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Environmental risks of shale gas development in China

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HIGHLIGHTS

- We assess the environmental risks of shale gas development in China.
- We use the US experience to identify the potential environmental burdens.
- The effectiveness of environmental regulations in China is generally weak.
- China lacks environmental regulations specific to the oil and gas sector.
- We recommend China to adopt policies to reduce environmental risks.

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ABSTRACT

Shale gas development in China can generate great potential economic benefits, but also poses serious environmental risks. In this paper, we offer a macro assessment of the environmental risks of shale gas development in China. We use the US experience to identify the nature of shale gas development activities and the types of potential burdens these activities may create. We then review the baseline environmental conditions and the effectiveness of environmental regulations in China and discuss the implications of these China-specific factors for risk assessment. We recommend China to conduct a strategic environmental assessment and to consider sector-specific environmental regulations.

1. Introduction

Rapid and low-cost development of shale gas resources in the United States and its concomitant effects on reducing natural gas prices, stimulating industrial activity from natural gas users and replacing coal with natural gas to generate electricity, have many countries in the world looking to the development of their own shale gas resources. Endowed with large shale gas resources, China has an ambitious plan for shale gas development, partly driven by growing energy demand and increasingly challenging environmental conditions. At the same time, the rapid development in the United States and the prospect of shale gas exploitation in China have many concerned that exploiting these resources will come at too high an environmental cost. Because of the low permeability of shale gas formations, it is typically necessary to use hydraulic fracturing to stimulate shale gas reservoirs. Since hydraulic fracturing, which may not be necessary for producing natural gas from conventional gas reservoirs, requires the use of chemicals and large amounts of water, the environmental risks from shale gas development, in the absence of effective regulations, are generally higher than those from conventional natural gas development. In the United States, environmental concerns have led to new regulations, bans on fracking, and efforts within the oil and gas industry to develop better "best practices."

In this paper, we offer a macro-level assessment of the environmental risks of shale gas development in China. The environmental risks of shale gas development in a country depend on the nature and scale of shale gas development activities, the potential type and quantity of burdens (e.g., impact on groundwater or surface water, etc.) created by these activities, and the degree and likelihood of exposure of end points (e.g., human health, ecosystem, climate, etc.) to these burdens. The quantity of burdens created by shale gas activities depends not only on the scale of shale gas activities, but also on the environmental practices of the firms involved, which, in turn, depend crucially on the effectiveness of environmental and operational regulations. Environmental regulations also affect the extent to which end points might be exposed to the burdens created by shale gas activities. For example, if firms are prohibited from drilling shale gas wells in areas close to communities or water resources, exposure would be smaller.

Exposures of human, ecosystem and other end points to burdens are highly site-specific: they depend on the locations of

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shale gas wells, the distance between the wells and local communities, and the characteristics of the local communities. Collecting site-specific information, while very important for assessing the environmental risks of shale gas development, is beyond the scope of this paper. Nonetheless, we attempt to review the baseline environmental conditions in China and, where possible, narrow down the field of view to the (potential) shale gas development areas.

We agree with the conventional wisdom that environmental risks from shale gas development in China are much higher than those in the United States. This is because the Chinese government has adopted an aggressive shale gas development plan, has paid less attention to potential environmental risks of shale gas development, has much weaker judicial enforcement of environmental regulations, and has far fewer environmental or operational regulations that are specific to the oil and gas industry.

A limitation of this assessment is that we do not consider the effects on the environment that are indirect consequences of shale gas development. Shale gas development, if successful, is expected to affect the fuel mix in power generation and possibly transportation, as well as the economics and competitiveness of sectors relying on natural gas as feedstock. Natural gas substituting for coal, for example, is likely to be a net plus for the environment (not counting life cycle carbon emissions, which are controversial and uncertain). But natural gas might also substitute or slow down the movement toward wind and solar power, which may leave the environment worse off. Working through these issues for China is important, but beyond the scope of this paper.

The rest of this paper is organized as follows. In Section 2, we offer a brief description of the status of shale gas development in China. In Section 3, we develop a framework for considering all the potential environmental risks from shale gas development – called a risk matrix – and then use this matrix to summarize environmental concerns for US shale gas development. In Section 4, we first discuss the baseline environmental conditions in China and then assess the effectiveness of its environmental regulations. In Section 5, we offer an overall assessment of environmental risks from shale gas development in China and make two policy recommendations.

