Renewable Energy 64 (2014) 266–275

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Analysis of wind power generation operation management risk in China

Cun-bin Li, Peng Li*, Xia Feng

School of Economics and Management, North China Electric Power University, Beijing 102206, China

ARTICLE INFO

Article history:
Received 10 October 2012
Accepted 11 November 2013
Available online 10 December 2013

Keywords:
China
Wind power operation management
Risk analysis
Feed-in tariff
Risk management strategy

ABSTRACT

The Chinese government has made an important effort to diversify the country's energy mix and exploit different sources of renewable energy. Although China's installed wind power capacity has undergone a dramatic expansion over the past six years, the electricity generated from wind power has not increased as expected. Meanwhile, operational risks, such as high generation cost, mismatch between capacity and generation, intermittent wind power generation, power grid construction lag, deficient policy, and operation mechanism, have become increasingly prominent. If not controlled, these risks will negatively affect wind power development in China. Therefore, this paper established a quantitative analysis model of wind power operation management risk from two aspects, feed-in tariff and grid electricity (electricity being connected to the grid), based on an analysis of wind power operation management risk in China. Moreover, this study quantitatively assessed the risk of the operational management of a wind farm in Inner Mongolia. Finally, corresponding risk control strategies for the healthy development of wind power generation in China were proposed.

1. Introduction

The demand for energy has continuously increased along with the rapid development of the global economy and continuous improvements lifestyle. To date, oil, gas, coal, and other fossil energies are still the primary energy sources of the world economy. However, limitations and hazard to the environment of fossil fuel energy significantly affect the security and development of human society. To stop global warming and environmental deterioration, as well as to construct a stable and sustainable developing society, countries around the world are paying more attention to the utilization of renewable energy. As a country that consumes large amounts of energy, China attaches great importance to the development and utilization of renewable energy, especially wind energy resources. Hence, wind power generation has become the main way of developing and using wind energy resources in China [1,2]. China's total installed capacity has continually increased since 2005. According to the preliminary statistics of the Chinese Wind Energy Association (CWEA), the total installed wind power capacity in China has reached 62.3 GW and maintained a leading global position by the end of 2011. In 2011, China's newly installed wind power capacity reached 18 million kW, accounting for 40% of the global total newly installed capacity (Fig. 1). After a decade of development, China has become the leading country in wind power development and utilization [3].

Thanks to the encouragement and promotion by both the central government and local government in China, wind power generation has experienced a rapid development period. The installed wind power capacity has reached a certain scale, which lays a solid foundation for energy structure adjustments and energy-saving emission reductions. However, wind power generation still experiences problems, and its operational management incurs significant risks. Specifically, the disharmony between the rapid development of installed wind power and power grid planning leads to overcapacity. The high generation cost and unreasonable wind power feed-in tariff result in a loss of many wind power generation enterprises. In addition, wind power operation suffers from certain related policies and mechanical problems. Despite the fact that China has been the leader in installed wind power capacity around the world, its operational management still poses several risks, which seriously influence the efficiency of wind power operation management and result in a loss of wind power operation enterprises. Therefore, the wind power operation management risk in China is a very important and meaningful topic to study.

Abbreviations: CWEA, Chinese Wind Energy Association; VAT, value added tax; NDRC, National Development and Reform Commission; SETC, State Electricity Regulatory Commission; SoEs, State-owned Enterprises.

* Corresponding author. Tel./fax: +86 10 51963572.
E-mail addresses: hdlp0830@163.com, ncepubjlipeng@163.com (P. Li).

0960-1481/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.renene.2013.11.055

