Environmental Impacts of Shale Gas Development in China and Recommendations on Management of their Environmental Impact Assessment

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Abstract： Shale gas, as with tight gas, coal-bed methane and natural gas hydrate, is considered an unconventional gas resource. China has already included shale gas in its national energy strategy, while large scale commercial development is yet to start. Due to its "low productivity" and "highly scattered" nature, shale gas development is much more complicated than conventional gas. Given the special geological and ecological characteristics of southwestern and northern China where shale gas is abundant, the environmental impacts are summarized as ecological impacts, underwater pollution, greenhouse gas emission and so on. Challenges and problems for the management of the environmental impact assessment (EIA) process for shale gas have been analyzed in this thesis. To resolve these problems in China, we need carry forward the Strategic EIA and Planning EIA, determine the EIA management principle and system of the shale gas development strengthen basic research and develop the EIA and pollution prevention technical guidelines conduct, and strengthen international cooperation and communication.

1 Distribution and Development Status of Shale Gas Resources in China

Shale gas, as with tight gas, coal-bed methane and natural gas hydrate, is considered an unconventional gas resource. Shale gas is trapped in shale formations and the main gaseous component is methane. Commercial exploitation of these resources provides new opportunities for clean and efficient energy production. The successful development of shale gas in the United States has significantly affected the global energy structure[1]. In recent years many countries have commenced shale gas exploration.

Data indicates that China has 134 trillion m^3 of shale gas in geological reserves, equivalent to 2.4 times the volume of conventional gas resources in China. 25 trillion m^3 of the shale gas resources are considered recoverable, distributed in the Upper Yangtze and DianQianGui areas. Sichuan, Xinjiang, Chongqing and Guizhou provinces hold the most resources.

China has already included shale gas in its national energy strategy. The *12th Five-Year Plan for Domestic Economic and Social Development* clearly states that "promote the development unconventional resources such as coal-bed methane and shale gas". In 2011, the National Development and Reform Committee issued the *Shale Gas Development Plan (2011-2015)* together with four other ministries/departments. The Ministry of Land and Resources has

since given identified 180 priority shale gas blocks and in 2012, China opened some for bidding, this indicates that shale gas development in China is now in a tangible exploration stage[2]. Currently, 30 exploration wells have been drilled in the Sichuan Basin, Ordos Basin and Eastern Depression of the Liaohe Basin. Of these, 18 wells have achieved industrial scale gas flow through the use of fracturing, while large scale commercial development is yet to start.

The shale gas deposits mostly in the Marine strata in U.S. and it both in marine, continental, marine and continental strata in China, However the shale gas hidden more deep in China compared with U.S. The characteristics of the shale gas determined the complexity of its exploitation.

2 Characteristics of Environmental Impacts of Shale Gas Development in China

Due to its "low productivity" and "highly scattered" nature, shale gas development is much more complicated than conventional gas. Special environment characteristics in China's shale gas favorable zone will exacerbate the potential risk of environmental pollution and ecological destruction.

1) Prominent Land Occupation and Ecological Impacts Caused by Large Numbers of Wells
Shale gas resources spread over extensive areas with have low concentrations of gas per unit area, as a result a large number of wells have to be drilled to obtain commercial quantities. A comparison of data between the famous Barnett Shale Gas Play in the United States and conventional gas developments in China show that to reach the same productivity, the footprint of shale gas well pads is more than 10 times that of conventional gas, and the number of wells is a hundred times or more than those for a conventional gas. In addition, the access roads, water channels, and gas gathering pipelines will require large areas of land occupation. In China, ecology in the north is fragile and most of the favorable shale gas fields in the south are situated in hilly areas where productive soil is limited in area. Therefore, attention should be paid to land occupation and surface disturbance issues resulting from well drilling as well as to providing ecological protection. Further, competition between shale gas development and agriculture, ecology and local land uses should be considered.

2) Water Resources and Water Contamination Issues Caused by High Water Consumption
Development of a shale gas project mainly includes exploration, drilling, and well completion. The key technologies are horizontal drilling and hydraulic fracturing. Fracking is a highly water-intensive process. Even with a high flow-back rate, its water consumption can be 10 times of that of conventional gas production. This will constrain shale gas development in water-scarce areas, and affect sustainable consumption of local water resources.

Wastewater generated during shale gas development contains more than a hundred types of chemicals such as hydrocarbons, heavy metals, salinity and radioactive substances. Deficiencies in the water injection process or injection formation selection will result in groundwater contamination. In China, most of the favorable shale gas fields are located in

Sichuan, Chongqing, Hunan and Guizhou provinces. The complicated geological conditions in these areas increase the difficulties concerning groundwater contamination prevention and control.

3) Impacts on Air Quality and Climate Change Cannot be Neglected

Natural gas is the major source of anthropogenic methane emissions, VOCs and other air pollutants. The shale gas reserves in China also contain hazardous levels (>1%) of H_2S. Inappropriate collection and treatment of these air pollutants will affect the local air quality. Compared with conventional gas, the development of shale gas has a higher risk of greenhouse gas (especially methane) release. Given the high population density in southwest China, the impacts of air pollution and climate change should not be neglected.

