

The Analysis of China's Water Environmental Protection in Exploiting Shale Gas

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ABSTRACT: In recent years, under pressures of the global energy crisis and climate change, shale gas(SG) was widely concerned as a relatively clean source of energy. One of the widely used technologies to exploit SG is hydraulic fracturing, which consumes a large amount of fresh water, pollutes water environment, and destroys ecological environment. China, which has the world's largest amount of SG, has begun to carry out researches and tests on SG exploitation by learning the technology and experience from developed countries. However, the imbalance between supply and demand of freshwater became the biggest constraint; water pollution situation and potential geological disaster risk put forward higher requirements for pollution prevention in exploiting SG. Water pollution could be effectively prevented by taking technological innovation, environmental supervision, environmental risks prevention and other measures in exploiting SG.

KEYWORD: Shale gas; Water environment; Protection

1 GENERAL INSTRUCTIONS

In recent years, under pressures of the global energy crisis and climate change, SG was widely concerned as a relatively clean source of energy. SG is mainly distributed in North America, Central Asia, Middle East, North Africa, South Africa and other countries and regions. There are many advantages, such as longer exploiting life, longer stable period and higher investment returns in the exploitation of SG, which is a hotspot and breakthrough of energy research.

Although the price of SG and natural gas is close, the exploitation of SG will output Natural Gas Liquid (NGL), which consists of ethane, propane and butane, and is the raw material for the production of ethylene and propylene. NGL's price is much higher than natural gas, and similar with oil in price trend, which could be a profit point in the exploitation of SG. If 1.54 billion m³ of water was used for irrigating 2.6 km² of arid land, the harvested corn will worth about \$ 200,000, while if the same amount of water was used in exploiting SG with hydraulic fracturing technology, the obtained oil will worth about \$ 2.5 billion[1].

There was a successful exploitation of SG in North America, especially in the US, which was the

only one in the world to achieve large-scale utilization and commercialization. Although the US has more developed techniques in exploiting SG, environmentalists still strongly oppose it. Taking into account that the exploitation of SG may bring serious environmental problems, opposition from ordinary people who object to exploit unconventional gas by hydraulic fracturing technology was rising. Some SG projects in European countries and the US were suspended. For example, France passed the bill to ban the application of hydraulic fracturing technology in June, 2011. It also became the first country to ban the exploitation of SG. In the following, Bulgaria, Romania and the Czech Republic respectively heed public opinion and enacted bans in January, May and August, 2012 [2-5].

2 REVIEW OF CHINA'S EXPLOITATION OF SG

SG is widely distributed, abundantly reserved, and has huge exploitation potential in China. SG resource of China is about 26 trillion cubic meters, accounting for 5.7% of the global SG resource which is about 456 trillion cubic meters, and ranks first in the world. Learning from foreign advanced technologies, and experience of domestic conventional oil and gas exploration, China

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successfully completed a number of SG well drilling, cementing and fracturing operation and accumulated a preliminary experience. Overall, the exploration and exploitation of SG in China is still in its infancy. Exploration and core exploitation technologies are immature, especially that the environmental impact on the exploitation of SG is hard to eliminate [6,7].

Hydraulic fracturing technology is the most common and effective means of exploiting SG. However, hydraulic fracturing technology is a double-edged sword, and consumes a lot of freshwater resources. Taking American Barnett Shale for example, the average water consumption of drilling wells is 180 cubic meters per well, and fracturing operations is 13,650 cubic meters per well^[8]. Since water is injected into the shale, which is much deeper than underground aquifers, and a lot of water is absorbed mainly by rocks, and can't be recycled. Therefore, the key to successful exploitation of SG is to obtain enough water for drilling wells and fracturing operations.

3 THE MAIN ENVIRONMENTAL PROBLEMS IN CHINA'S EXPLOITATION OF SG

3.1 *The imbalance between supply and demand of freshwater constraints the exploitation of SG*

The imbalance between supply and demand of freshwater has becoming increasingly serious in China. The total amount of freshwater resources is 2.8 trillion cubic meters, accounting for 6% of global freshwater resources, ranking fourth in the world. But there is only 1.1 trillion cubic meters of available freshwater resources, deducting flood runoff that is difficult to use and groundwater scattered in remote areas. According to statistics of Chinese 600 cities, over half of the cities are lack of water in varying degrees, and more than 110 cities are in serious water shortages. Coastal cities are no exception, and even more serious. It is predicted that without controlling, China's water demand will reach to 818 billion cubic meters in 2030, and water shortage will be 201 billion cubic meters. When Chinese population reach to 1.6 billion in 2030, the per-capita share of freshwater resources will fall to 1750 cubic meters, which is close to the international standards of water stress[9,10].

