Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(7):1225-1230

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Opportunities and challenges of the CBM development environment in China

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ABSTRACT

Rich reserves of CBM resource, an ever-growing energy demand, and huge emission reduction pressure altogether contribute to the rapid development of CBM industry. As a clean and efficient energy, Coal Bed Methane (CBM) development is able to effectively better China's energy consumption structure, enhance the living quality of the public and promote energy conservation and emission reduction, which will significantly guarantee China's implementation of its economic transition strategy as well as the development of our low-carbon economy and green economy. However, in the process of CBM development, there also happens some detrimental influence on the environment, which would bring a series of difficulties to the development itself. Therefore, the key issue, which calls for a solution today, is to reduce the detrimental influence on the environment during the development as much as possible. This paper offers some solutions to and measures for preventing the potential negative influence on the environment from aspects including technology and practice, as well as the government's regulation and control.

Key words: Coal Bed Methane (CBM) development; environment problem; environmental protection

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INTRODUCTION

The development of unconventional gases, represented by Coal Bed Methane (CBM), has transformed the U.S. from a natural gas importing country into a country with the capability of exporting its own natural gas and evidently reduced its carbon emission, which successfully guaranteed the U.S. energy security and promoted its environmental protection. With abundant CBM resource as support, China's CBM development is also actively going on. According to the National CBM resource survey's primary assessment result, the geological reserves of CBM buried less than 2,000 meters deep are approximately $36.81\times10^{12}m^3$ among which the proved reserves reach approximately $2734\times10^{8}m^3$[1]. The proved reserves have a huge increasing space in the future, which will provide a reliable resource guarantee for China's CBM development's use. In addition, with the Chinese government's strong support over the CBM development in recent years, the resource management, pricing policies, financial subsidy and tax relief policies targeting at the CBM industry have been continually promulgated, which has provided a stable policy environment for the development of CBM industry. Therefore, relying on resources and policies, our CBM industry has obtained a beneficial external environment and good opportunities; thus made our CBM development step into a rapid development phase. Nevertheless, with our current technology and conditions, as well as on-site exploration activities, the CBM development may exert influence on the environment to different degrees, and the potential negative influence on the environment proves one of the big headaches for CBM development. As a result, how to take effective measures to reduce the negative influence on the environment brought about by CBM development and realize the sustainable exploitation of CBM turn out to be most significant.

1. COAL BED METHANE (CBM) DEVELOPMENT'S ENVIRONMENTAL OPPORTUNITIES

2.1 The pressure of energy conservation and emission reduction will promote the CBM development

Greenhouse gases (GHG) emission reduction has attracted wide attention across the world and China is currently facing a rather severe energy conservation and emission reduction situation. China's Outline of the Twelfth Five-Year Plan has proposed for a bounded target, which is to reduce the energy consumptions per GDP by about 17% from the year of 2011 to 2015. However, according to statistics, this figure dropped only 1.2% in the year of

2012, while the chemical oxygen demand (COD) and sulfur dioxide emissions was still increasing [2]. As can be seen, China is currently facing a rather severe energy conservation and emission reduction situation. Within the current energy consumption structure, it is most demanding to fulfill this task. Therefore, as a clean energy with high heating value, CBM should be developed and used to reduce the greenhouse gases emission.

1.2 A strong market demand for high quality energy

The rapid development of China's economy has greatly promoted its energy consumption and thus the problem of conventional gas supply and demand has clearly emerged. Within the existing natural gas use policies, the government has already begun the co-ordination of supply and demand via the natural gases' use sequence. A kind of clean energy with methane as its main component, CBM is able to act as an important strategic complement for natural gas. According to International Energy Agency (IEA)'s prediction, China's natural gas demand, from the year of 2009 to 2030, will increase from $930\times10^8 m^3$ to $4440\times10^8 m^3$, with an annual growth rate of 7.5% [3]. The CBM development is expected to effectively mitigate the contradiction between supply and demand of natural gas.

1.3 The surface drilling and underground extraction are required by CBM safe production

Gas explosion is the primary cause for China's coal mine accidents. Based on foreign experience, the development and use of CBM is a major means to make CBM beneficial to us, ameliorate the safe production conditions in coal mines fundamentally and check coal mine accidents. The Chinese government pays great attention to the safe production of coal mine and stipulates that coal exploitation in high gas area should combine both surface drilling and underground extraction, and the production cannot continue unless the coal-bed gas pressure have dropped below 0.74 MPa and all the indexes have met the safety standards. As can be seen, the development of CBM resource plays an important role in preventing coal mine accidents.

