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Challenges of using natural gas as a carbon mitigation option in China

Yue Qin[a,*], Fan Tong[b,c], Guang Yang[d], Denise L. Mauzerall[a,e,**]

[a] Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, NJ 08544, USA
[b] Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213, USA
[c] Department of Global Ecology, Carnegie Institution for Science, Stanford, CA 94305, USA
[d] Energy Research Institute, National Development and Reform Commission, Beijing 100038, China
[e] Department of Civil and Environmental Engineering, Princeton University, Princeton, NJ 08544, USA

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ABSTRACT

Under the Paris Agreement, China committed to peak its carbon dioxide emissions on or before 2030. Substituting natural gas for coal may facilitate it meeting this commitment. However, three major challenges may obstruct progress towards desired climate benefits from natural gas. 1) A fundamental price dilemma disincentivizing a coal-to-gas end-use energy transition: low city-gate gas prices discourage an increase in gas supplies while high end-use gas prices impede an increase in gas demand. 2) Insufficient and constrained access to natural gas infrastructure hinders connections between gas supplies and end-users, and obstructs a balance in seasonal supply and demand. 3) Methane leakage from the natural gas industry compromises the direct greenhouse gas emission reductions from combustion. To address these challenges, government and industry must work together to facilitate natural gas market reform, increase investment in natural gas infrastructure, and control methane emissions.

1. Introduction

China's rapid economic growth over the past two decades has been accompanied by substantial increases in national energy consumption and resulting air pollutants and CO_2 emissions (Qin and Xie, 2011a; Sheehan et al., 2014). Currently China, with 19% of global population, contributes 16% of global gross domestic product (GDP) and 30% of global CO_2 emissions (The World Bank, 2017). China is by far the world's largest emitter of CO_2 and has pledged to peak national CO_2 emissions by 2030 or sooner (NDRC, 2015a). Meanwhile, the Chinese government is committed to reducing China's severe domestic air pollution (Sheehan et al., 2014; State Council, 2013a). Many air-quality improvement measures, including substituting natural gas for coal (NDRC, 2015a), may also bring climate benefits. Indeed, in its Nationally Determined Contributions (NDC), the Chinese government plans to increase the use of natural gas to over 10% of national primary energy consumption by 2020 (NDRC, 2015a). Here we examine the key challenges that may constrain the carbon mitigation potential of natural gas uses in China. These include a need to expand natural gas supplies, encourage coal-to-gas substitution, and ensure a lower lifecycle carbon footprint for natural gas than coal.

2. China's natural gas supply

Primarily for geologic reasons, China has abundant coal reserves but is relatively poor in conventional natural gas resources (IBP, 2012). Abundant and cheap coal has dominated China's energy supply throughout its industrialization and modernization. As a result, even with government incentives, natural gas use barely reached 6% of China's total primary energy consumption in 2015, compared with 64% from coal (NBSC, 2016). In 2014, China's total natural gas supply was about 187 billion cubic meters (bcm), with 64%, 0.7%, 4%, 0.4%, 14%, 2%, and 15% from domestic conventional gas, shale gas, coalbed methane (CBM), coal-based synthetic natural gas (SNG), imported liquefied natural gas (LNG), and imported pipeline gas from Myanmar and Central Asia, respectively (NBSC, 2016). To further increase natural gas supplies, the Chinese government has actively promoted exploration and production of domestic unconventional natural gas. The central government has set production goals for year 2020 at approximately 30–100, 20–40, and 20–60 bcm of shale gas, CBM, and SNG, respectively (NDRC, 2016a, 2016b; NEA, 2012a, 2012b, 2014a, 2014c, 2016). Meanwhile, China has established natural gas import contracts with major gas producing countries (NDRC, 2012, 2016b). According to the existing contracts, China's natural gas import capacity in 2020 will

* Corresponding author. Present adress: Department of Earth System Science, University of California, Irvine, CA 92697, USA.
** Corresponding author at: Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, NJ 08544, USA.
E-mail addresses: yq@princeton.edu, yqin8@uci.edu (Y. Qin), mauzeral@princeton.edu (D.L. Mauzerall).

