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A brief status on condition monitoring and fault diagnosis in wind energy conversion systems

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ABSTRACT

There is a constant need for the reduction of operational and maintenance costs of Wind Energy Conversion Systems (WECSs). The most efficient way of reducing these costs would be to continuously monitor the condition of these systems. This allows for early detection of the degeneration of the generator health, facilitating a proactive response, minimizing downtime, and maximizing productivity. Wind generators are also inaccessible since they are situated on extremely high towers, which are normally 20 m or more in height. There are also plans to increase the number of offshore sites increasing the need for a remote means of WECS monitoring that eliminates some of the difficulties faced due to accessibility problems. Therefore and due to the importance of condition monitoring and fault diagnosis in WECS (blades, drive trains, and generators), and keeping in mind the need for future research, this paper is intended as a brief status describing different types of faults, their generated signatures, and their diagnostic schemes.

Contents

1. Introduction

Wind energy conversion is the fastest-growing energy source among the new power generation sources in the world and this trend should endure for some time. At the end of 2006, the total United States wind energy capacity had grown to 11,603-MW, or enough to provide the electrical energy needs of more than 2.9 million American homes. Wind capacity in the United States and in Europe has grown at a rate of 20–30% per year over the past decade (Fig. 1). Despite this rapid growth, wind currently provides less than 1% of total electricity consumption in the United States. The vision of the wind industry in the United States and in Europe is to increase wind fraction of the electrical energy mix to more than 20% within the next two decades [1].

Harnessing wind energy for electric power generation is an area of research interest and nowadays the emphasis is given to the cost-effective utilization of this energy aiming at quality and reliability in the electricity delivery. During the last two decades wind turbines sizes have been developed from 20-kW to 5-MW, while even larger wind turbines are being designed. Larger sizes

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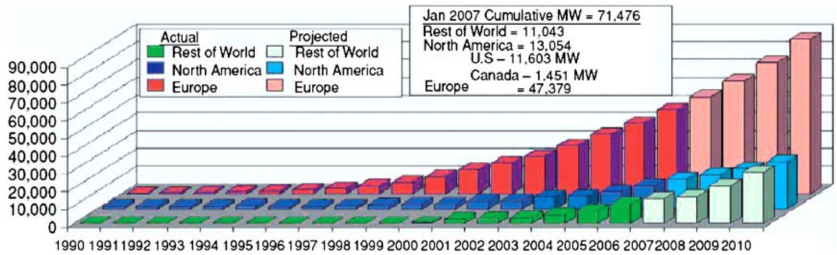

Fig. 1. Worldwide growth of wind energy installed capacity [1].

Fig. 2. Currently largest onshore wind turbine and offshore installations [8].

are physically possible; however, logistical constraints of transporting the components and obtaining cranes large enough to lift the components are potential barriers. Moreover, a lot of different concepts have been developed and tested [2].

Autonomous online condition monitoring systems with integrated fault detection algorithms allow early warnings of mechanical and electrical faults to prevent major component failures.

Side effects on other components can be reduced significantly. Many faults can be detected while the defective component is still operational. Thus, necessary repair actions can be planned in time and need not to be taken immediately. This is important as Wind Energy Conversion System (WECS) generators are inaccessible since they are situated on extremely high towers, which are normally 20 m or more in height (Fig. 2). It is also important especially for offshore plants, where bad weather conditions (storms, high tides, etc.) can prevent any repair actions for several weeks (Fig. 2). Moreover, condition monitoring will also detect extreme external conditions, such as icing or water induced tower oscillations of offshore plants, and can trigger appropriate control actions to prevent damage of plants components. This way, overall maintenance costs and downtime of wind energy converters can be significantly reduced [3–7].

Therefore and due to the importance of condition monitoring and fault diagnosis in WECS (blades, drive trains, and generators), and keeping in mind the need for future research, this paper is intended as a brief status based on an exhaustive review of the state of the art, describing different types of faults, their generated signatures, and their diagnostic schemes. As the Doubly-Fed Induction Generator (DFIG) is one of the most used WECS configurations, the review will be mainly focused on it (Fig. 3).

2. Failure mode analysis

Real wind turbine failure data quantitative analyses have shown important features of failure rate values and trends [9–12].

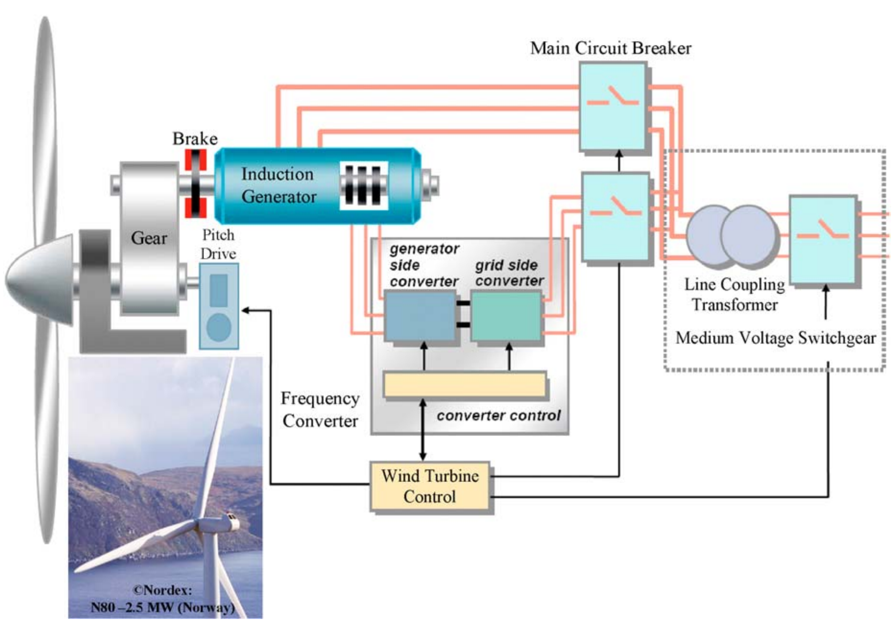

Fig. 3. Most used WECS configuration (with DFIG arrangement) [8].