China's natural environment for exploiting SG is harsher than America. Data show that SG reserves of China are mainly distributed in the Sichuan Basin and Tarim Basin, and mostly buried in the underground between 4000 to 6000 meters. These places are mostly mountainous or deserts, which are inaccessible, and in severe water shortages. In the Yangtze River basin where the water is relatively plentiful, SG is found only in Sichuan and Jiangnan Basin. In the northwest and north China, SG reserves

are abundant, while local freshwater resources are very tight. Considering the recent drought-prone in southwestern region, large-scale exploitation of SG may make the local situation worse in water shortages[11]. If 1.5 billion m³ of SG in the Sichuan Basin were exploited by drilling 1000 wells, which would take 24 hours uninterrupted work with all drilling wells for four years. Then 171 million m³ of water would be used, which was equivalent to 1.1 percent of the mineable groundwater resources in the Sichuan Basin. Although 171 million m³ of water accounts for a small proportion of freshwater resources, there are regional and seasonal water shortage problems in this region. Thus, the exploitation of SG will further exacerbate the imbalance between supply and demand of freshwater in China. Meanwhile improper wastewater treatments easily pollute the water environment. These will seriously affect the safety of China's industrial and agricultural water supply and household water. Therefore, it is a challenge to obtain adequate water supply in the process of exploiting SG, and without confliction between the residents' drinking water and industrial and agricultural water.

3.2 *Water pollution situation puts forward higher requirements on the exploitation of SG*

The exploitation of SG primarily uses hydraulic fracturing method, and hydraulic breaker requires a lot of water, in which chemicals are added, including crosslinking agents, demulsifiers, and stabilizers. Hydraulic fracturing and SG production process will produce wastewater, including fracturing waste fluid and wastewater. These two kinds of wastewater contain potentially harmful contaminants, including salts, organic hydrocarbons, inorganic and organic additives, and naturally radioactive material. Especially, the chemical composition of the fracturing fluid will cause potential impact on groundwater. Taking fracturing waste fluid for example, a single horizontal SG wells generally consume 7,600-19,000 cubic meters of freshwater, and 15%-80% of fracturing waste fluid is discharged into the ground after fracturing operation. For contacting with the strata, the fracturing waste fluid has higher levels of metal ions, organic matter, chloride, and other pollutants. There is a risk of environmental contamination for improper disposal. Therefore, this technique will waste freshwater, and contaminate groundwater. Water pollution reduces the water function, exacerbates the imbalance between supply and demand of freshwater, and bring a negative impact on the implementation of the sustainable development strategy[12].

3.3 *The exploitation of SG will induce potential geological disasters*

American geological experts believed that hydraulic fracturing method used in exploiting SG would collapse fault line in deep underground, which may cause extremely powerful large-scale earthquake and damage buildings. The study found that the strong earthquakes which happened in 10 thousand kilometers deep in the ground would cause the continuous tremors near injection wells. Recently, the increased oil and gas exploration activities by hydraulic fracturing method in America had association with increased earthquakes in five states. Earthquakes which happened in Oklahoma, Colorado and Texas were related to exploiting activities[13].

SG reserves of China are mainly distributed in the Sichuan Basin and Tarim Basin, and accordingly exploitation activities will also be taken in these regions. In recent years, two strong earthquakes occurred in the Sichuan Basin: 8.0 magnitude earthquake occurred in Wenchuan in 2008, and 7.0 magnitude earthquake occurred in Ya'an in 2013. The study found that 9-10 years after more than 7.0 magnitude earthquakes, there was a high-incidence season in landslides, mudslides and so on. In Chengdu, before the earthquake, there were almost no geological disasters, while geological disasters happened frequently after the earthquakes. Sichuan Basin's frequent geological disasters were mainly related to two strong earthquakes and heavy rainfalls. Two strong earthquakes caused fracture inside the mountains, crushing surface rocks, loose soil, and destruction in vegetation ecosystem, which reduced induce conditions of the geologic hazards. Meanwhile, there were abnormal rainfalls in the Sichuan Basin. In flood reason of 2013, more than six heavy rainfalls occurred in western regions of the Sichuan Basin. The hourly rainfall, daily rainfall and others data, broke through historical extremes several times in Anxian, Suining, Dujiangyan, Mianyang and other places. Sudden, sustained and intense heavy rainfalls are more easily to induce landslides, mudslides and other secondary disasters. In addition, there is leakage risk in SG transfer process like ordinary natural gas. Once the leak occurs, the atmosphere will be contaminated. Therefore, it is better to do a good job of the maintenance of pipelines, monitoring and early warning.

