Environmental management issues in shale gas development

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Abstract

The Energy problem is one of important part in today's economic development. Extracting conventional natural gas cannot meet the needs of energy growth. Shale gas, which is a kind of unconventional natural gas, gives us a new energy sources. Hydraulic fracturing is an effective method of exploiting shale gas, but it also brings serious environmental pollution. China has no clear rules to govern the pollution because the development of the shale gas has begun recent years. This paper introduces the environmental problem in gas water and geology which may bring from the hydraulic fracturing .At the same time, proposing how to solve these pollutions.

Keywords

Shale gas; environment pollution; environmental management.

1. Introduction

Shale gas refers to natural gas that is trapped within shale formations (EIA defined). Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas. Shale gas, a new type of unconventional energy, is widely distributed in the world. Compared with conventional natural gas, shale gas has more potential long mining life and long production cycle to develop. There is a great value of development and utilization.

Nowadays, not only the United States but also other countries and regions which include Britain, Poland, Austria of Europe, China, India from Asia, Oceania's Australia, and South America's Argentina, Brazil, Chile have been fully aware of the value of shale gas resources and broad prospects [1]. In North America, shale gas has become an important source of natural gas supply and the scale of its exploration and development, especially rapid, has achieved a high efficiency, economy.

Assessment results of Global shale oil and gas resource show that Global shale gas resources are extremely rich, and the total amount of shale gas resources is about $456\times10^{12}m^3$, accounted for about 50% of the total amount of unconventional natural gas resources. Technology available resources are about $220.36\times10^{12}m^3$, which are contained by 95 shale gas basins and 137 shale formations from the world's 10 major geographical regions. They are mainly distributed in North America, Central Asia and China, the Middle East and Africa, Europe, South America and other regions of the 42 countries. Among them, the largest amount of resources in North America. Specific forecast forms are as follows:

The United States is the first country to develop shale gas, and also the only country to achieve large-scale development of shale gas in the world. In 2000~2011, shale gas production in America increased by about 14 times. In 2010,production reached $1378\times10^{8}m^3$, accounting for 23% of the national total annual production of natural gas, more than annual natural gas production of China in 2011. Production more than $1700\times10^{8}m^3$, accounting for 34% of annual natural gas in 2011.

In recent years, Chinese economy develops rapidly, in the meantime, the demands for the resources increase sharply, and increasing pressure on energy and the energy pressures continue to increase. In order to solve the current energy shortage situation, shale gas was clearly put forward as an important strategic resource in the "12th Five-Year" planning period. October 2009, the first China shale gas resource exploration project was launched in Qijiang County, Chongqing [2] .That is the beginning of

exploration and development of shale gas in China officially. China is the third country to explore this new energy after the United States and Canada.

There are some objective reasons limits the development of shale gas in China. Such as, shale gas development in China has just started, lack of the experience about mining, and the technology for shale gas is not advanced. However, we broke through in some aspects. Currently single horizontal well development cost has been reduced to 5000 from 120 million yuan to 70 million yuan, drilling period from 5 ~7months to 2 ~ 3 months, the shortest is only 46 days.

The lacking of technology and experience is not a barrier to the development of shale gas in China, environmental problems caused by hydraulic fracturing technology is the most important issue. Since the implementation of sustainable development strategy in China, the construction of ecological civilization is always what we insist on .And how to achieve the development of shale gas as well as does not destroy the ecological environment, is what we want to explore.

Table 1 Shale gas resources forecast in the world

Area	Shale gas	Coalbed methane	Tight sandstone gas	Total
North America	108.7	85.4	38.8	232.9
Central Asia&China	99.8	34.4	10.0	144.2
Middle East& Africa	79.9	1.1	45.5	126.5
Pacific	65.5	13.3	20.0	98.8
Latin America	59.9	1.1	36.6	97.6
Soviet Union	17.7	112.0	25.5	155.2
Central&Western Europe	15.5	7.7	12.2	35.4
Asia-Pacific region	8.9	1.1	21.0	31.0
Total	456.0	256.1	209.6	921.7

2. Environmental problems caused by shale gas development

Horizontal well and multi stage fracturing is one of the most important technologies used in shale gas exploitation at the present, as shale reservoir is thin thickness and low permeability. A series of environmental pollution in atmosphere, water resources, geology will be led if the pollutants of hydraulic fracturing are not disposed well.

2.1 Pollution in atmosphere

Development of natural gas is one of the sources of methane, volatile organic compounds and other air pollutants. 80% of the gas in shale gas is methane. Methane slightly soluble in water and will flow back to the liquid outflow. Its Greenhouse effect is stronger than carbon dioxide.

In the process of shale gas development, the main sources of pollution are caused by the atmosphere drilling equipment, trucks and other large machinery and equipment emissions of exhaust ,the leakage of methane gas in the mining process and the volatilization of the fracturing fluid. Exhaust emissions of mechanical equipment will form the ozone smog which has a strong corrosive, strong stimulation of respiratory and pulmonary function; affects the body's motor function, and high concentration of ozone also destruct crops and forest vegetation.

Some studies have shown that about 1.19% of the methane gas leak in the process of shale gas development, adding the processing, gas transmission and distribution of the entire leak is about 2.01%. Methane gas leak will accelerate the greenhouse effect. This will result in increased global temperatures, sea level rise, resulting in increased sea storms, and the impact of the marine climate. At the same time, the greenhouse effect also causes the land arid, the desertification increase, the

disease and insect pest survival probability increases [3] .Even it will increase the frequency of El Nino phenomenon, expand its negative impact.

