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Exploitation of wind-energy resources in proximity to weak electric grids

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Abstract

Many sites with favourable wind conditions exist in proximity to relatively weak electric grids. This may imply that the sites only to a limited degree can be exploited for wind farms producing electricity due to technical constraints related to the weak grid. The paper first describes these constraints and secondly a number of ways for connecting more wind power to a weak electric grid are presented. The methods and technologies presented are relevant for all projects involving exploitation of wind energy in proximity to weak electric grids. © 1999 Elsevier Science Ltd. All rights reserved.

Keywords: Wind power; Weak electric grid; Power quality

1. Introduction

Wind farms are best situated at designated areas with good wind resources. These are often remotely located areas with a weak electric grid infrastructure. This may imply that the sites, only to a limited degree, can be exploited for wind farms producing electricity due to technical constraints related to the weak grid. These technical constraints are commonly associated with the effect that wind power has on voltage quality, and seldom the thermal capacity of the grid. Thus, in this paper, focus will be on voltage quality, whereas the issue of thermal capacity is not dealt with any further.

The voltage-quality constraints related to a weak grid infrastructure that may limit the exploitation of wind energy depend on the characteristics of both the wind turbine installation and the grid.

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As of now, most wind turbines come with an induction generator connected directly to the grid. These are operated at almost constant rotational speed, or if the induction generator is a special design, at semi-variable speed by controlling its rotor resistance. Recently, more wind turbine designs include a full bridge power electronic frequency converter between the generator and the grid. This allows for operating the turbine at variable rotational speed, as well as the ability to regulate the reactive power freely within the limits of the power converter.

A point on an electric network may be characterised as being either weak or strong. A weak point on a network is one where changes in the real and reactive power flows into or out of the network will cause significant changes in the voltage at that point, and at neighbouring points on the network. Therefore, the stronger the network, the less likely it is that wind turbines will cause voltage-quality problems. Networks in rural areas are generally weaker than in urban or industrial areas. Weak networks can also be referred to as having a 'low short-circuit level' or 'low fault level'.

There exist several ways to overcome the possible voltage-quality constraints enabling more wind power to be connected to a weak grid. The options presented include the following

- Grid reinforcement by installation of new lines.
- Regulation of reactive power.
- Introduction of load management.
- Dissipation of wind energy.
- Application of energy storage.

The methods and technologies presented are relevant for all projects involving exploitation of wind energy in proximity to weak electric grids.

2. Voltage-quality constraints

The main technical constraint for connecting wind-power to a weak electric grid is commonly related to the effect that the wind power might have on the voltage quality. Three topics are of concern. These are to what degree the wind power might affect the steady-state voltage level, impose voltage fluctuations and possibly disturb the voltage waveform.

2.1. Steady-state voltage level

Injection of wind power into a distribution network affects the steady-state voltage level. The impact depends on the strength of the network and the output power of the wind-power installation. Fig. 1 illustrates this. It is seen from the figure that the wind power gives less voltage deviations the higher the short-circuit power. Further, the figure shows that, for the same short-circuit power, the same injection