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The situation analysis of shale gas development in China-based on Structural Equation Modeling

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ABSTRACT

Shale gas is a significant source of unconventional energy. With the largest recoverable reserves in the world, China has 36.1 trillion cubic meters of shale gas, which will contribute to ensuring its national energy security and promoting the diversity of energy supply. Chinese government spares no effort to support the utilization and development of shale gas. However, the development of shale gas remains deeply troubled; thus the authors would like to reveal the factors influencing shale gas development in China. Through the study of various literature and carrying out interviews with experts about shale gas development, the authors collected 206 valid questionnaires from experts, scholars or researchers in shale gas field and then used Structural Equation Modeling to analyze the data, illustrate the relationships among environment, technology, resource, market and shale gas development and finally establish a shale gas development implementation model. The research findings would help Chinese government advance shale gas development, and improve further studies in shale gas area.

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Abbreviations: AGFI, Adjusted Goodness of fit index; AVE, Average variance extracted; CFI, Comparative fit index; CIF, Cost, insurance and freight; CR, Construct reliability; C.R., Critical value; DF, Degree of freedom; EIA, Energy Information Administration; EU, European Union; GFI, Goodness of fit index; H, Hypothesis; NFI, Normed Fit Index; NCP, Estimated Non-centrality Parameter; P, Probability; R & D, Research and development; RMS, Root mean square; RMSEA, Root-mean-square error of approximation; S.E., Standard error; SEM, Structural Equation Modeling; SPSS, Statistical Product and Service Solutions; TCM, Trillion cubic meters; U.S., United States of America; U.S.A, United States of America

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1. Introduction

Facing the pressure of environment and resources, many countries in the world are actively developing renewable and sustainable energy, among which shale gas is of critical importance. With the remarkable development of shale gas in the United States (see Fig. 1), more and more countries and corporations focus on the shale gas exploitation. According to the analysis of Energy Information Administration (EIA) in 2012, the total reserve of shale gas is about 623 trillion cubic meters and the recoverable reserve is around 187.6 trillion cubic meters in the world. The USA has the second largest recoverable reserves of 24.41 trillion cubic meters and China leads the world with the recoverable reserves of 36.1 trillion cubic meters, becoming one of most significant fields for shale gas development.

The substantial recoverable reserve of shale gas in China will ensure its energy security and diversified energy supply [1], and also provides an effective way for the country to accelerate its transformation into the pattern of clean energy economy. Despite the fact that the large-scale exploitation of shale gas will bring many benefits, the government of China should realize the hardships and difficulties in the actual operation. First, corporations in China have not grasped the core technology including drilling and fracturing techniques in developing shale gas. Second, the financial subsidies now fail to meet most participants' expectations. Third, the lack of fresh water in the sedimentary basins of northwest China hinders the development of shale gas and even in the areas where fresh water is available, the access to land is severely restricted due to high population density and related economic activities. In addition, many scholars believe that China's market mechanism, namely, the low price of natural gas as well as the monopoly of national oil companies is unfavorable for the development of shale gas.

Because of the significance of shale gas, Chinese government attaches great importance to its utilization and development and leads the shale gas industry into a crucial period of high-speed development. And this has attracted an increasing number of studies in shale gas, but most of them concentrated on the drilling and fracturing techniques as well as economic evaluation instead of the influencing factors. Therefore, this paper adopted the method of questionnaire survey by interviewing researchers and scholars in shale gas field and used the Structural Equation Method (SEM) to find out the major factors influencing shale gas development in China and present strategies and suggestions for the development of shale gas industry based on the research findings.

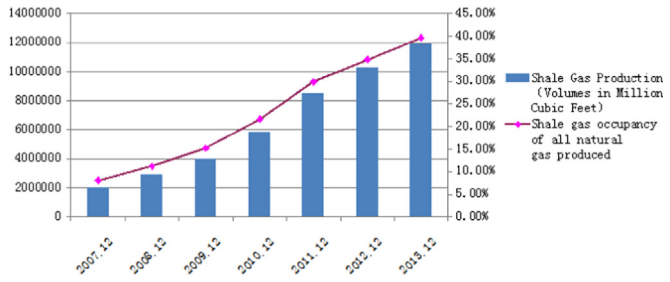

Fig. 1. U.S. Shale gas production.

SEM is a statistical technique for testing and estimating causal relations through the use of combination of statistical data and qualitative assumptions. SEM has been widely used in healthcare, logistics, information management, banking, psychology, marketing and tourism management. Structural equation model has become a preferred data analysis method for empirical research. Following the trend in empirical research, authors adopt SEM to analyze the first-hand data from survey.

2. Literature review

Among the various studies of Chinese shale gas industry, most researchers believe that China's shale gas revolution is related to resources, environmental effects, the land ownership system, the price mechanism and technology. So authors will discuss the issue from the following four aspects.

2.1. Resource

According to the initial assessment of shale gas resources in the world by Energy Information Administration (EIA) in 2012, China possesses abundant shale gas. In the 32 countries surveyed, China ranks first with reserves of about 144.4 trillion cubic meters (TCM) of shale gas. Technically recoverable shale gas resources are estimated to be 36.1 TCM, 50% higher than those of the U. S [2]. However, The Ministry of Land and Resources P. R. C cautiously estimated that the shale gas geological resource potential is around 134.42 TCM and the recoverable shale gas reserve is about 25.08 TCM [3].

Although the evaluations from institutions at home and abroad are different in terms of the recoverable shale gas resources in China, the opinions on shale gas distribution are basically similar, namely, shale gas resources are mainly distributed in Upper Yangtze and Dian-Qian-Gui Areas, North and Northeast China, Mid-lower Yangtze and Southeast China and Northwest China [5]. Zou et al found that the development prospect of marine shale is the best in China [4]. In all the major distribution areas, the Sichuan Basin (in south-central China) and the Tarim Basin (in north-west China) have the most prospective with favorable reservoir qualities. Many countries' governments have invested a lot of resources to develop shale gas industry; the main reason is the rich reserves of shale gas, like Poland and Mexico. In Poland, where estimations of its shale gas resources were the highest in Europe with 187 trillion cubic feet (EIA, 2011), subsequent official re-assessments by the Polish authorities have reduced this potential significantly, to a range between 12.2 and 27.1 trillion cubic feet [6]. So authors believe that the shale gas reserve is one of the most influential factors in the shale gas development.

2.2. Environment

Hydraulic fracturing technologies and horizontal drilling have caused water pollution in USA, and shale gas exploitation may bring adverse impacts on air quality, land use and even induce earthquakes. China would be fraught with the same problems. Some scholars argue that the negative effects of developing shale gas on environment are much more serious than those of

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