Although Chinese people look forward to the prospects for SG as an alternative energy, the amount of land and freshwater resources per capita is far less than America, and long-term exploitation of SG will bring more vulnerable ecological environment to our country, which faces with the growing imbalance between supply and demand of freshwater, and worsening groundwater pollution and other issues. Therefore, the status quo of

freshwater resources and the needs of environmental protection should be fully considered in SG exploitation in China, and appropriate measures should be taken.

4 WATER ENVIRONMENTAL PROTECTION MEASURES IN CHINA'S EXPLOITATION OF SG

4.1 *Strengthen technological innovation*

Some technologies, such as drilling, completion and well fracturing, are involved in exploiting SG. Cost of exploiting SG significantly decreased by technologies innovation such as designing specialized drilling machines for SG, reusing fracturing and drilling fluid and paving temporary roads in America, Canada, etc. Foreign exploiting techniques are not suitable for China, for most of SG in China distributed in mountainous or deserts, as well as drilling depth of SG is deeper. The exploiting cost will increase in lack of infrastructure, and without convenient road and pipeline networks. Hence, renowned universities, research institutes and some state-owned enterprises, such as Sinopec, should make more contributions to technological innovation based on their strong technical strength. Specifically, above-mentioned organizations should develop the drilling machines and fracturing technology with independent intellectual property, as well as recycling and pollution control technology of fracturing wastewater, which are suitable for local geological and storage condition of SG.

4.2 *Strengthen environmental supervision*

Although there are several laws for environmental protection, such as "Environmental Protection Law", "Water Pollution Prevention Law", "Atmospheric Pollution Prevention Act", and "Environmental Impact Assessment Law", Ministry of Environmental Protection has not established a specialized law for SG. Therefore, it is necessary for China to reference American experience and establish comprehensive environmental monitoring system including groundwater, geology, soils, ecology, etc. and covering the entire life cycle in exploiting SG. Firstly, Congress should promptly formulate laws about the exploitation of SG, especially mandatory emissions standards. Secondly, enterprises which take the whole life cycle of the business model for exploiting SG should be approved by government. Taking SG pollution problems after exploitation into account, negative impact on the environment should be reduced to the lowest level[14].

4.3 Prevent Environmental Risk

Due to environmental risk within the process of exploiting SG, protection measures should be taken into account. Firstly, distribution and activity characteristics of deep and active faults zone should be concerned, especially high-pressure hydraulic fracturing and the injection of wastewater in SG wells. Meanwhile, geological environment monitoring can help to focus on the state of underground faults, prevent excessive pressure damage underground faults, and avoid earthquakes and other geological disasters. Secondly, the allocation of regional water resources should be coordinated before the exploitation of SG. Under the precondition of satisfying domestic, industrial and agricultural water usage, exploiting SG could be carried out, and freshwater resources should be recycled in exploiting SG. SG storage blocks are mainly located in the northwestern regions where water resources are scarce. It is the most economical and safe way to recycle water in the process of exploiting SG. Fracturing drainage could be treated before reusing in hydraulic fracturing or drilling wells[15]. Thirdly, air and water environment monitoring should be used for preventing environment pollution by greenhouse gases—methane in all process including drilling and wells completion, hydraulic fracturing, gas transmission and distribution[16]. Finally, a reasonable choice of exploiting sites and access roads should be made before exploitation, which will reduce the damage to farmland and vegetation, and ecological restoration should be taken after exploitation.

5 SUMMARY

During the process of the exploitation of SG in the future, we should:

(1) Learn from foreign advanced exploiting technologies and experience of SG, combining with Chinese circumstances;

(2) Explore exploiting methods to save the land, water, money, and to protect environment, combining with Chinese status of hydrogeology, water resources and transport;

(3) Reduce the consumption of freshwater resources by technological innovation in exploiting SG;

(4) Improve access threshold of enterprises, and strengthen environmental supervision of the entire process of exploitation and transportation of SG;

(5) Protect the environment in exploiting areas by unique, advanced exploiting technologies, and promote the healthy exploitation of SG in China.

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