Prospects for Shale Gas Transition: A Case Study of China

by

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Abstract

This paper reviews the development of shale gas industry in China. Due to its special resources endowment, coal resource plays an important role in China's energy matrix and accounts for nearly 70% of total energy consumption, which has given rise to serious environmental problems, such as acid rain, atmosphere and water pollution. To promote sustainable prospects of social economy and ecological environment, Chinese government published a series of energy policies to accelerate the shale gas commercialization. This paper applies Grey Theory to exploring China and America's shale gas production tendency by 2020. Grey theory is one of Time Series Models that can be utilized in the condition of small data and poor information. The final results show the huge gap between China and America with regarding to the shale gas commercialization. In 2016, Natural Energy Administration issued the Shale Gas Development Planning for the next five years, which was aimed at the breakthrough for technical, regulatory and market infrastructure problems that are likely to delay rapid development in the shale-gas exploitation. The intention of this study is to review the shale gas scenario in China, and explore the possibility that China can meet its increasing natural gas demand. Finally, this paper will put forward some effective recommendations for the shale-gas exploitation in China.

1 Introduction

The investment and research of unconventional gas has gained extensive interest in the world. The unconventional gas mainly contains shale gas, coalbed methane and tight gas. Shale gas is primarily trapped in fine grained sedimentary rock called shale which requires 'hydraulic fracturing' technology to be produced. Tight gas is trapped in relatively impermeable hard rock, limestone or sandstone, sometimes with quantified limit of permeability. Coalbed methane is trapped in coal seams, adsorbed in the solid matrix of the coal [1]. Among the three separate categories of unconventional gas, the shale gas is perhaps of the most sophiscated type with best prospects for commercial development.

Shale gas, an emerging unconventional energy source in recent decades, has received increasing attention worldwide. Compared with other fossil fuels, shale gas is a kind of clean-burning and efficient energy resource, which contributes to reducing a country's overdependence on high-energy and high-pollution resources. Therefore, shale gas offers more options for reducing air pollutants and greenhouse emissions. According to statistics from US Energy Information Administration in 2013, the total available shale gas reserve was 187 trillion cubic meter, which far surpassed the conventional natural gas reserves in the selected 32 countries [2]. Along with the maturity of "fracking" technology, the shale gas is extensive exploited in America, which gradually changes its energy structure. In 2017, the shale gas production in United States reached 0.46 trillion cubic meter, which accounted for half of its total natural gas production [3, 4]. Due to the boom in shale gas production, America has become the net natural gas exporter for the first time in 2017.

The success on shale gas revolution in the US enlightened Chinese government. Due to its distinct resource endowment and continuously urbanization process, China is facing severe challenges for growing energy demand and environmental pollution simultaneously. Among all the total primary energy, 83% are from coal and petroleum, which has caused terrible air pollution in the northern China [5]. According to the statistics, China is the largest CO_2 and SO_2 emitter in the world, and many cities are troubled with water pollution and hazy weather challenges in recent years. Nearly 180 thousand patients died of SO_2 pollution in 2016, and the medical expenses surpassed 300 billion RMB. The economic losses caused by air and water pollution accounted for 8%~12% of total Gross Domestic Product (GDP) [6]. All these issues are bringing negative effect on the increasing urbanization process. Therefore, Chinese government attaches great importance to exploitation of natural gas resource, which are regard as the key element to alleviate air pollution and improve energy structure. However, the domestic natural gas production cannot satisfy its increasing demand, China has to import large amounts of natural gas to bridge its

demand-supply gap. According to statistics, the total natural gas consumption was 2.34×10^{11} m^3 in 2017, 38.7% of which depended on import. The reliance on gas import will further increase rapidly in the future [7].

China, like the United States, has substantial potential shale gas resources. The total available shale gas reserve is 36 trillion cubic meter, which accounts for nearly 20% of the global reserve [8]. If shale gas resource can be large-scale exploited successfully in China, the dependence on foreign gas will be reduced greatly and the energy structure will be more sustainable. Thus, Chinese government attaches great importance to the commercialization of shale gas resource, which is regarded as the key element to alleviate air pollution and optimize energy structure. In 2016, Natural Energy Administration issued the Shale Gas Development Planning for the next five years, which was aimed at the breakthrough on technical, regulatory and market infrastructure problems that are likely to delay rapid development in the shale-gas exploitation. The aim of this study is to review the shale gas scenario in China, analyze the main challenges which exist in shale gas industry at present in China, and investigate the possibility that China can meet its increasing natural gas demand. Finally, this paper will put forward some effective recommendations for the shale-gas exploitation in China.

