Energy Policy 113 (2018) 123–134

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Local residents' risk perceptions in response to shale gas exploitation: Evidence from China

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ARTICLE INFO

Keywords:
Risk perception
Benefit perception
Shale gas exploitation
Environmental awareness
China

ABSTRACT

In 2014, China became the world's third country to accomplish shale gas commercial development, following the United States and Canada. China still however lacks a comprehensive analysis of its public's concerns about potential environmental risks of shale gas exploration, particularly those of local residents near extraction sites. This paper specifically aims to explore risks perceived as associated with shale gas development in the Changning-Weiyuan area of Sichuan Basin, by conducting a face-to-face household survey with 730 participants interviewed. Some 86% of respondents reported their belief that shale gas exploitation causes more than three types of negative impacts, the most commonly perceived being noise, underground water contamination and geological disruption. Associated variables that were statistically significant predictors of risk perception include demographic characteristics (age, gender, education), environmental awareness level, landslide experience, awareness of past shale gas accidents, information sources, general knowledge about shale gas, and perspectives on whether negative impacts can be observed and controlled, along with trust in the central government and the petroleum company. Our findings implications are discussed, with the goal of informing both central and local authorities' policy development in protecting local residents from risks of shale gas exploitation and better communicating risks to residents.

1. Introduction

There has been a long history of shale gas exploitation since its first extraction in New York (U.S.) in 1821. Environmental and economic concerns about shale gas development are much newer. The year 1986, when an air-drilled multi-fracture horizontal well was first applied to shale gas development to overcome a more than century-long technical bottleneck, can be seen as a key threshold date. The modern technology of hydraulic fracturing has dramatically expanded commercial development of shale gas and moved the business into a much higher gear.

On the one hand, this new energy source provides many countries a much improved chance to comply with the commitments of the Kyoto Protocol and Paris Agreement, because natural gas is a less carbon-intensive fuel than most in use, so replacing other fossil fuels with natural gas reduces carbon emissions and other atmospheric contaminants (Burnham et al., 2012; Liu et al., 2015; Newell and Raimi, 2014, 2015; 2017a, 2017b; Zhang and Peng, 2017). Development of this new, until recently unconventional source, meanwhile contributes to local economies, adding job opportunities, increasing household income, expanding local businesses, and enhancing urban development while growing tax revenue (Anderson and Theodori, 2009; Boudet et al., 2014; Kay, 2011; Theodori, 2009).

On the other hand, horizontal well-drilling and hydraulic fracturing technology require injection of a chemical reagent containing high-viscosity fracturing fluid into the shale during the extraction process. If the fracturing fluid penetrates underground or overflows during a rainy season, it can easily pollute local shallow and underground water. Shale gas extraction also produces oily sludge and wastewater as by-products, both of which have become major sources of pollution that haven't yet received adequate attention, prominently in China, with the world's largest extractable shale resources. Wastewater produced by shale gas extraction contains more than 100 chemicals, including hydrocarbons, heavy metals, salts and radioactive materials. Failure to properly meet the requirements of infusion technology or improper selection of the infusion layer may meanwhile also cause underground water pollution. In addition, the extraction of shale gas consumes a huge amount of fresh water, affecting water quality and the sustainability of local and regional water resources as well as wastewater disposal (Brown et al.,

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http://dx.doi.org/10.1016/j.enpol.2017.10.004
Received 31 May 2017; Received in revised form 29 September 2017; Accepted 2 October 2017

2013; Osborn et al., 2011; Rabe and Borick, 2013; Vengosh et al., 2014; Warner et al., 2013; Willits et al., 2016). Other environmental issues related to development of shale gas include air pollution, noise pollution, threatened ecosystems, and potential hazards such as landslides as well as earthquakes (Finkel and Law, 2011; Howarth et al., 2011; Israel et al., 2015; Stedman et al., 2012).

Potential environmental risks posed by shale gas exploration have created requirements for risk analysis, better governance, and a better understanding of the public's perceptions and attitudes toward such activity (Boudet et al., 2014; Brasier et al., 2013; Clarke et al., 2016; Schafft et al., 2013; Stedman et al., 2012; Whitmarsh et al., 2015; Willits et al., 2016). For governments to avoid or at least mitigate future conflicts about shale gas risks, there needs to be clearer communication about them and a better understanding of current public perceptions. Public perception of, and attitudes toward, shale gas in the U.S., Canada, U.K., and other western countries have been studied extensively. However, such analysis is still lacking for China.

China became the world's third country to accomplish shale gas commercial development in 2014, following the United States and Canada. The report 'World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States', published in 2011 by the US Department of Energy,[1] estimated that China's shale gas recoverable reserves were 36.1 trillion cubic meters, ranking first in the world. To our knowledge, the existing literature on shale gas in China focuses on the development opportunity as well as environmental risks, regulations and policies, predicaments and comparisons with experiences of other countries (Deemer and Song, 2014; Gunningham, 2014; Guo et al., 2015; Hu and Xu, 2013; Krupnick et al., 2014; Lozano-Maya, 2016; Tian et al., 2014; Wan et al., 2014; Yuan et al., 2015; Zhang et al., 2017a, 2017b) but none analyzes the Chinese public's risk perceptions, and this study aims to fill this research gap. The Chinese government is recently paying increasing attention to the public's opinions and attitudes toward local development projects, and increasing its related efforts in public participation and communication. To provide better guidance for relevant policy formulations on shale gas development, there is urgent demand for a comprehensive risk perception study of local populations in China, which our study seeks to accomplish.

