



Fault analysis of wind turbines in China



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ARTICLE INFO

Article history:

Received 6 June 2014

Received in revised form

23 July 2015

Accepted 27 October 2015

Keywords:

Fault analysis

Wind turbine

Failure

Reliability

ABSTRACT

The installed capacity of wind turbines in China increased rapidly in the past 10 years. Against the backdrop of growing wind turbine capacity, the failure of wind turbines is becoming increasingly serious. Based on the three primary configurations and failure statistics analysis of wind turbines in China, this paper summarizes the failures of wind turbine components, such as frequency converters, generators, gearboxes, pitch systems, yaw systems, blades, braking systems and sub-synchronous machines. Although there are many failure types and various causes, we can deduce four primary reasons for these failures: lack of core technologies; inferior quality due to price competition; design standards and wind farm climate differences; and no mandatory quality certification and exterior factors, such as wind farm construction, power grids and maintenance. Finally, while aiming to improve the reliability, a reliability management method with regard to the design, manufacturing and maintenance of wind turbines was proposed.

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1. Introduction

Renewable energies represent a cornerstone that steers our energy system in the direction of sustainability and supply security [1,2]. Wind is one of the world's fastest-growing renewable energy sources. The rapid growth in wind power is a result of improvements accomplished in technology [3]. The worldwide demand for renewable energy is increasing rapidly because of climate problems and limited oil resources. Electricity generated from wind power currently represents only 3.86% of global electricity production with 318.1 GW of wind power operating in 103 countries [4]. The world's wind energy capacity has been increasing year after year and is expected to continue increasing [5].

As a renewable and clean source of energy, wind energy has been developing rapidly in China in recent years and has become China's third energy source, following thermal power and hydropower [6]. In the last several decades, the total installed capacity of wind energy in China is approximately 91 GW, and even though the new installed wind turbine capacity in 2012 was 26.5% less than in 2011, it still exceeds 13 GW. From 2013, the market environment for wind energy began to recover, and the expected new installed capacity will be 15–18 GW in 2014.

At the same time, China's wind power industry has entered into a transformation period by focusing on quality instead of quantity [7–9].

However, more problems arose with the growth in capacity. In 2010, there were 80 off-grid accidents with wind turbines in China, and in 14 of them, the lost power exceeded 100–500 MWh. In 2011, the number of off-grid accidents reached 193 in the first eight months, and the number of accidents with a 100–500 MWh power loss were 54 [10]. Meanwhile, other wind turbine failures, e.g., nacelle fire and tower collapse, also occurred at the wind farms of the Liaoning, Inner Mongolia, Gansu and Jilin Provinces (Figs. 1 and 2). Although most of the failures were attributed to the chaos of wind farm construction, the violation of wind energy grid-connected standards and the examination lag has led to a greater focus on wind turbine quality.

Due to the emerging energy crisis and growing environmental pollution in China, strengthening the exploitation and utilisation of renewable energy sources, which has caused increasing concerns from the government and social sectors, becomes an important energy development strategy. The new installed wind turbine capacity doubled each year from 2005 to 2010, and in 2010, the new installed capacity was over 18,000 MW and the total installed capacity reached 44,733 MW in China, both of which ranked as first in the world (Fig. 3) [11]. Nevertheless, hidden problems emerged during the rapid expansion. From January 2009 to December 2012, China had 37 wind power catastrophic failures in which 34 were turbine failures and 3 were component failures, and 34 wind turbines collapsed or burnt down (Figs. 1 and 2) [12]. Quality issues are becoming the priority of wind turbine manufacturers [7,13]. Although the new installed capacity for China in 2012 declined dramatically, and it was difficult to revive the wind power industry in 2013 (the new installed capacity in China was 16,089 MW in 2013 [14]), wind power has strong potential as the primary focus of China's renewable energy policies.

2. Current status of wind turbines in China

2.1. Main configurations of wind turbines in China

The first wind turbine developed in China dates back to the 1970s, which joined the power grid in the Sijiao Island, Zhejiang Province. After the 18-kW wind turbine, 200 kW, 250 kW, 600 kW, and 750 kW fixed pitch wind turbines were developed, and the MW level wind turbine was developed in 2003. Currently, the majority of wind turbines in China are 1.5 to 3 MW. In 2013, the 6-MW offshore wind turbine succeeded in power integration, and the 12-MW turbine is under study [15].

Fixed pitch wind turbines are no longer in production due to the evolution of wind power technologies. There are mainly three configurations of pitch controlled wind turbines in the Chinese market.

2.1.1. Doubly Fed Induction Generator (DFIG) with gearbox

This type of wind turbine incorporates the blades, multi-stage gearbox, DFIG, frequency converter and control unit (Fig. 4). The blades drive the gearbox, and in turn, spin the generator to output electricity. The stator of the DFIG is connected directly to the grid, while the rotor circuit is attached to a bi-directional AC–AC, AC–DC–



Fig. 1. 1.5 MW wind turbine nacelle fire in Xilingol wind farm in Inner Mongolia.



Fig. 2. Collapsed wind turbine tower in North Bridge wind farm in Guazhou, Gansu.

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