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Development of energy storage industry in China: A technical and economic point of review

Yun Li^a, Yanbin Li^{a,*}, Pengfei Ji^b, Jing Yang^c^a School of Economics and Management, North China Electric Power University, Beijing 102206, China^b Department of Mechanical and Aerospace Engineering, University of Missouri, Columbia, MO 65211, USA^c Guodian Materials Corporation, China Guodian Corporation, Beijing 102206, China

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ABSTRACT

With the global attention and continuous investment in the field of clean energy and carbon emission reduction, the renewable energy occupies an increasingly large proportion in the power system. China, as the world's fastest developing country, the development of renewable energy becomes an inevitable path in the context of low-carbon economy. However, due to the intermittent and stochastic property of renewable energy, the renewable energy system cannot be widely used without the configuration of energy storage system. The aforementioned requirement precipitates the industrial application of energy storage technology becomes increasingly urgent. However, according to the present status of energy storage industry in China, there are enormous difficulties to be overcome promptly. In this work, the development status of China's energy storage industry is analyzed from the perspectives of technology, application and policy, by referring to a large number of statistical literatures. Subsequently, the existing problems are categorized in terms of technology, cost, promotion, policy mechanisms. In the end, suggestions to solve the above problems are put forward, aiming at facilitating the rapid development of energy storage industry in China.

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* Corresponding author. Tel.: +86 13311175255; fax: +86 010 6177 3108.

E-mail address: liybn@ncepu.edu.cn (Y. Li).

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1. Introduction

In the modern society, with the increasing growth of population and demand of power consumption, to ensure the sufficient and steady power supply becomes an essential. Traditionally, the power generation is from fossil resources. However, under the crisis of global warming and worsening of climate change induced by greenhouse gas emission from burning of fossil sources, the renewable energy has drawn continuous investment. Owing to the intermittent and stochastic property of renewable energy, the renewable energy system cannot be widely implemented without the configuration of energy storage system. In order to provide reliable energy to the power grid, the renewable energy sources (such as solar, wind and tidal energies) have to be converted in terms of other stable form by using the energy storage technology. Nowadays, the significance of large-scale energy storage technology and its industrial application has become a world widely consensus, which is an essential guard for the safe, stable and economic operation of power system, as well as the large-scale development and utilization of the renewable energy. Developed countries, represented by the United States and Japan, have supported the energy storage industry as national strategic projects. The rapid advancement of energy storage technology accelerates the transformation of the energy storage industry into a relatively independent, promising and strategic industry. It is estimated that a large number of large-scale energy storage products will be used in the power system. The estimated amount of global energy storage product market will reach trillion dollars. According to the statement addressed by the research institutions in the Department of Energy in the United States, the energy storage products will become the most worthwhile investment market and the most concentrating field of finance in the future. As conservatively estimated, the global energy storage market will reach \$30 billion by 2015 [1]. Report released by *Markets and Markets* in 2012 shows that global energy storage market is expected to maintain at a high double-digit compound annual growth rate from 2011 to 2016, which will result in growth from \$39.7 billion in 2011 to \$61.9 billion in 2016 [2].

The starting point of the energy storage industry in China is behind those in the developed countries. Nevertheless, in the recent years, the terminology “energy storage” appears in the Chinese vision more and more frequently with the rapid popularization of the renewable energy generation. Because the energy storage technology can effectively solve the contradiction between the power grid and the power generation. On one hand, it effectively coordinates the output of renewable energy sources. On the other hand, it regulates the grid voltage, frequency and phase change caused by the renewable energy and improves the electric power quality, so as to achieve the grid-connection of large-scale renewable energy. The above factors indicate the energy storage system helps to make the renewable energy to get more exploited than ever. Therefore, China, as a country exploiting the renewable energy in large scale, has urgent practical needs for the energy storage industry [3,4].

However, severe constraints coming from the technology, cost, promotion, policy mechanisms, are the major obstacles impeding further development of energy storage industry. To precisely grasp the trend of energy storage technology and its application, get a

comprehensive understanding of its development status, clarify the challenges in the process of developing energy storage industry, and put forward effectively strategies to tackle the challenges, are of great importance at present. For the purpose of occupying the competitive high ground of the long term development of energy storage industry, it is crucial to carry out in-depth study focusing on the energy storage industry in China.

2. Technical development

Energy storage technology is classified into physical storage, chemical storage, etc. The main methodologies of physical storage are pumped storage, compressed air energy storage and flywheel energy storage. Chemical energy storage mainly refers to lead-acid batteries, lithium ion batteries, flow batteries, molten salt batteries, and nickel hydrogen batteries. Besides the aforementioned storage approaches, electrochemical capacitors, superconducting magnetic energy storage, fuel cells, and metal–air batteries are also widely used. Researches on these technologies have been carried out in various aspects [5].

2.1. Physical storage

2.1.1. Pumped storage power station

Pumped storage power station utilizes extra electric power to pump water to the upstream reservoir, when the generated electrical power is greater than the load. The pumped storage power station makes full use of the potential of water to flow to the downstream, which generates electricity at the peak of power load. The efficiency of pumped storage ranges from 70% to 85%. Its response time ranges from 10 s to 4 min. At the present, pumped storage is not only the most cost-effective energy storage technology for large-scale electricity storage, but also the most widely used large-scale energy storage technology. In 2009, Bureau of National Energy in China held a special symposium on pumped storage power station construction work, intending to clear the direction for the properly and orderly development of the pumped storage resource. After recent years of technology introduction, digestion and absorption, China has the ability to produce the equipment by itself, rather than purely relies on the imports of large-scale mechanical and electrical equipment. Furthermore, the construction technology of pumped storage power station has reached the world's leading level. Since the Shisanling Pumped Storage power station was built, pumped storage technology in China had been able to catch up with the developed countries in the past 20 years of development [6]. On May 29, 2013, the key project of “12th five-year plan for Development” in China – Fengning pumped storage power station started to construct. The total installed capacity of the power station was planned to get 3.6 MkW. Upon construction, it will become the world's largest pumped storage power station.

2.1.2. Compressed air energy storage system

Compressed air energy storage system is mainly implemented in the large scale power plants, owing to its advantages of large capacity, long working hours, great number of charge–discharge cycles. The maximum capacity of the compressed air energy storage system

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