We analyze the perceptions of local residents on shale gas development. As negative effects of shale gas extraction burden local residents near development areas, and the public's awareness of risks is enhanced by generally heightening consciousness of both environmental and legal issues, there will be more conflicts of the kind known in the U.S. as 'Not In My Back Yard' (NIMBY).

Many studies on shale gas development emphasize risk and opportunity perceptions of local residents (Ashmoore et al., 2016; Brasier et al., 2013; Ladd, 2013; Schafft et al., 2013; Stedman et al., 2012; Wynveen, 2011). Taking the U.S. Marcellus Shale region as an example. Stedman et al. (2012) studied perceptions and attitudes of residents in both New York and Pennsylvania. Brasier et al. (2013) conducted a household survey in core areas of the Marcellus Shale region in those states to study risk perceptions and the effects of possible influencing factors. Schafft et al. (2013) explored how both risk and opportunity were perceived by local stakeholders within the Pennsylvania portion of the region. These researches not only aid in understanding the implications of shale gas exploration but provide reference material for U.S. legislation and regulation. China can learn from U.S and Canadian governance experiences in shale gas development. However, it is still necessary to examine local Chinese residents' risk assessments and its influences to minimize or transcend 'NIMBY'-like conflicts. As we explore Chinese local residents' risk perceptions, we also provide a simple comparison with studies of the U.S. Marcellus Shale region (i.e., Brasier et al., 2013; Stedman et al., 2012).

[1] The report is the first comprehensive worldwide assessment of shale gas recoverable reserves in 48 shale gas basins in 32 countries.

The following section outlines previous literature in this area; Sections 3 and 4 discuss, respectively, the status of shale gas development in China and study methodology; Section 5 provides the study's results; and Section 6 concludes with our findings and policy implications.

2. Literature review

Early planning and political theories (e.g., Habermas, 1984; Habermas and Shapiro, 1971) suggested that better understanding of social and environmental contexts would guide the public to pursue better solutions to problems. Nonetheless, a study by Arlikatti et al. (2007) on earthquake adjustment finds that such efforts are generally mediated by the public's risk perceptions. Risk perception has since become a popular topic in behavioral implementation studies.

Risk perception has been discussed in an extensive body of research. The earliest work on perceived risk can be traced to the 1960s (Sjöberg, 2000), when Starr (1969) provided one of the first methods to measure risk. Since then, subsequent studies have examined local residents' risk perceptions of different hazards among different demographic groups. Slovic et al. (1980) developed a quantified model to measure the public's risk perception, based on Starr's work (Brasier et al., 2013; Slovic, 2000). Technical experts and laypeople generally have different risk perceptions of hazards (Fischhoff et al., 1982; Siegrist and Cvetkovich, 2000; Sjöberg, 1998, 2000) and an extensive body of research has recently intensified interest in laypeople's perceived risks. For instance, Slimak and Dietz (2006) conducted a mail survey on ecological risk perception to reveal the lay public's concerns about ecosystems. Risk perceptions have been recognized as individuals' interpretations of social and environmental contexts in relation to their perceptions of threats (Huang et al., 2017; Lindell and Perry, 2004, 2012). However, the mechanisms of risk perception vary by specific hazards, (as well as geographic locations and ethnic differences) so studies on each specific threat are indicated (Lindell and Perry, 2004).

Shale gas commercial development has created a new growing domain for studies examining risk perception (Boudet et al., 2014; Brasier et al., 2013; Clarke et al., 2016; Whitmarsh et al., 2015; Willits et al., 2016). Brasier et al. (2013) categorized the influences on risk perception into three sets, including perceived knowledge of effects of technologies, institutional trust, and demographic and geographic characteristics of participants. Other factors included public attitudes toward environmental issues, political ideologies, and frequency of media exposure (Clarke et al., 2016; Sjöberg, 2000; Whitmarsh et al., 2015).

Boudet et al. (2014) explored public perceptions of hydraulic fracturing in the U.S. and found that half of respondents had heard or read about hydraulic fracturing but only 22% had positive attitudes toward it. Boudet et al. (2014) further examined determinants of support and opposition and found that supporters of hydraulic fracturing technology are more likely to be female, older, having a higher educational level, and politically conservative. Frequency of media use was another factor influencing respondents' attitudes. Willits et al. (2016) in particular studied perceptions of residents in the Marcellus Shale region toward safe uses of hydraulic fracturing wastewater. That study showed that females were less likely than males to express confidence in the safety of current wastewater treatment and reuse practices, and that familiarity with hydraulic fracturing increased respondents' acceptance of wastewater reuse by the gas/oil industry but decreased such acceptance in municipal applications. Willits et al. (2016) also found that respondents' trust in selected sources played a crucial rule in alleviating their concerns about wastewater from hydraulic fracturing. Clarke et al. (2016) also investigated factors that influenced the U.S. public's level of support for shale gas development via hydraulic fracturing and found people were likely to support development if they both perceived its benefits as outweighing risks and if their political ideology were conservative.