1.4 China has a mature policy environment for its CBM development

China's current CBM preferential policies mainly includes three aspects, namely pricing, financial subsidy and tax relief. In terms of pricing policies, the price of the CBM for civil use (that not included in municipal public gas distribution network) shall be decided upon through the suppliers and demanders' negotiations rather than the national limit price while the price of the CBM for civil use (that included in municipal public gas distribution network and regulated by the government) shall be decided upon following the principle of maintaining a reasonable price parity relation to its substitute fuel with the same heating value. As for financial subsidy policies, for each cubic meter CBM, the Ministry of Finance shall provide a subsidy of 0.2 Chinese yuan and Shanxi province shall provide a subsidy of 0.05 Chinese yuan. When it comes to tax relief policies, the equipment for CBM exploitation shall be exempted from import tariff, import linkage VAT as well as resource tax while enjoy VAT refund after collection; Chinese foreign cooperative CBM exploitation enterprises enjoy a preferential policy as the "2-Year Free And 3-Year Half[1]" applies to their income tax.

2. THE ENVIRONMENTAL CHALLENGE CBM DEVELOPMENT FACES AND ITS SOLUTION

With the acceleration of CBM development, whether the detrimental influence on the environment will be generated and how much of it will be generated in the process of CBM development has been drawing bigger and bigger attention. In light of the features of CBM development, it may generate potential detrimental influence on the environment within its whole life circle, including construction, operation as well as disposal, especially in the CBM emerging areas. These influences usually manifest in the negative impacts on water, air, surface and communities, among which those on waters and air draw bigger attention.

3.1 Impacts on water

The CBM drainage's impact on the environment

The exploitation of CBM will bring about a series of problems, among which the most evident one is the drainage problem of produced water. Therefore, the disposal and comprehensive use of CBM's produced water should be attached great importance to. The CBM development follows primarily the theory (also the procedure) of five steps: drainage, depressurization, analysis, diffusion and seepage. The whole process of the CBM production calls for water drainage and its volume increases first yet decreases later, which proves greatly different from that of conventional gas. The surface water, if not dealt with, will do great damage to the environment. The produced water's quality, the amount and sorts of pollutants it contains vary from region to region. The commonly seen pollutants include sewage with suspended particles, high salinity sewage, sewage with high chloride and produced water with fluoride, with pollutants such as heavy metal, benzopyrone and radiation [3]. Besides, the excessive drainage in the coal bed will lower the water table, increase the possibility of self-combustion with the beds and lead to the other impacts on the environment.

[1] The first two years of exemption and the following three years of half-exemption.

Hydraulic fracturing's impact on water resource

As the modulus of elasticity of the CBM reserves' coal beds is smaller than that of sandstone or limestone reservoirs, and the coal beds have the features including high coefficient of compressibility, gas-water coexistence, low gas reservoir pressure, gas layer susceptibility as well as natural fractures, the conventional mining method alone cannot yield a satisfactory result. Therefore, some stimulation measures are required for better exploitation.

Hydraulic fracturing, as a major stimulation measure for CBM, is widely applied to the practice of CBM development. Currently, the fracturing fluid it uses is generally gel, active water, fresh water or foam. The additives are generally thickener, crosslinker and PH regulator, and most of them are chemical additives. During the hydraulic fracturing process, the fracturing fluid is pumped into the strata by high pressure so as to break the target strata. This special technology adopted in CBM development is very likely to get water exposed to pollution, which generally manifests in two aspects, potential underground water pollution and surface water pollution. Before reaching the target bed, the CBM wells have to pass through the aqueous stratum and saltwater stratum. Because of technology problems or operation problems, or the corrosion attack brought by the fracturing fluid, protective measures such as annular tubes and cement will lose their effectiveness, which will get the underground water exposed to pollution. The other possibility is that during the CBM well fracturing, the escaped methane (CH4) will infiltrate into the water table and thus, get the underground water polluted. In the process of the fracturing, fluids like the fracturing fluid and diesel may infiltrate into the soil and get integrated into the surface water with the help of rainwater so that the surface water gets polluted [4].

3.2 Impacts on air

CBM development's potential impacts on air also draw lots of attention. In terms of generating air pollutants, the CBM is generally the same as conventional gases development. But they are distinct when it comes to the emission source of the air pollutants and the gas components of them. The negative impacts CBM development may have on the environment mainly include that on the air quality and greenhouse gases emission. There are primarily two kinds of impacts on the air quality: 1. In the process of the exploitation, the equipment and vehicle that consume large amount of diesel oil or gasoline will emit noxious pollutants including carbon dioxide, sulphur dioxide and particles. 2. During the exploitation and operation of CBM, noxious pollutants or gases like hydrogen sulphide, benzene and methylbenzene may be produced, among which some noxious pollutants like nitrogen oxide are likely to form ozone on the surface through the effects of the sunlight, which, once enters the air, will do harm to human beings, crops and forests. As for the greenhouse gases emission, it is primarily because of the methane emitted from the well fracturing, pipeline and the equipment. As a kind of greenhouse gas, methane's greenhouse effect is 20 times [2] larger than that of carbon dioxide, and therefore the emission of methane is very likely to aggravate the greenhouse effect.

