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Prospects for shale gas production in China: Implications for water demand

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ABSTRACT

Development of shale gas resources is expected to play an important role in China's projected transition to a low-carbon energy future. The question arises whether the availability of water could limit this development. The paper considers a range of scenarios to define the demand for water needed to accommodate China's projected shale gas production through 2020. Based on data from the gas field at Fuling, the first large-scale shale gas field in China, it is concluded that the water intensity for shale gas development in China (water demand per unit lateral length) is likely to exceed that in the US by about 50%. Fuling field would require a total of 39.9–132.9 Mm^3 of water to achieve full development of its shale gas, with well spacing assumed to vary between 300 and 1000 m. To achieve the 2020 production goal set by Sinopec, the key Chinese developer, water consumption is projected to peak at 7.22 Mm^3 in 2018. Maximum water consumption would account for 1% and 3%, respectively, of the available water resource and annual water use in the Fuling district. To achieve China's nationwide shale gas production goal set for 2020, water consumption is projected to peak at 15.03 Mm^3 in 2019 in a high-use scenario. It is concluded that supplies of water are adequate to meet demand in Fuling and most projected shale plays in China, with the exception of localized regions in the Tarim and Jungger Basins.

Contents

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1. Introduction

At the Asia-Pacific Economic Cooperation (APEC) forum 2014, China committed to peak its CO_2 emissions by 2030 [1]. In order to achieve this goal, China must reduce the coal share of its primary energy use. China's Energy Development Strategic Action Plan [2], covering 2014–2020, and announced prior to the APEC commitment, seeks not only to raise the share of total energy consumption supplied by renewable sources, but includes also plans for increased supply from natural gas, rising from 5% of total primary energy supply in 2013 to at least 10% in 2020. In 2014, more than 32% of the gas consumed in China was supplied by imports, delivered either in the form of liquefied natural gas (LNG) or through long-distance pipeline [3]. Due to a lack of conventional gas reserves, China has sought to increase its production from unconventional resources, notably from shale. Production of gas from shale has increased rapidly in the US benefiting from two enabling technologies, horizontal drilling and hydraulic fracturing ("fracking"). Production of gas from shale increased from 6.7% of total US gas production in 2007 to 46.9% in 2013 [4]. The U.S. Energy Information Administration (EIA) has estimated China's technically recoverable shale-gas resources at 31.6 trillion cubic meters (tcm) [5], higher than those of the U.S., while China's Ministry of Land and Resources (MLR) estimated them at 25.1 tcm [6]. China's plan sets a goal for annual production of at least 30 billion cubic meters (bcm) annually by 2020 [2]. Achieving this objective will be critical to meet the stated goal of a peak in carbon emissions by 2030.

Influenced by the success of the recent shale-gas boom in the U.S., China's government has established a series of policies to support and promote extraction of gas from shale. A production subsidy of 0.4 RMB/m^3 was introduced between 2012 and 2015, though it is scheduled to decline to 0.3 RMB/m^3 between 2016 and 2018 and to decrease further to 0.2 RMB/m^3 between 2019 and 2020. These policies include also waivers of price controls and fees, and reclassification of shale gas as an independent mineral resource, which allows for development policies distinct from those for conventional gas [7]. Two rounds of auctions for exploration rights have been held, in 2011 and 2012. By April 2014, total investment had reached more than 2.42 billion U.S. dollars and 322 exploration wells had been drilled, including 96 with horizontal extensions [8]. Although China's shale-gas development has progressed more slowly than *anti*cipated and remains at an early exploratory stage, considerable progress has occurred at a few favorable fields in the Sichuan Basin of southwest China [9]. These are led by the Fuling field, which currently includes roughly one third of total existing horizontal wells in China and is the first to achieve large-scale production. In 2014, the Fuling field produced 1.08 bcm of gas from shale, accounting for 73.3% of China's total production [10].

A key challenge for shale gas development is the requirement for water employed both in drilling and fracking, with related concerns for economically feasible disposal of waste water. The International Energy Agency (IEA) estimates that the water volume required per unit shale gas production is, at a minimum, 200 times that for conventional gas [11,12]. The potentially large scale of unconventional gas development increases the risk for water contamination [12]. Experience in the U.S. is instructive. More than 1.1 million wells have been fracked in the U.S. [13], a number that is increasing. While use of water for shale-gas production accounts for less than 1% of total water consumption in a state such as Texas, which is both a center of the U.S. industry and largely arid, it could have serious impacts for water resources at more local levels depending on availability and competing demands [14–18]. And although federal regulations prohibit direct discharge of wastewater from shale-gas operations, discharges of shale-gas effluent from water treatment plants have been shown nonetheless to pose negative impacts on the local environment [19,20]. Additional impacts on water resources are also being studied [11]. The relationship between shale gas production and water consumption remains controversial in the U.S.

Given China's existing water scarcity and water quality problems, the effect of potentially large-scale development of shale gas on water resources is of critical concern, requiring more intensive investigation. Per capita renewable internal freshwater resources amount to only a third of the world average while about 400 of 660 cities in China suffer from water shortages, close to 50% of Chinese rivers are severely polluted, and availability of safe drinking water is inadequate to meet the needs of 300 million rural people [21,22]. Some have concluded that water constraints represent the key obstacle to China's shale-gas development [23,24], with one commentator suggesting that this could lead to a national disaster [25]. Such pessimistic assessments tend not to be based on quantitative analyses, however, but rather on inferences from water use in the U.S. shale-gas industry and general characteristics of China's water resources such as its uneven distribution and low per capita consumption rates. The few quantitative assessments of water availability in China's shale-gas regions, moreover, fail to estimate water use based on actual shale-gas production [26–28]. Some studies suggest that water supply is less of a concern [29], at least in the short-term [7], but that the lack of regulations to limit wastewater discharge from shale-gas operations means that impacts on water quality deserve greater attention. Few of the existing findings result from quantitative analysis, reflecting lack of data for water use and wastewater treatment on current China's shale-gas operations.

This paper focuses on the requirements for water if China is to meet the anticipated production targets for shale-derived natural gas (30 bcm by 2020). It begins by developing a methodology that can be used to project the demand for water in the development of shale-gas wells in China, a function both of the geological conditions defining particular sites and the extent and spacing of the horizontal drilling wells. Values for water intensity, defined as the water demand per unit lateral length (i.e., the length of the horizontal bore section in which fracking is performed), were derived from water use data published for major U.S. shale plays and collected also in the field at China's Fuling shale gas development. The paper continues with assessment of the future demand for water through 2020 for the Fuling field and more extensively for the seven shale gas basins identified for future development in China. The demand for water to supply these shale developments is compared with available supplies and current aggregate consumption. With a few local exceptions, the conclusion is that China's future development of shale gas is unlikely to be limited by the availability of water. It will be important nonetheless to impose regulatory requirements to ensure safe disposal of the resulting wastewater.