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ScienceDirect
Renewable and Sustainable Energy Reviews
11 (2007) 1858–1872

RENEWABLE & SUSTAINABLE ENERGY REVIEWS

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Connection requirements for wind farms: A survey on technical requierements and regulation

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Received 31 January 2006; accepted 31 January 2006

Abstract

The increase of the wind power penetration in the electrical grids of Denmark, Germany, Spain and other countries and regions is challenging the stability of the system. The subject of this paper is to review the main problems of the connection of wind farms to the grid and how the grid codes must be adapted in order to integrate wind power generation capacity without affecting the quality and stability of the grid. This paper also summarizes the grid codes that have already been modified to incorporate high levels of wind power.

Keywords: Wind farm; Voltage control; Reactive power control; Frequency control; Fault ride-through; Grid code

Contents

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doi:10.1016/j.rser.2006.01.008

1. Introduction

Wind turbines have been treated as embedded generators, and they were not expected to contribute to the control of power system voltage or frequency. In addition, wind farms were required to disconnect from the grid under abnormal operating conditions. Until recently, wind farms connected to the grid were small-sized installations, connected at distribution voltage levels and the total amount of wind power generation capacity installed was (and still is in most countries) small in proportion to the total amount of installed generation capacity. As a result, there was previously little need for such installations to meet a defined set of grid connection technical performance requirements.

As the amount of wind power connected to the grid increases, this situation has started to change in countries such as Denmark, Germany, Spain and other regions in the world. The number of medium and large wind farms (greater than 50 MW) connected to the high voltage transmission system is likely to increase dramatically, specially with offshore wind farms. Wind power is expected to be an important contributor to power generation. Denmark has a 20% of the generation capacity supplied by wind power and expects to reach a level of 50% penetration thanks to strong grid connections with Norway, Germany and Sweden [1]. Other countries and regions (Schlesswig-Holstein in Germany, Navarra and Galicia in Spain, etc.) present similar situations.

The growth in medium and large size wind farms has reached the point in Denmark (and will reach it soon in other countries) where they have a major impact on the characteristics of the transmission system [2–4] and under low load and high wind conditions 100% of the power may be generated by wind power [5]. Denmark has been a pioneer in the connection of wind farms to the grid and is a good example of what may happen in the near future to other countries. Many of the wind farms installed in Denmark use old squirrel cage induction generator technology which has limited ability to provide voltage and frequency control. The key operational issues that have arisen in Western Denmark are described in [1]. Western Denmark has more or less reached saturation and turbines have to be temporarily shut down under certain network conditions.

Another example of a country that must already cope with these problems is India. The case of India is a good example of the problems associated with weak power grids. The penetration of wind power has reached levels high enough to affect the quality and stability of the grid [6]. Islands with high wind resources also present power quality problems. New Zealand expects a 30% share of wind power in the grid in the next 10 years [7]. Canary Islands and New Caledonia present similar situations.

Conventional power plants employ synchronous machines, which are well understood by Network Operators and Generators. Synchronous machines will assist in maintaining transient stability, good voltage control, reactive power support, frequency control and fault ride-through capabilities, thus being able to meet the connection requirements defined