3.3 *Impacts on the surface*

Compared with conventional gas wells, the CBM yield per well is relatively low. To ensure the profitability of CBM development, a higher well spacing density is required. More wells bring more drilling platforms, on-site facilities like gathering pipelines and their corresponding routes, public facilities like power communication, which will inevitably increase its disturbance on the surface during its construction phase. The surface disturbance effect may do damage to vegetation, soil structure and habitats for animals and plants and further influence the environment. In addition, the practice of hydraulic fractures calls for a large number of construction equipment. The moves and operations of these equipments may also have impact on the surface environment.

3.4 Impacts on communities

Apart from the fact that potable water and air may get polluted, CBM development also consume large amount of water, which will not only have impact on urbanite, city, industrial and agricultural water consumption, but also have effects on aquatic organisms as well as the existence of the other animals and plants and therefore influence the environment and living quality of communities. This is particularly evident in areas of water shortage. The other aspect mainly refers to traffic congestion, road damage, light, dust and noise. On normal conditions, some of these negative impacts are short-term and controllable.

Besides, CBM development may also have impact on the health of on-site employees. Drill cuttings and flowing-back water can bring formation substances onto the surface, among which there are probably many radioactive ones that will cause radiation hazard to the employees. As has been stated above, the exploitation and operation of CBM may produce some noxious substance and may get the on-site employees.

3. MEASURES AND SUGGESTIONS

Although some negative impacts on the environment may be produced in the process of CBM development, the development is of great significance to China, especially this China today that is implementing economy

transformation strategy, highlighting sustainable development, developing low-carbon economy and recyclable economy. The key issue, which urgently calls for attention, is to reduce the potential negative impact on the environment as much as possible so as to decrease the resistance against CBM development. In the following text, this paper will specifically put forward some solutions and measures to reduce the potential negative impact on the environment from aspects including technology and practice, corporates HSE management and the government regulation and control.

4.1 Technology and practice

Now that the impact on the environment is an inevitable issue of CBM development, the best way to solve it completely is to prevent or reduce the happenings of environment problem from the sources as many as possible. In the CBM development process, the existing technology and skills should be carried out and improved and the best operation practice should be actively implemented so as to ensure that less negative impact on the environment will be produced in the meantime of CBM resource development.

Horizontal well technology

Normally, every vertical shaft needs a drill platform. The adoption of horizontal well technology can evidently reduce the number of drills and that of drill platforms. When one horizontal well is used, four vertical shafts can be replaced and a certain number of horizontal wells can share one drill platform. The horizontal well technology can not only optimize the yield and profitability but also have evident environment protecting advantages. Meanwhile it can also reduce the number of drills and that of drill platforms so that the land use, waste drilling fluid, drill cuttings and sewage water will be less produced, the use of roads and public facilities will decrease. In the end the surface disturbance and impact on communities will be effectively cut down and the impact on the environment will be lowered to the least[4].

Alternative fracturing technology

Although hydraulic fracturing is an economical fracture stimulation technology now, there are controversies and criticism over its negative impact on the environment. In order to reduce the potential impact on the environment and promote CBM development, a feasible way is to substitute green and harmless chemicals or more ecological technology for the harmful chemicals or additives in the fracturing fluid. Normally the fracturing fluid contains various sorts of chemicals, and even noxious substances such as benzene and lead. This is just the crucial reason why hydraulic fracturing has negative impact on the environment. If those harmful chemicals were substituted for, the potential threat hydraulic fracturing, in the process of CBM development, poses to the environment would be reduced greatly. Then the economical hydraulic fracturing could still be adopted to increase yield, which would forcibly promote the process of CBM development.

Currently, two more ecological and sustainable alternative fracturing technologies under experimental applications are carbon dioxide fracturing and LPG fracturing. The former can not only enhance the recovery efficiency and yield, but also keep the reserves clean, water resource less consumed and sewage less produced. It can also seal up the carbon dioxide permanently so that it can protect the environment, increase the profit and lower the cost [5]. The latter, LPG fracturing is environmentally safe and feasible in business, free from chemical additives so that less damage will be done to the reserves and the water bearing strata will not get polluted. In the meantime it does not require water or produce sewage for disposal. The adoption of green, sustainable exploitation fracturing stimulation technology can fundamentally avoid or reduce the pollution and the eco-friendly and sustainable fracturing stimulation methods can lower the impact on the environment to its least. It is not only able to strengthen environmental protection, but also further promote CBM development.