2 Shale gas potential in China

The shale gas resource is very rich in China and is widely distributed nine basins, such as Tarim, Dzungaria. In 2011, Ministry of Land and Resources launched a program to evaluate and investigate the nationwide shale gas potential. According to the investigation result, the total recoverable reserve of shale gas is 25.1 trillion cubic meter in the land, which has surpassed the conventional gas reserve in China. Among all the shale gas resource, 80% of the reserve is distributed in ten provinces, such as Sichuan, Xinjiang, Chongqing, Guizhou, Hubei, Hunan, Shanxi, Guangxi, Jiangsu and Henan, as is shown in Table 1 and Figure 1.

Although China has rich shale gas reserve, the exploitation is very difficult. Most of shale gas resource is distributed in remote area, and the geologic feature is very complex. Nearly half of the shale gas exploration zone is buried more than 3500 meters deep in China, which increases the difficulty of mining greatly.
In 2015, China International Mining Conference announced that, by keeping up with America and Canada, China became the third country that realized the commercial exploitation of shale gas. According to Shale Gas Development Planning from 2016 to 2020, the shale gas output will reach 3×10^{10} m^3 by 2020, and nearly 1.0×10^{11} m^3 by 2030. Thanks to the reduction of exploitation cost, the shale gas production enters boom period. In 2016, 6% of total natural gas production was from shale gas resource, and the percentage will reach 16% by 2020, as shown in Figure 2.

At present, there are five commercial basins for shale gas exploitation in China.

1.Fuling exploration zone
Fuling is the first field for shale gas commercialization, which is located in east of Chongqing. The total geological reserve is 4.8×10^{11} m^3, and its current production capacity is 7.5×10^{9} m^3. In 2017, the shale gas production was 6×10^{8} m^3, 95% of which entered the commercial market.

2.Changning exploration zone
Changning field is located between Sichuan basin and the Yunan-Guizhou Plateau. Its total reserve is 1.9 trillion cubic meter, its production was only 1.5×10^{9} m^3 in 2017.

3.Weiyuan exploration zone
Weiyuan field is located between Sichuan and the Chongqing. Its total reserve reaches 3.9 trillion cubic meter, its production was 2.5×10^{9} m^3 in 2017.

4.Fushun-Yongchuan exploration zone
Fushun-Yongchuan field is located in Sichuan. Its total reserve reaches 0.5 trillion cubic meter.

5.Zhaotong exploration zone
Zhaotong field is located between Sichuan and Yunan. Its total reserve reaches 0.5 trillion cubic meter, and its production capacity is 5.5×10^{8} m^3 every year.

3 Challenges for shale gas transition

Compare to America and Canada, the production of shale gas is limited in China with various reasons. In this section, we utilized grey prediction model GM (1,1) to forecast shale gas output in America by 2020, and the result is shown in Figure 3.

3.1 Absence of geological survey

Chinese government have not implemented a comprehensive survey for shale gas reserves and just investigated the primary areas with rich shale gas reserves. There are many reasons for this phenomenon and the economic factor is the most important. Due to its low permeability and deep burial, the shale gas exploitation is very expensive. In China, the shale gas reserve is mainly buried at 3000-4000 meters. To drill a horizontal well, the expense will reach 60-80 million RMB, which is nearly three times as much as in the United States. The final cost of mining has reached 2.5 RMB per cubic meter, which don't have any advantage over conventional gas. Chinese petroleum monopolies, like China National Petroleum Corporation, Sinopec, takes more attention on conventional gas, which is cheaper than shale gas, and the shale gas commercialization process is limited. The overall spending for shale gas reserves investigation in China is less than 7 billion in recent years. In the meantime, China will spend 66 billion RMB for conventional gas exploration annually.

