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Constraints on the effective utilization of wind power in China: An illustration from the northeast China grid

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ABSTRACT

Even though China's wind power industry has experienced a rapid growth since the beginning of this century, the utilization of wind power is still worrisome. In 2010, about 30% of China's total installed capacity could not get access to the grid. And about 10% of China's total wind power generation was curtailed. The problem of wind power curtailment is more prominent in Northeast-China region. The main particularity of Northeast China Grid is as follows: during the long heating period in winter, combined heat and power thermal plants need to modify the turbine generator's output to meet the heating demand and thus the thermal power peak regulation capacity is reduced, as a result the barriers of wind power consumption are increased. This paper provides a new perspective of the constraints on the effective utilization of wind power in the Northeast China Grid. We argue that there are two categories of constrained factors: structural factor and operational factor. The former includes grid structure, wind source structure, power source structure, and market structure. The latter includes power price mechanism, dispatch mode arrangement, wind power integration codes, and wind power forecast. At last, we make policy recommendations: promote the coordination between wind farm investment and grid construction, strengthen interprovincial power trade mechanism, implement flexible pricing mechanisms as well as improve current dispatch mode, etc.

Contents

1. Introduction

As climate change becomes an increasingly pressing concern, China now is facing many challenges from the extensive use of fossil energy resources [1], such as the mounting international

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and domestic pressures to cut back CO_2 emission [2]. Hence, it is imperative for China to promote renewable energy development. China is rich in wind resources. According to the China Meteorological Administration, onshore wind power resources at an altitude of 10 m total about 3226 GW in terms of electricity, of which 253 GW is available for development and utilization [3]. The development of China's wind power was initiated in the 1980 s, represented by the establishment of China's first demonstration wind farm with imported units, Malan Wind Farm, in Rongcheng, Shandong Province on May 8, 1986. Since then, the Chinese government has attached great importance to wind power development, and a series of policies have been formulated to promote the development of wind power, including *Regulation on Wind Farm Parallel Operation* (*Trial*), *Electric Power Law of the People's Republic of China and Program for the Development of New and Renewable Energy Source* (*1995–2010*). At the beginning of this century, China's wind power industry began to grow dramatically. From 2000 to 2005, China's installed wind power capacity increased at an annual average rate of 20% [4]. Since the promulgation of *the Renewable Energy Law* in 2005, China's installed capacity of wind power has grown dramatically, reaching 44.73 GW by the end of 2010, exceeding the target set in China's long-term energy planning for 2020 [5]. It was the first time that China surpassed the United States and ranked the first in the world in terms of installed capacity of wind power [6].

China's Northeast area is one of the three most wind-rich interiors (Northeast, North-China and Northwest) and possesses abundant wind energy reserves [7]. The Northeast China Grid ranging from Heilongjiang, Jilin, Liaoning to the East of Inner Mongolia(EIM) covers a power supply area of 1.27 million km^2, taking a share of 13 percent of the country's total power supply territory (Fig. 1). The population in this area is 121 million, accounting for 9 percent of the country's total (data at the end of 2009). Physical grid infrastructure in this area is mainly framed with 500-kV transmission lines, extended by 220-kV circular lines connecting most part of power generation units and load centers within the region. The longest transmission line of the north to south grid in this region, being linked to the North China Grid (in the Beijing and Hebei area) by a 500 KV back-to-back HVDC system, is 1643 km.

The Northeast China Grid has experienced a rapid development of wind power in recent years. Its installed capacity of wind power surged from 847 MW in 2006 to 8510 MW in June 2010, accounting for 39.12% of the nation's total, growing at double rates for three consecutive years. At present, its total installed capacity of wind power ranks the first among all Chinese regional Grids (Northeast Grid, North China Grid, Northwest Grid, Middle China Grid, East China Grid, and the South Grid). Meanwhile, the Northeast China Grid has paid much attention to wind power integration into grid, and the amount of wind power it purchased was 9.693 billion KWh at the end of 2009, an increase of 97.3% over the same period in the previous year, a proportion of 48% of the wind power purchased by the State Grid system. From January to June 2010, the cumulative wind power generation of the Northeast China Grid reached 8.557 billion KWh, accounting for 5.18% of the national total[1] , rivaling the best in China.

