

# Policy recommendations to promote shale gas development in China based on a technical and economic evaluation



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## HIGHLIGHTS

- We explore the economic feasibility of shale gas development in China.
- Current incentive policies cannot render shale gas development economically viable.
- These incentives must be improved to effectively promote shale gas development.
- We investigate the effect of the major policies available in China to light a path.
- Recommendations are proposed to continually improve the incentive policies in China.

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## ABSTRACT

Because of its resource potential and clean burning advantages, the development of shale gas can significantly increase the supply of cleaner energy while offering the associated benefits. To foster shale gas development, many policy incentives have been introduced in China. However, the current incentives have not been sufficiently aggressive, and the shale gas industry has been slow to develop. Existing policies thus need to be further improved. To provide effective support for decision makers in China, a technical and economic evaluation is performed in this study to explore the profitability of shale gas production in pilot zones. The results show that shale gas production is subeconomic under the current technical and economic conditions. Based on this evaluation, a policy analysis is conducted to investigate the profitability improvement offered by the major policies available in China to elucidate a path toward improving incentive policies. The results indicate that policy instruments related to gas prices, financial subsidies, corporate income taxes or combinations thereof could be used as priority options to improve policy incentives. Based on these results, recommendations are presented to improve the current incentive policies aimed at accelerating shale gas development.

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## 1. Introduction

In its pursuit of sustainable development, China has been increasing its efforts to generate cleaner energy. However, China's current energy mix is still dominated by coal and oil, as shown in Fig. 1 (BP, 2014). Natural gas, which is much cleaner, accounts for only 5.4% of China's energy consumption, a level far below the global average of 25% (National Bureau of Statistics (NBS) of China, 2014). In recent years, the growth in natural gas consumption in China has remained high (Zhang, 2014; Zhao et al., 2013), while the growth in natural gas production has slowed. As illustrated in Fig. 2, the current natural gas shortage is substantial, increasing reliance on foreign gas and further diminishing China's energy

security (China National Petroleum Cooperation (CNPC), 2014; Sandalow et al., 2014; Zhang et al., 2014). Although renewable energy resources are widely recognized as the most efficient and effective solution to sustainable development, progress in developing these solutions has been slow due to technology and cost issues as well as other risks (Jin et al., 2010; Wang and Lin, 2014). Achieving a transition from the current era, dominated by high-carbon fossil fuels, to a green and low-carbon future will be a long-term project for China. Shale gas, like all natural gases, has remarkable advantages, and increasing its use as a transitional energy solution to help bridge this gap is one realistic option (Hu and Xu, 2013; Melikoglu, 2014; Wang and Lin, 2014).

In addition to the resource endowment, some factors such as companies' inefficiencies, lack of learning and economy of scale explain why it is currently not profitable to extract shale gas in China. However, given its enormous potential, shale gas

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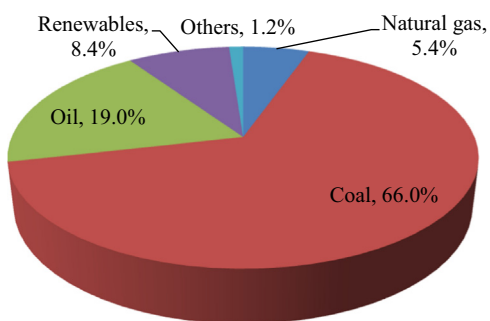


Fig. 1. China's primary energy consumption mix in 2013 (BP, 2014).

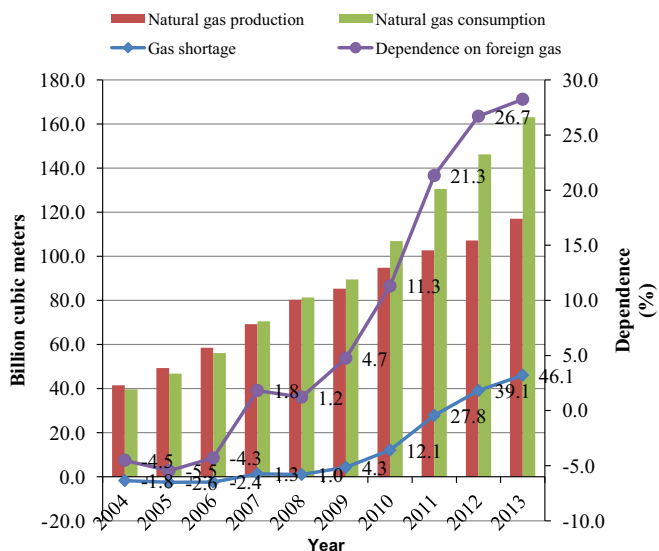


Fig. 2. The worsening natural gas shortage in China and increasing dependence on foreign gas (CNPC, 2014; Sandalow et al., 2014; Zhang et al., 2014).

