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The key technologies and development of offshore wind farm in China

Jie Wu *, Zhi-Xin Wang, Guo-Qiang Wang

Department of Electrical Engineering, Shanghai Jiao Tong University, 200240 Shanghai, China

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ABSTRACT

China is one of the largest energy consumers in the world. Excessive consumption of coal and other primary energy causes serious environmental pollution and energy crisis. China must wean from the over-reliance on coal and needs to make great efforts to develop clean and efficient renewable energy. In recent years, offshore wind energy has been developing rapidly with the advantages of not taking up land resources and high utilization rate. By the end of 2012, the total installed capacity of offshore wind power was 389.6 MW in China. The planning capacity will be 5 GW by 2015 and 30 GW by 2020 [1,2]. Compared to onshore wind power, the development of offshore wind power is facing some new problems and challenges, for example power transmission, offshore harsh natural environments, multi-sectoral coordination and management, and so on. This paper firstly analyzes the irrationality of China's energy consumption structure and the necessity for developing offshore wind power. Secondly, an overview of offshore wind farm access, AC (Alternating Current) and DC (Direct Current) transmission technologies and offshore wind turbine control strategies are given. The development status and future plans of offshore wind power are also introduced. Finally, we analyze the existing problems and obstacles during the construction process of offshore wind farms from three aspects, including technical, economic, and national policies. And some corresponding recommendations to accelerate the development of offshore wind farm are also proposed.

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* Corresponding author.

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1. Introduction

China's rapid economic development requires a lot of energy consumption. Coal is the first choice with the advantages of abundant resources and cheap price. Primary energy structure is dominated by coal, which is the main feature of China's energy structure. In recent years, despite the increase use of hydropower and other renewable energy sources, the proportion of coal consumption in the energy structure is still too high. The proportion of various energy consumptions of China in 2013 (from Jan. to Dec.) is shown in Fig. 1 [1,2]. The coal consumption is 3.76 billion tons, accounting for 65.7% of the total primary energy consumption. However, the world's coal consumption average proportion accounted for less than 30% of the total primary energy [3,4]. In the developed countries such as the United States and Japan, the proportion is less than 25% [5,6]. The consumption proportion of high-polluting fossil energy such as coal is too high in China, much higher than the developed countries, even higher than that of some developing countries, such as Brazil, India [2]. So China's energy structure is unreasonable. Meanwhile, because of the relatively low proportion of oil, gas, hydropower, wind power, solar and other kinds of clean energy in China, the energy consumption intensity is slowly declining. In 2013, China's elasticity coefficient of energy consumption (a ratio of China's energy consumption growth rate in to the economic growth rate) was 0.6 and energy consumption intensity decreased by 3.7% compared with last year. Energy consumption of each ten thousands yuan GDP is 0.737 t of standard coal [7]. Therefore, energy saving and emission reduction are the key problems, and the energy structure needs strategic adjustment.

China is committed to change the energy structure because of the pressure induced by huge energy consumption and the ecological environment. In recent years, China's renewable energy development is fast. According to the national energy administration monitoring data, the total national wind power installed capacity of China (excluding Taiwan) is 77160 MW in 2013. In the aspect of solar energy, national photovoltaic power installed capacity has reached 17,160 MW by the end of 2013 [8]. The PV growing speed is faster than all the other countries of the global. In addition, the development and utilization of biomass energy have also made great achievements. “China's Energy Policy (2012)” White Paper, released in Oct. 2012, proposed to speed up the R&D (research and development) of the core technology for shale-gas exploitation and achieve the overall goal of national yield reaching 6.5 billion cubic meters in 2015. Meanwhile, the target that non-fossil energy consumption accounts for 15% of primary energy by 2020 was also proposed [9]. To sum up, the wind power development enjoys a good momentum growth, and shows good prospects for development. But the onshore wind power development is near saturation and offshore wind power has become the new trend. By the end of 2013, the global offshore wind power cumulative installed capacity is about 7100 MW [10]. China Wind Energy Association statistics showed that there were 11,409 sets of new installed wind turbines, the increased installed capacity of 17,631 MW in 2011 China (excluding Taiwan). Compared with 2010, it decreased by 6.85% (the increased installed capacity was 18,928 MW in 2010), and that was the first negative growth in new installed capacity of nearly 10 years. At the same time, the National Energy Administration issued “about giving the authorization notice of the second batch of wind power projects during the12th Five-Year Plan”. It shows that the total authorized capacity of the second wind power projects is 14,920 MW, reducing 13,910 MW compared with the planning approval released in August 2011, the decreasing amplitude is approximately 50%. This shows that the rhythm of wind power industry development is limited in China. The traditional onshore wind is of depression and the Chinese market is almost saturated. But offshore wind power is still listed as one of the development priorities in “the 12th Five-Year Plan”. Therefore, the development of offshore wind power will be the future trend. It will become the new battlefield of enterprise competition.

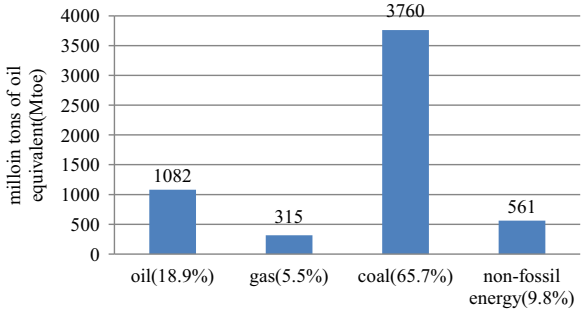

Fig. 1. China's energy consumption structure in 2013.
Source: Authors′adaptation based on [2].

Based on the above situation, the paper discusses the related technologies and development of offshore wind power in China. Firstly, the basic control principles of offshore wind turbines based on permanent magnet synchronous motor (PMSM) and doubly fed induction generator (DFIG) are introduced. After that, some key technologies of offshore wind power are summarized, including offshore wind farms grid integration, technical requirements for accessing and wind power prediction, especially including high voltage direct current transmission based on voltage source converter (VSC-HVDC) and low voltage ride through (LVRT) technology for offshore wind farms. Then, Chinese offshore wind power development and future prospects are introduced. Furthermore, due to the harsh natural environment at sea, offshore wind turbines are facing new technical challenges, for example, the impacts of typhoons, ice and salt-spray corrosion, which are described in detail later. Also, they enhance the requirements of wind turbines manufacturing technology and make the maintenance of offshore wind farms difficult. Finally, some appropriate development proposals are given for the difficulties existing in the first round projects bidding of China's offshore wind power, on the aspects of national policy and economy.

2. Technologies of large-scale offshore wind turbines

China has already had the ability to design and manufacture large-scale offshore wind turbines. Hoisting and trial operation for 6 MW offshore wind turbines have been completed. “the 12th five-year special plan of wind power technology development” formulated by