3 Challenges and Problems for the Management of the Environmental Impact Assessment (EIA) Process for Shale Gas

1) National Development Plans and Schedules do not Fully Consider the Nature of Resources and Environment in China

Currently, the land resources, energy and other authorities responsible for shale gas development are over-optimistic concerning potential environmental impacts. The criteria for the selection of favorable shale gas blocks mainly consider the reserves, formation depth, surface conditions and preservation conditions, but are yet to consider environmental protection, ecological and human health impacts.

From strategic planning stage to the time sequencing for trial development, environmental impact evaluation is inadequate. Adverse environmental impacts which have occurred in the United States including ecological damage, groundwater and surface water contamination and air pollution could not be avoided at the source of decision making. In addition, the shale gas-rich areas in China have unfavorable conditions such as fragile ecology, sensitive groundwater and dense population, the environmental impacts on which are yet to be estimated.

2) Lack of Specific Environmental Protection Regulations and EIA Technical Guidelines

Currently, environmental supervision regarding shale gas development in China mainly references the regulations and technical guidelines developed for conventional resources. These regulations and technical guidelines do not fully consider the specific environmental issues brought by this new mineral resource.

In particular, there are no regulations or technical guidelines concerning environmental management of wastewater injection in China. Hence, a lack of appreciation of the potential environmental impacts and feasibility studies of wastewater injection has become one of the difficulties in EIAs for shale gas developments.

3) Uncertainties from Phased Development Make EIA Difficult

As opposed to conventional gas, shale gas development usually requires continuous

exploration and drilling across the project's life span. As such, during the initial phase, without clear definitions of well locations and layout and intensity of wastewater production and air emissions, there will be a number of uncertainties in the engineering analyses, which in turn makes it difficult to predict and assess the environmental impacts. In addition, the project construction phase and operational phase will have a long period of overlap due to the phased nature of development. This overlap should be reflected in the EIA.

4) Lags in Basic Research as well as Insufficient Management Experience and Technical Expertise

Currently, the scientific understanding of the ultimate consequences of environmental effects from shale gas development is limited. Technical measures for the prediction and control of potential geological, ecological, environmental and risk-related impacts are inadequate. Basic research on environmental protection concerning shale gas development still lags behind the needs.

No research has been conducted to date on the process parameters, pollution sources and their intensity of the pilot projects in China. Data collection on various process and pollutants' discharge parameters is inadequate. Systemic studies on environmental issues related to shale gas in other countries are yet to be undertaken. Also, studies on potential environmental impacts in the context of the resource distributions and environmental characteristics in China have not been conducted. Therefore, the technical expertise is insufficient.

4 Solutions and Recommendations

1) Carry forward the Strategic EIA and Planning EIA, Optimize the Development Plan and Time Sequence from both Resource Development and Environmental Protection Perspectives

Collect existing information on the distribution of shale gas resources and conduct strategic EIAs. Categorize the resources from the perspective of environmental protection. Identify areas which are not favorable for development. Optimize the planning for shale gas development from the perspectives of resource efficiency and environment efficiency, ecological and environmental loads and level of environmental risk. Take into consideration regional environmental characteristics; categorize, screen, prioritize and optimize the shale gas development time sequence from the perspectives of both environmental protection and risk management. For pilot development areas such as the Ordos Basin, Sichuan, Guizhou, Hubei and Hunan provinces, speed up the planning EIAs of the key and pilot blocks. By initiating EIA at an early stage, it can optimize environmental protection measures adopted during shale gas development and avoid impacts to the sensitive receivers.

2) Determine the EIA Management Principle and System, Conduct Area-specific and Life-cycle EIA Supervision

Improve the EIA management system of unconventional gas resources such as shale gas. Study and develop an environmental protection entry threshold for shale gas exploration and

production. Develop area-specific shale gas project management measures based on the results of the strategic EIAs, planning EIAs and the local environmental conditions and sensitivities. Given the phased nature of shale gas development, develop and improve the life-cycle management system covering the planning EIA, project EIA and "three-simultaneous" requirements.

3) Strengthen Basic Research and Develop the EIA and Pollution Prevention Technical Guidelines

Launch an unconventional gas (including shale gas) EIA special study program. Select domestic pilot projects as focal points for the study and reference international empirical data. Conduct quantified study on the ecological, groundwater, air quality impacts and human health impact from VOCs. This will support collection of pollution source intensity data as well as developing methods for environmental impact consequence analysis. Based on the current technical conditions, develop an environmental management standards system and technical guidelines for shale gas development in China, including water use, air emission, wastewater treatment and injection, site restoration and risk prevention.

4) Strengthen International Cooperation and Communication, Reference Mature International Experiences

Currently, both the United States and Canada have achieved commercial production of shale gas and have mature technologies. Companies from these countries have already participated in the pilot projects in China. In the United States, legislation includes specific provisions concerning the environmental issues brought by shale gas production. Also, the environmental supervision in the United States is becoming increasingly stringent in recent years. For the shale gas development in China, we should strengthen international cooperation, and collect pollution prevention and pollution source intensity data from the United States and Canada[3]. China should scientifically develop environmental management provisions and technical guidelines by adopting international management experience and taking into consideration the local resource and environmental conditions.

Reference:

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[3]U.S.EPA. EPA's Study of Hydraulic Fracturing and Its potential Impact on Drinking Water Resources[R]. 2013-2-15.http://www.epa.gov/hfstudy/.