Symbols

P	wind power feed-in tariff;
GC	generation cost;
T	tax
PF	profit
DC	depreciation cost
MC	maintenance cost
SW	salary and welfare
IF	insurance fee
ME	material expense
OF	other fee
VAT	value added tax
VATA	value added tax additional
IT	income tax
SEI	sell electricity income
C_1	the per kilowatt wind turbine cost
G	total installed capacity
λ	station service power consumption rate
α	wind turbine cost accounting for the proportion of initial investment
n	depreciation period
r	discount rate
T_i	equivalent utilization hours of ith
μ	value added rate
τ	wind power plant for profit margins
ω	operating cost according to the initial cost investment proportion withdrawal
P'	the final price after the changes in risk factors
Δt	the change in the annual equivalent utilization hours
R_P^T	the fluctuation risk value of the wind power feed-in tariff caused by the annual power generation
ΔC	the changes in the system cost
R_P^C	the risk value of wind power feed-in tariff due to system cost change
$\Delta\mu$	VAT rate changes
ΔP	wind power feed-in tariff variation value
R_P^μ	the risk value of wind power feed-in tariff due to VAT changes
Δr	the discount rate variation
R_P^r	the price change risk due to changes in the discount rate
c	the scale factor of Weibull function
k	the shape factor of Weibull function
v	wind speed
$f(v)$	the probability density function
$F(v)$	cumulative distribution
v_{in}	cut-in speed
v_{out}	cut-out speed
P_r	rated power
v_r	rated speed
T_w	the operation time of the wind turbine
$E[P(v)]$	desired output of the wind turbine
$\mathrm{Var}(P(v))$	changes in the wind power output
Q	wind farm generation
r_A	the wind power acceptance rate of the regional grid
$Q_{On\text{-}grid}$	the wind power delivered to the grid
$R_{On\text{-}grid}$	value of risk for wind power to be delivered to the gird

Some studies have already examined the operational challenges in the development of wind power in China, such as the mismatch between capacity and generation, the contradictions of high generation cost and the fixed feed-in tariff, the lag in grid construction, some regulatory uncertainty and policy inconsistency. Taking the northeast power grid as an example, Zhao et al. analyzed the cause of the conflict between the market mechanism and traditional planning and its impact on large-scale wind power, and finally suggested some measures to mitigate the conflict [4]. The split of plants and grids causes multiple subjects of interest to participate in the competition for their own benefits. However, the absence of government management in the development and grid planning of wind power results in inconsistencies between wind power development and grid planning and construction, which results in overcapacity risks [5]. Zhao et al. provided a new perspective of the constraints on the effective utilization of wind power in the Northeast China Grid and argued that constrained factors can be divided into two categories: structural factor and operational factor [6]. Yang et al. proposed that the large discrepancy between the installed capacity and generation was mainly caused by the inadequacy of the power transmission grid, the absence of economic incentives to transmission and backup generation providers, and the lack of a generation-based renewable portfolio standard [7]. According to the three large problems (high generation cost, low feed-in tariff, and stagnating development of domestic manufacture) of wind power generation in China, Han et al. carried out a specific analysis and put forward a corresponding policy to solve these problems and promote the development of wind power generation [8]. Yu et al. proposed a useful model to assess seasonal and daily wind power generation by considering the wind power generation, and the analysis result showed that the main influence factors included capacity and power output [9]. Zhao et al. established an improved dynamic diamond model to study and evaluate the important factors that influence the current wind power industry development in China [10]. Liao et al. reported the technical and economic potentials of wind power, the recent development, existing obstacles, and related policies in China. The results showed that the commercialization barriers of the wind power market are very important and may deter the 100 GW capacity target of the Chinese government by 2020 [11]. Despite the recent growth rates that have promised a bright future, Li et al. proposed that two important issues (the capability of the grid infrastructure and the

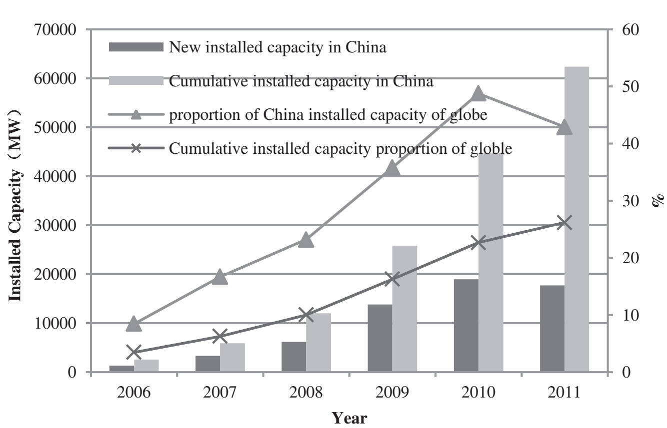

Fig. 1. The installed wind energy capacity in China and its proportion to that of the world sources: Chinese Wind Energy Association (2011); Global Wind Energy Council (2011).