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Reactive power control of wind farm made up with doubly fed induction generators in distribution system

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ABSTRACT

In recent years, the number of small size wind farm made up with doubly fed induction generators (DFIG) located within the distribution system is rapidly increasing. DFIG can be utilized as the continuous reactive power source to support system voltage control by taking advantage of their reactive power control capability. In this paper, considering both reactive power control and distribution network reconfiguration can be used to reduce power losses and improve voltage profile, a joint optimization algorithm of combining reactive power control of wind farm and network reconfiguration is proposed to obtain the optimal reactive power output of wind farm and network structure simultaneously. The proposed algorithm has been successfully implemented on the 16 bus distribution network and the results obtained demonstrate the efficiency of the algorithm.

1. Introduction

Wind energy is one of the most important and promising renewable energy resources in the world. The penetration of the wind energy in electrical system is rapidly increasing. Currently, a growing number of small size wind farms used as DG sources are located within the distribution system. Installing wind farm in the distribution system can defer the investments for the distribution system expansion, but the intermittent and volatile nature of wind power generation may impact distribution system voltages, frequency and generation adequacy, so the electrical parameters of the distribution network have to be maintained [1–4]. When wind energy penetration is high, voltage control in the distribution system becomes particularly important. As the consequences, in many countries, the new established grid codes demand that wind farm made up with doubly fed induction generators should actively participate in improving voltage control in the distribution system [5].

The variable-speed wind turbine equipped with DFIG is the most popularly employed generator for the recently built wind farm. The variable-speed wind turbine has the ability to obtain the maximum active power from wind speed and control the reactive power independently [6,7]. Utilizing DFIG reactive power control capability, wind farm composed of DFIG can be used as the continuous reactive power source to support system voltage control with fewer costs on the reactive power compensation device. Wind farm reactive power control can reduce power losses and improve the voltage profile at the user terminal by providing reactive power compensation in distribution systems. Wind farm reactive power output is controlled by the system optimal operation condition and the reactive power control capability of each DFIG wind turbine.

There are many previous works on wind farm reactive power control. Ref. [8] proposes a detailed mathematical model of the DFIG and two alternative simulation models for the analysis of both the active and reactive power performances associated with a wind farm constituted exclusively by DFIG. Ref. [9] proposes an optimized dispatch control strategy for active and reactive powers delivered by a doubly fed induction generator in a wind park. Ref. [10] presents a control strategy developed for the reactive power regulation of wind farms made up with DFIG, in order to contribute to the voltage regulation of the electrical grid to which farms are connected. Ref. [11] describes the relation between active and reactive power in order to keep each DFIG operating inside the maximum stator and rotor currents and the steady state stability limit. Ref. [12] describes a PI-based control algorithm to govern the net reactive power flowing between wind farms composed of doubly fed induction generators and the grid.

Network reconfiguration is one of the most significant control schemes in the distribution system, which alters the topological structure of distribution feeders by changing open/closed status of sectionalizing and tie switches. The purpose of the optimal distribution network reconfiguration problem is to identify an

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