Dynamic Influences of Wind Power on The Power System

The thesis first presents the basic influences of wind power on the power system stability and quality by pointing out the main power quality issues of wind power in a small-scale case and following, the expected large-scale problems are introduced. Secondly, a dynamic wind turbine model that supports power quality assessment of wind turbines is presented. Thirdly, an aggregate wind farm model that support power quality and stability analysis from large wind farms is presented. The aggregate windfarm model includes the smoothing of the relative power fluctuation from a wind farm compared to a single wind turbine. Finally, applications of the aggregate wind farm model to the power systems are presented. The power quality and stability characteristics influenced by large-scale wind power are illustrated with three cases. In this thesis, special emphasis has been given to appropriate models to represent the wind acting on wind farms. The wind speed model to a single wind turbine includes turbulence and tower shadow effects from the wind and the rotational sampling turbulence due to the rotation of the blades. In a park scale, the wind speed model to the wind farm includes the spatial coherence between different wind turbines. Here the wind speed model is applied to a constant rotational speed wind turbine/farm, but the model is suitable to variable speed wind turbine/farm as well. The cases presented here illustrate the influences of the wind power on the power system quality and stability. The flicker and frequency deviations are the main power quality parameters presented. The power system stability concentrates on the voltage stability and on the power system oscillations. From the cases studies, voltage and the frequency variations were smaller than expected from the large-scale wind power integration due to the low spatial correlation of the wind speed. The voltage quality analysed in a Brazilian power system and in the Nordel power system from connecting large amount of wind power showed very small voltage variations. The frequency variations analysed from the Nordel showed also small variations in the frequency but it also showed that the wind turbines excite the power system in the electromechanical modes. Concerning the stability analysis, the study cases showed that large-scale wind power modifies the voltage stability of the power system and can cause power oscillations. It is showed here that the reactive power from the wind farms is the key factor onthe voltage stability problem. During continuous operation, the distributed wind power variations did not give any problems to the power system stability concerning the power oscillations.

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