and the consumption, or between the production and the specific needs of the grid. The advantages of the decentralized wind generation appear at maximizing incomes from the production with minimal impact on the power system reliability.

Currently, the wind turbines do not participate in the production settings. The mentality has already been changed; the decentralized production is destined to grow part into centralized production plant. The randomness of wind results that a single wind turbine cannot adapt the production to the consumption. Nevertheless, this adaptation should be done by the intervention of sources having a power reserve allowing a fast regulation of the production.

2. Impacts of the wind nature on the controllability of the wind energy production

The impact's evaluation of wind variability on the production is very important given perspectives and growth targets for the wind energy worldwide [1]. Two characteristics coming from the transfer of the climatic vagaries to the produced power and from the automation of production processes allow concluding that the wind technology offers uncontrollability on the generated production. So, this energy is variable (Fig. 1) and weakly predictable.

Indeed, the mechanical processes of power production from wind turbines transfer all the variability of the wind to the electric production as defined "intermittent". This intermittence corresponds here to the weakly predictable variation of the wind energy. It is characterized by high variability with regard to the forecasts established of the production for one day early. Because the climatic variations of the wind (gusts, variations of speeds, change of direction) are directly transmitted to the production, each variation of wind speed increase or decrease the generated power. Then, the wind energy is considered variable. The variability is defined here as the high frequency of change in output power and variability according to different time scales: second, minute, hour, day, week, month, season or year [2].

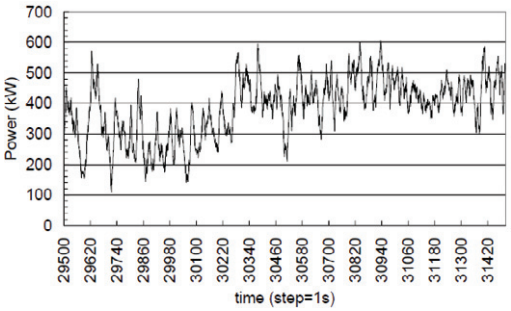

Fig. 1. Example of wind power fluctuation on a microscale [3]

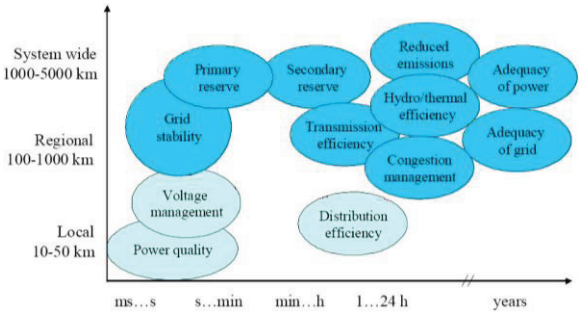

Fig. 2: Impacts of wind power in power systems [4]

The controllability analysis of wind energy requires the ability to anticipate these variations in order to afford itself some degree of production controllability. The foreseeability of the wind energy is the key to