3.2 Deficiency of exploitation technique

There are many advanced technologies that support the shale gas industry, such as well drilling, fracturing, well logging and seismic technologies. These technologies can seek the shale gas core accurately, improve per-well production and reduce the cost of mining. Any deficiency in these techniques will interference shale gas exploitation and commercialization. Just thanks to the breakthrough of horizontal well technology and fracturing technology, the shale gas production is booming in America. Compared to the successful commercialization of shale gas in America, the geological characteristic of shale gas in China is more complex and requires more advanced mining technology. The current proven technology in U.S. is not suitable for shale gas exploitation in China. However, the shale gas development is in its infancy in China. Although China has made large advances with regarding to shale gas technologies, these technologies can't conduct an integrated system to promote the development of shale gas commercialization. The shale gas industry in China is far behind the United States and can't satisfy the increasing gas demand. According to the statistics, the production cost of shale gas is 11.2 dollars per million British thermal units in China, which is nearly 4 times as much as in United States.

3.3 Obstacles to market mechanism

The oil and gas industry is highly monopolized in China. Most of the exploring rights for shale gas reserves are controlled by several state-owned enterprises, such as China National Petroleum Corporation, Sinopec. Private capital is restricted strictly in oil and gas field. Chinese petroleum monopolies occupy the vast majority of financial subsides and policy support for shale gas exploration, but the progress is slow. The current management system can improve national energy stability, but it can't promote the market competition in the emerging field and leads to deficiency in resources allocation. On the other hand, there are enormous barriers of mining right between shale gas and conventional gas. Nearly 80% of the shale gas production areas are overlapped with conventional gas mining areas, which are controlled by several petroleum monopolies, such as China National Petroleum Corporation, Sinopec. The shale gas exploitation is mainly limited in the other 20% production areas to avoid property right dispute. Furthermore, the shale gas reserves are widely distributed in remote areas. The natural gas pipe network in these areas is incomplete and can't transport the produced shale gas to the lower-reach market. In addition, the current gas pipe network is pretty well monopolized by state-owned petrochemical enterprises and are closed to other recovery enterprises. All these barriers violates the principle of fairness and impedes the development of shale gas market.

3.4 Environmental risk

The shale gas reserve mainly exists in Sichuan basin, there are many natural villages and residents in this area. The government must pay large amounts of money for land requisition compensation before large-scale centralized exploitation, and have to ensure the safety during exploitation process. Besides, some exploitation zones are exposed to water shortage, such as Tarim region and Junggar region. The hydraulic fracturing technology is widely used in the shale gas exploitation process, which will consume abundant water resources. Along with the large-scale development of shale gas industry, it's very likely that the water resource conflict will occur between local residents and shale gas commercialization, and the natural environment will be influenced gradually.

4 Suggestions for shale gas transition

4.1 National survey for shale gas resource potential

In 2011, Ministry of Land and Resources launched a program to investigate the nationwide shale gas reserve and verified the primary areas and resource potential of shale gas. To accelerate the development of shale gas, Chinese government should strengthen international communication and cooperation with petrochemical enterprise, scientific research institution and academic institution to formulate grading standards of shale gas reservoir and reserve, obtain detailed distribution characteristics and growth feature of shale gas resource. On this basis, Chinese government should conduct a scientific plan for shale gas development to reduce the risk of shale gas commercialization and accelerate shale gas exploitation.

4.2 Financial support for key technology research

Shale gas exploitation is technically difficult. Chinese government should attach great importance to the technology innovation in the area of shale gas commercialization. In order to tackle problems in key technologies and promote shale gas development, the government should establish special fund for shale gas technology research and resource exploration. Furthermore, the government should increase the investment for strategic investigation of shale gas resource, encourage social capital to enter into shale gas industry, and offer financial subsides for technology research, key equipment import, and various tax with regarding to the shale gas industry.

4.3 Promoting international cooperation

Due to the weak technical reserve, shale gas commercialization faces many challenges. On the contrary, the shale gas revolution has made significant progress in America. If China can obtain the technical support from America shale gas companies, China's shale gas market will be improved greatly. Chinese government should strengthen international cooperation with Canada and U.S. in the area of shale gas exploitation, introduce advanced management philosophy and core technologies of shale gas commercialization, put forward suitable technology and standard systems for geology assessment, gas analysis, reservior evaluation, well drilling and fracturing to improve shale gas industry level.