Water treatment technology

Based on the difference of the water quality and pollutant kinds sampled from different areas, the adoptable water treatment technologies also vary. In practice, which specific water treatment technology to adopt should be decided upon according to its feasibility and economic practicability: 1. For sewage with suspended particles, the main procedure includes coagulation, precipitation and filtration. Let's take the CBM exploitation in Alabama, U.S. as an example. Among the produced water, that whose total salinity is lower than 2000mg/L should be precipitated, filtrated and enter the rivers nearby. As is shown by the analysis on the monitoring data, as long as the necessary operations are done, the produced water will not have evident impact on the river quality and the organisms in it [1]. 2. Large amount of sewage with high salinity and high chloride, once emitted, will have impact on the quality of surface water environment, lead to bad effects, say, soil hardening and salinization. As a result, sewage with high salinity and chloride should not be emitted directly and its solution mainly include reverse osmosis treatment, evaporation from land and back injection into the sandstone formation. 3. For the CBM produced water with fluoride, the main disposal method includes lime milk precipitation method, aluminium salt cohesion method, electro coagulation method, ion exchange method. In addition to the pollutants mentioned above, the produced water

also contains pollutants like heavy metal, methylbenzene and radiation, which normally attach themselves to particles and are of low viscosity. They are able to be deleted through the common method of coagulation and filtration. After the produced water is disposed, for arid areas, the CBM exploitation can reduce its fresh water demand and thus provide additional water resource to those areas.

4.2 The government regulation and control

Financial measures

The CBM development industry is typically a technology-intensive industry, with a high level requirement for technology and production facilities. The increase or improvement for a certain technology is bound to require more investment. If CBM enterprises are expected to strengthen their environmental protection, the government should take corresponding financial stimulation mechanism. VAT refund, income tax abatement and exemption and accelerated depreciation can be used to encourage environmental protection measures. 1. VAT full or part refund can be used for special research on the enterprises' CBM development technology and environmental protection technology. 2. An enterprise can enjoy its income tax deduction and exemption or pre-tax weighted deduction if they innovate their technology and develop new technology for better environmental protection. 3. The equipment CBM development enterprises purchase for better environmental protection can participate in the accelerated depreciation (double declining balance method/Sum-of-the-years-digits method) so that the enterprises can quickly take back their investment and use it in new environmental protection work.

Environment supervision

As the country with the longest history of CBM development, the U.S. has its CBM resource monitored and regulated by a series of federal, state and local laws and regulations. In order to reduce the carbon dioxide and methane emissions, the U.S. has set a series of compulsory technology standards and set requirements upon the methane emission and its picking rate that the exploitation enterprises should meet. Besides, the enterprises should pay an amount of deposit in advance, and the government will give them refunds according to their CBM development achievements. The government also set up a subsidy fund [1], which is for CBM development use, by charging for disposing pollutants. In addition, states in the U.S. also have their laws and regulations on well spacing density, water disposal standards, and so forth to prevent the damage to regional ecological environment caused by CBM development. Compared to what foreign CBM industry has done, our CBM industry has not laid enough emphasis on the environmental problem taking place in the process of CBM development and should attach greater importance to improving related laws and regulations so as to provide effective environment supervision over the environment problem CBM development may cause, reduce the potential damage to the environment to the largest extent and realize the sustainable development of CBM industry.

CONCLUSION

The high efficiency and clean combustion features of CBM will make it popular and help it play an important role in promoting the harmonious development of China's economy and society. Nevertheless, based on some fixed development features of CBM, during its development process, some detrimental influences over the environment may take place, including those on water, air, surface and communities. In company of the progress of CBM development, these impacts will draw more and more attention and even trigger some worries among the public, which adds much resistance against CBM development. In order to tackle the key issues that hinder CBM development, this paper specifically puts forward some measures and suggestions related to the environment problems of CBM development from aspects including technology and practice, government regulation and control, etc.

1. The horizontal well technology, alternative fracturing technology and water treatment technology should be actively adopted so as to reduce the impact on the environment from the technology link.
2. The VAT refund, income tax deduction and exemption, along with accelerated depreciation should be adopted to ensure the financial support for the environmental protection in CBM development so as to promote the environment protection work.
3. The environment supervision over CBM development should be strengthened and a set of careful laws and regulations should be enacted so as to reduce the potential impact on the environment to the largest extent.

Acknowledgments

This paper is funded by China's National Key Projects for Science and Economic Evaluation of Coalbed Methane Development project under project number 2011ZX05038-004. In addition, the authors wish to thank the editors and anonymous reviewers of this manuscript for their elaborate efforts.

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