The liquid will be mixed with trace toxic gas, which may lead to the occurrence of skin allergies in the vicinity of shale gas mining area, severe cases may be due to inhalation of toxic gas poisoning.

Due to the exploitation of shale gas carrying a small amount of H2S, may cause acid rain, and inhibit the decomposition of soil organic matter and nitrogen fixation.

The United States Environmental Protection Agency published in 2011 after the completion of the unconventional gas wells in the process of methane emission estimates are estimated to be 2 times the initial value. In April 2012, the United States Environmental Protection Agency issued the first regulations to control the air pollution in shale gas production, requiring the use of hydraulic fracturing method to produce all the shale gas wells must install harmful gas trapping devices.

2.2 Water resources

Great demand for water resources

Shale gas is a very low permeability unconventional natural gas, so the traditional natural gas extraction technology is not suitable for effective access to shale gas. Horizontal well and horizontal multi stage fracturing technology as the main technology to explore the shale gas requires a lot of water. According to the Zhang Dawei ,a Ministry of land and resources experts ,estimate that to complete the "gas development plan (2011-2015)" in the proposed 600-1000 billion cubic meters of production, we need to play 20 thousand production wells(Not including experimental well and no industrial airflow). It is expected to that China will need 380 million cubic meters of water, equivalent to 12 million 660 thousand of the city's population of one year's water consumption, if the single well water consumption of 19000 cubic meters. However, China is lacked of freshwater resources and how to solve the water demand is the first question should be solved.

Water pollution

The water pollution in the process of shale gas extraction can be divided into several aspects: the more flow, the leakage of the shaft, and the return of the liquid. The return of the liquid is the most important point of water pollution.

Due to the huge amount of fracturing fluid containing chemicals , even chemicals percentage is very low, the underground water pollution problems which caused by the fracturing fluid should not be underestimated. During the hydraulic fracturing, the chemical substance directly cross through the cracks, fracture from the ground up to the surface and shallow layer, and some gas run out caused by gas pipeline problems or improper operation and other reasons for leakage into the underground water layer. They pollute rivers, lakes, water storage layer and other water resources.

In December 2011, the U. S. Environmental Protection Agency announced arms of gas field of groundwater pollution in Wyoming Pavilions shale preliminary investigation report, for the first time, the hydraulic fracturing operation and pollution of groundwater sources officially associated [4].

2.3 Geological problems

Shale gas development which covers a wide area and has great influence .It has the characteristics of the scale of fracturing, the grid of the cracks, and the operation of the factory. Drilled holes are needed in the process of shale gas development, if the development wells is more intensive, human disturbance is likely to cause landslides, and other geological disasters.

USGS data show that the earthquake occurred frequently in the central and eastern regions of the United States. Between 2010 and 2012, nearly 300 of these areas had a magnitude higher than 3, while, between 1967 and 2000, the average annual number of earthquakes was only 21 times.

Larry Brown, Dean of the school of earth and Atmospheric Sciences, Cornell University believes that the hydraulic fracturing technology and wastewater treatment process can be said is to speed up the process of natural earthquakes, the than natural pressure lower level earthquake, but not directly caused by the earthquake.

3. Management suggestions for environmental problems

3.1 Air management

Set air detection standard. To check the air quality at any time, and carry out sampling of air in development zone at any time, test strictly, solve the problem at once. Improve the development process to avoid the problems caused by the completion process and quality problems, such as shale gas leak contaminated environment. Ensure the strict implementation of gas well design, construction, cementing and integrity testing criteria.

Set gas well natural gas evacuation and combustion limits, clear requirements for installation of methane capture equipment.

Promulgate a law to regulate the air pollution of shale gas.

3.2 Water resources management

There should be strict management measures for the return liquid. The approach can take deep well injection, discharged after treatment or site reuse; treatment technology can be used in accordance with the situation of different liquid back to the use of physical or chemical methods. Choose the best way to treat waste water to make sure the ground water not be pollution. Save water to the greatest extent.

3.3 Geological problems management

Monitoring the trend and shape of crack growth, to ensure the accuracy of the fracturing area, evaluate the fracturing effect and optimize the fracturing program. The micro seismic technique can image and monitor the complex fracture network produced by hydraulic fracturing. To speed up the pace of independent research and development, in-depth research and development mechanism, make the development plan suitable for our country.

Comprehending geological prospect in the area of shale gas field, we preferred drilling and hydraulic fracturing sites, and assess the risk of deep faults or other geological features that cause earthquakes, or to allow fluids to pass through different strata [5]. Appropriate development programs can reduce the number of drilling to a large extent, reducing the risk of hydraulic fracturing and improving the recovery of gas well.

4. Conclusion

The problems of Water scarcity and flow back pollution have constrained the development of shale gas. Since the hydraulic fracturing used in the shale gas development is difficult to change under the current technology, the better actions are the transforms of thoughts and problem. Rational treatment of flow back water to relieve pressure, and dynamic simulation of block pollution to optimal control based on the mechanism of shale gas development.

1) Reservoir parameter identification and numerical simulation to predict the amount of fluid flow back;

2) Predict flow back pollutant index to determine the pollutant components; (formation water sampling, water-rock reaction)

3) Establish an optimized allocation model for each processing mode based on comprehensive forecasting total pollution.

The shale gas development of China is still at an early stage, in order to avoid environmental effects, three actions could be taken to make the lowest pollution and the highest efficiency and achieve the true sense of maximize benefits. There are the three actions: a) coordinate the allocation of water resources to optimize the exploitation of shale gas; b) establish and improve the environment for shale gas laws and regulations; c) learn to the countries of mature shale gas development technology to seek the suitable for development mode.

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