4.4 Improving management mechanism

Chinese government should establish a new mechanism for data management and service of shale gas, strengthen the management and public service of shale gas geological data in accordance with the law, which is aimed at improving the socialized benefits of shale gas geological data and providing service for the whole related enterprises and society. Furthermore, the government should take attention to the talent cultivation, and appointed young experts with strong professional proficiency as project leaders. The government can implement strategic survey of shale gas and exploitation process to train large amounts of outstanding persons for shale gas industry.

5 Conclusion

Due to the special resource endowment, coal and petroleum are the main energy source in China, which put great pressure on the ecological environment and greenhouse emission control. The shale gas exploitation can expand the sources of natural gas, reduce environmental pollution, optimize energy structure and ensure energy security. To accelerate the process of shale gas commercialization, China must strengthen international cooperation, bring in advanced technologies and reduce exploitation cost.

At present, the conventional gas production is booming in China, and the shale gas resource will not be the development priority in recent years. To promote the shale gas industry, China should create a favourable development environment as the primary guarantee. The shale gas industry exists many shortcomings, such as high cost of exploitation, long investment cycle, and absence of short-term economic benefit. The government can offer financial and policy support to accelerate the development of shale gas commercialization. What's more, Chinese petroleum monopolies enjoy the majority of technology reserve, policy and financial support in terms of shale gas industry, but shale gas commercialization makes slow progress. In the future, the government should adjust energy policies to open up shale gas exploitation to social capital, which is the most effective method to optimize resource allocation and stimulate the development of shale gas industry in China.

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Table 1 Estimated shale gas reserves in different basins of China

Basin	Geological reserve	Basin	Geological reserve
Sichuan	$27.5\times10^{12}m^3$	Hunan	$9.19\times10^{12}m^3$
Xinjiang	$16.01\times10^{12}m^3$	Shanxi	$7.17\times10^{12}m^3$
Chongqing	$12.75\times10^{12}m^3$	Guangxi	$5.61\times10^{12}m^3$
Guizhou	$10.48\times10^{12}m^3$	Jiangsu	$5.33\times10^{12}m^3$
Hubei	$9.48\times10^{12}m^3$	Henan	$3.71\times10^{12}m^3$

Figure 1 Estimated shale gas reserves in different basins of China

Figure 2 Output for shale gas and total gas in China

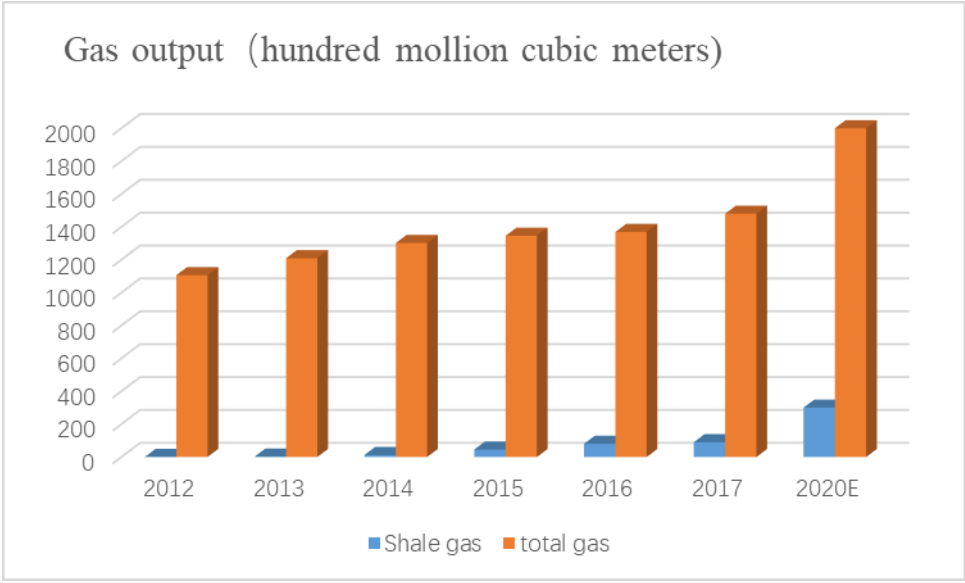

Figure 3 Production comparision of shale gas between China and United States