2. Status of shale gas development in China

China has large shale gas reserves, so the potential scale of shale gas development is large (Tian et al., in press). China's official estimate of technically recoverable shale gas reserves is 25.1 trillion cubic meters (Tcm), and Energy Information Administration's (2013) estimate is 31.5 Tcm.

China is heavily promoting the development of shale gas. In March 2012, four ministries in China – the National Development and Reform Commission (NDRC), Ministry of Finance, Ministry of Land and Resources (MLR), and National Energy Administration – jointly released the *Shale Gas Development Plan, 2011–2015*. This plan calls for producing 6.5 billion cubic meter (Bcm) (0.23 trillion cubic feet (Tcf)) of shale gas by 2015 and 60–100 Bcm (2.12 to 3.53 Tcf) per year by 2020. This is an aggressive plan considering that China's commercial production of shale gas is negligible at the start of the planning period.

The Sichuan Basin, which contains over 55% of China's shale gas reserves (EIA, 2013), is the most promising shale gas basin in China and is the focus of the early shale gas development activities. The Sichuan Basin contains portions of Sichuan, Yunnan, Guizhou, Hubei, and western Hunan Provinces. Other basins are unlikely to be developed on a large scale in the near future due to unfavorable geology or lack of water. Sinopec, one of China's large national oil companies, recently said it achieved major breakthroughs in the Fuling area of the Sichuan Basin and that it expects to build an annual production capacity of 5 Bcm in the Fuling field by 2015. It is widely reported that the cost of drilling shale gas wells in China is much higher than that in the United States. For example, Bloomberg New Energy Finance (2014) reports that the average costs of drilling a shale gas well in the Fuling area at least double those in the Unites States. High drilling costs may push firms not to take costly measures to protect the environment.

3. Environmental risks: the US case

In this section, we examine what environmental risks can arise in theory, how the regulatory system in the United States is designed to address these risks, and in light of what is being regulated, what risks remain of concern.

3.1. The shale gas development process

Site development and preparation begin before an operator selects an area for drilling. Many companies in the United States perform pre-drilling examinations such as seismic and water quality tests before finalizing the site choice. The operator must first ensure that the location adheres to siting rules, including any setback restrictions, which regulate the distance between wells and other entities like schools, homes, streams, and water wells that are thought to merit special protection. Once a site has been selected, the land must be cleared – usually two to five acres, but up to twelve depending on the location and number of wells on the pad. All of the requisite equipment and materials are then brought to the site. An impoundment is often built to hold freshwater, which is either trucked or piped to the location in preparation for drilling.

After the site is prepared and the drilling rig is set up, drilling can begin. As the well is drilled, casing must be put in place and cemented. Poor casing and cementing can provide a potential conduit for groundwater contamination; therefore most US states have detailed casing and cementing regulations. Once the surface casing is set and cemented, the well is drilled deeper and an intermediate string of casing is often set and cemented. When the wellbore is just above the production zone, the drill turns and drills along the seam ("horizontally"). The production casing is then set and cemented.

To begin the hydraulic fracturing process, a fracture gun is detonated in the horizontal wellbore to create fractures in the rock, which are then propagated by the introduction of fracturing fluids under high pressure. Fracturing fluid is composed of water, chemicals, and proppants (such as sand) that prop the fractures open to allow gas to flow up the wellbore. Although most of the water used remains underground, anywhere from 10 to 50 percent will flow back up and out of the wellbore. Flowback fluids (also called produced water) must be stored, disposed, or recycled. Storage and disposal options vary by state and depend in large part on the chemical makeup of wastewater and whether deep well injection sites are available. Before and during production, excess gas may be vented or flared if it cannot be stored or used commercially. When a well is no longer producing, it should be permanently plugged and abandoned.

3.2. Risk matrix for shale gas development

Shale gas development raises new environmental and health concerns that are less well understood than the risks associated with conventional fossil fuel extraction. In addition, concerns traditionally associated with drilling are being raised in areas that have not had to manage these issues until recently.