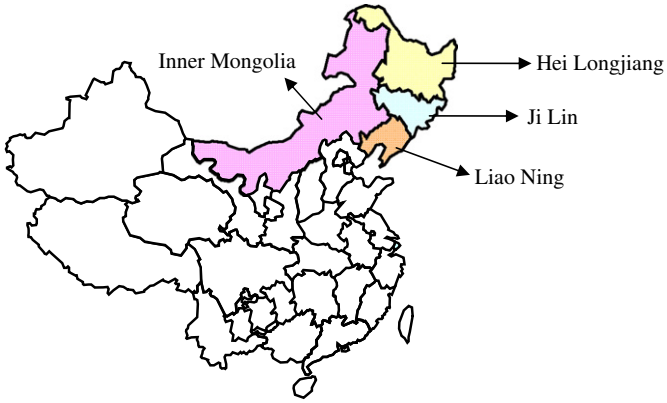

Fig. 1. Map of China with highlighted three Northeast provinces and Inner Mongolia (Northeast China Grid includes three Northeast provinces and Eastern Inner Mongolia).

Behind the successful story of wind power development, challenges exist in China [5–15], especially in the Northeast Grid. In 2010, China's grid-connected installed capacity of wind power was only 31,000 MW, which means about 30% of China's total installed capacity could not get access to the grid. According to a report by the State Electricity Regulatory Commission (SERC), in the first six months of 2010, wind power curtailment was as high as 2776 GWh, about 10% of China's total wind power generation. The problem of wind power curtailment is more prominent in the northeast China region. In 2009, the curtailed wind power generation in the Northeast China Grid was about 912 GWh, a proportion of 9.41% of the total possible wind power output[2]; in 2010, approximately 1,963 GWh wind power were curtailed, an increase of 11.33% than in 2009. The exacerbated curtailment of wind power would not only drive people away from wind power [8], but also further reduce the already fairly low efficiency of wind farms in China. Hence, it is crucial to explore the constraints on the effective utilization of wind power and find solutions for improving the low efficiency (or low "capacity factor") of China's wind farms.

Some studies have paid attention to the challenges China faces in the development of wind power, such as low quality of turbines [9–11], regulatory uncertainty and policy inconsistency [9,12], high generation cost and stagnating development of domestic manufacture [13]. A few studies explore the factors directly related to China's low efficiency of wind power including inadequate grid infrastructure which leads to power transmission congestion [6,8–11,14,15], system economics (more wind power integration would bring about more system operation cost) which leads to the fact that grid corporations dislike wind power [8,9], and huge backlogs [8] (dispatch mode adjustment, publication of codes at state level, improvement of wind power production forecasting capacity).

Although the above studies provide some valuable insights, to our best knowledge, few make particular analysis on the factors that constrain the effective utilization of wind power in China. Our study makes an attempt to fill the gap. We first analyze the current situation of wind power integration and curtailment in the Northeast China Grid, then explore the factors influencing the low efficiency of wind power from two broad aspects: one is structural factors such as grid structure, wind source structure, power source structure, and market structure; the other is operational factors such as power price mechanism, dispatch mode arrangement, wind power integration codes, and wind power forecast. At last, conclusion and policy recommendations are provided.

2. Current situation of wind power integration and curtailment in the northeast China grid

In 1993, there was only one wind farm with four units and 300 KW installed capacity in the Northeast China Grid. This situation has changed rapidly since the year 2005 (Table 1).

[1] Data source: Northeast Grid Limited Company. Report of wind power development of Northeast Grid (in Chinese), July 2010.

[2] Data source: Northeast Electricity Regulatory Authority. Annual Report of Electricity Regulatory of Northeast Region (2009) (in Chinese), 2010.