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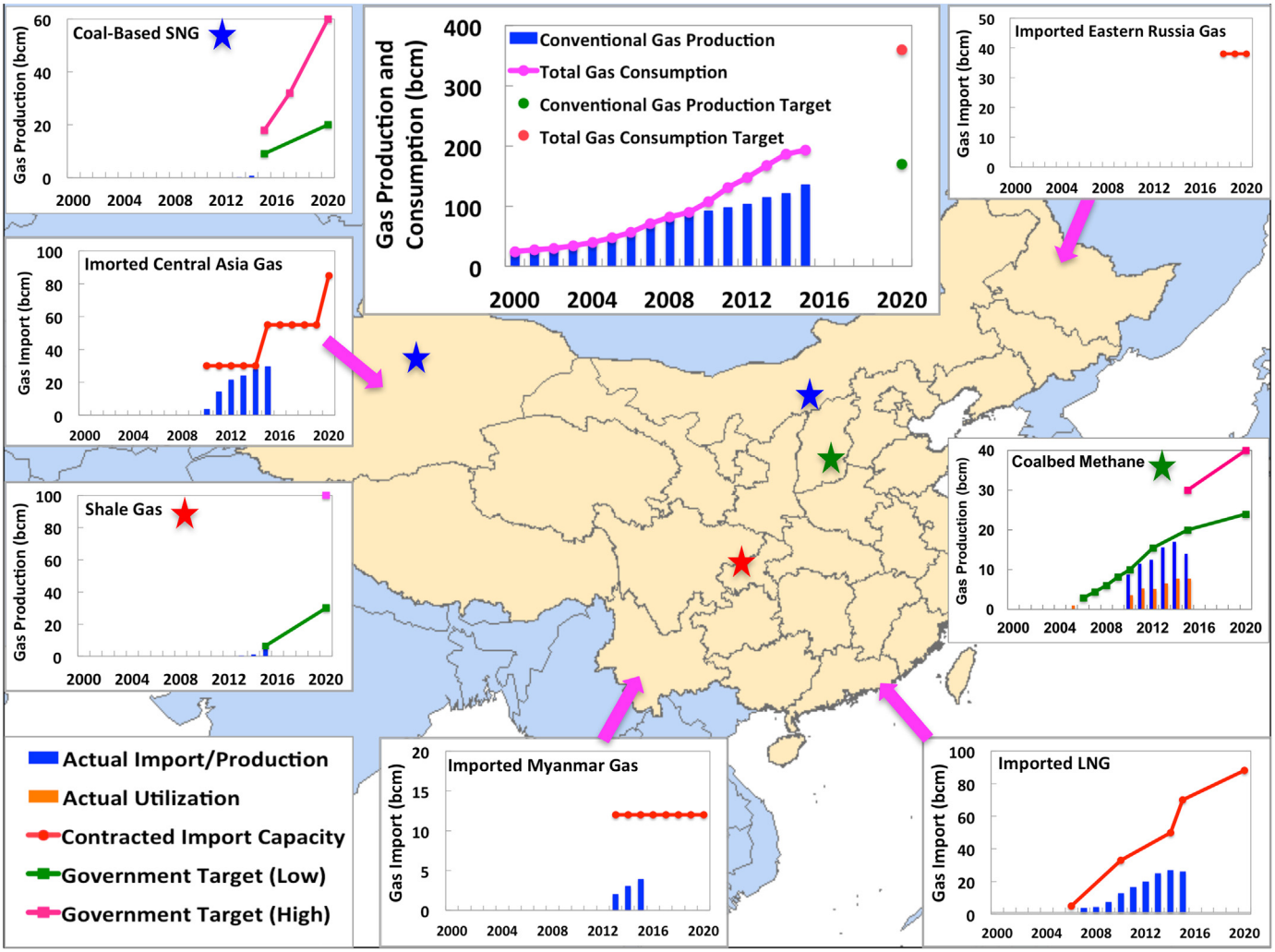

Fig. 1. Historic and planned natural gas supplies from China's major natural gas sources. Information is gathered from government documents (for government targets) (NDRC, 2012, 2016a, 2016b; NEA, 2014b; State Council, 2013b), a statistical database (for historical gas production and consumption) (NBSC, 2016), published literature (Paltsev and Zhang, 2015), and news articles (when no other information is available). Representative production regions and import locations for major gas sources are illustrated on the map with colored stars (shale gas with red stars, coalbed methane with green stars, and coal-based synthetic natural gas with blue stars). Pink arrows point to major provinces importing pipeline gas and LNG from indicated regions. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

increase to 85 bcm/yr (via pipelines from Central Asia, ~55 bcm/yr in 2015), 38 bcm/yr (via pipelines from eastern Russia, contracts will start in 2023), and 88 bcm/yr (via LNG from Qatar, Australia, Malaysia, and Indonesia; ~50 bcm/yr in 2014) (Dong et al., 2014; Paltsev and Zhang, 2015).

In Fig. 1, we summarize historical natural gas supplies and near-term production or import goals for China's primary natural gas sources. We find that despite strong political interest in increasing natural gas supplies, domestic unconventional natural gas production and actual natural gas imports are consistently below the government's targets (NDRC, 2012, 2016b; NEA, 2012b, 2014b; Paltsev and Zhang, 2015). Furthermore, the Chinese government has continuously lowered production targets for all types of unconventional gas over the past five years to adjust for slow growth in natural gas supplies (NDRC, 2012, 2016a, 2016b; NEA, 2012a, 2014a, 2014c, 2016). For example, in 2012, the central government planned to have annual shale gas production of 60–100 bcm by 2020; this target was reduced to 30 bcm four years later (announced in 2016) (NEA, 2012a, 2016).

Slower-than-expected domestic natural gas development is partly due to constraints such as unfavorable geology and immature technology (Chang et al., 2012; Yang, 2015). Shale gas has experienced such development constraints and we list the main barriers for China's shale gas development compared to the U.S. in Table 1. Geological constraints such as deeper shale resources and insufficient water availability cause substantially higher costs for shale gas production in China than in the U.S. Meanwhile, market barriers have also played an important role in delaying natural gas development in China. Until now, China's natural gas market was essentially controlled by three national oil companies (NOCs) that own virtually all natural gas production facilities and pipeline infrastructure. Natural monopolies result in an uncompetitive gas production market. This, consequently, leads to low incentives for NOCs to invest in technology advancement and efficiency improvement, which could have significantly reduced gas production costs (Victor et al., 2011).

More importantly, natural gas markets in China are heavily regulated by central and provincial governments. In Fig. 2, we illustrate China's natural gas pricing mechanisms. As shown in Fig. 2, under the traditional pricing mechanism, city gate natural gas prices are determined by the wellhead gas prices and long-distance pipeline transmission prices, both of which are regulated by the central government. City gate gas prices, for which natural gas distribution companies pay the pipeline companies (subsidiaries of the three NOCs), are thus regulated wholesale natural gas prices (Paltsev and Zhang, 2015). China started to implement a new pricing mechanism nationwide in 2013. Under the new pricing mechanism, city gate natural gas prices are associated with two imported substitutes: fuel oil and liquefied