development should be encouraged by the government. For example, the government should provide reasonable incentive policies to make shale gas production profitable, thereby contributing to the healthy development of this industry. Perhaps because the history of shale gas production in China is very short, very few studies have combined technical and economic evaluations with a policy analysis to address improving incentive policies to promote shale gas development in China. Guo et al. (2010) offered a simple economic evaluation of shale gas development without clear details such as model assumptions. In their study, the authors discussed policy issues separately from their economic evaluation, and no specific policy measures were proposed. Compared with shale gas development in the US, Liao et al. (2012) reported that shale gas development in China faces many constraints, such as a lack of policy support, key technologies and pipeline networks, and they proposed several policy recommendations without quantitative analyses. Hu and Xu (2013) and Wang et al. (2014) recommended policy options related to key technologies and environmental issues based merely on an analysis of the opportunities and challenges facing shale gas development in China. Moreover, in their work, Feng et al. (2013), Fu et al. (2012) and Zhao et al. (2013) presented development strategies and policy recommendations based solely on a SWOT analysis of China's shale gas industry. Furthermore, these studies focused on common policies without highlighting incentives such as fiscal support.

The purpose of this paper is to provide details explaining why shale gas development in China is not currently profitable and to conduct an analysis to demonstrate which incentive policies may be more effective for improving profitability. The subsequent

policy recommendations are not based on a quantitative analysis of the social benefits or social costs of shale gas development in China. Given existing incentive policies, a technical and economic evaluation model using the discounted cash flow (DCF) method is created to examine the current economic feasibility of shale gas production in China. This evaluation then provides a basis for the subsequent policy analysis. This analysis investigates the effects of the major policies available in China on improving the profitability of shale gas production and provides guidance to improve incentive policies. Based on the combination of technical and economic evaluations and policy analysis, potentially helpful ideas and approaches for improving incentive policies aimed at accelerating shale gas development in China are proposed.

## 2. The current status of shale gas development in China

### 2.1. The progress of shale gas development in China

With its abundant shale gas resources (Fig. 3), China has vigorously pursued shale gas opportunities (Zhang et al., 2012). Due to technological advances and policy support, a series of breakthroughs has been achieved in the development of shale gas resources. China has developed the necessary key technologies and corresponding equipment for shale gas development, such as hydraulic fracturing. Furthermore, several pilot zones for shale gas development have been established, for instance, in Weiyuan-Changning, Zhaotong, and Fuling (Table 1). Of these, the Fuling pilot zone is currently the most productive, with production totaling over 3 million cubic meters per day (Mcm/d). As of 2012, apart from North America, China was the only nation producing commercial quantities of shale gas (Energy Information Administration (EIA), 2013), with an annual production of approximately 0.035 billion cubic meters (Bcm). In 2013, China's shale gas production reached more than 0.2 Bcm (Ministry of Land and Resources (MOLR), 2014a), a fivefold increase over 2012. In 2014, shale gas production in China was approximately 1.3 Bcm, a further annual increase of 550% over 2013 (MOLR, 2014b; Qian et al., 2015). Nonetheless, given the current situation, China will struggle to achieve its annual production target of 6.5 Bcm in 2015 (Wan et al., 2014).

### 2.2. The role of incentive policies for shale gas development in China

Because shale gas is an unconventional, low-grade resource, advanced technologies and large capital investments are required to exploit it (Aguilera, 2014). Thus, shale gas development is usually not economically viable and includes high uncertainty and risk. Without profitability, Chinese firms are not motivated to

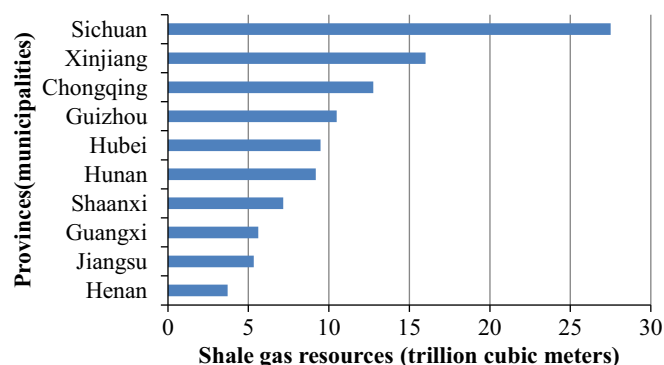


Fig. 3. Top 10 provinces (municipalities) with shale gas resources in China (Zhang et al., 2012).

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