Research Article

Gas production peaks in China: Research and strategic proposals☆,☆☆

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Abstract

The peaks of natural gas production are of great significance to the planning of national energy strategy, the coordinated development of natural gas industry chain and the investment decision-making for oil and gas companies. Therefore, based on natural gas geological and development characteristics, the production peaks of conventional gas (including tight gas), CBM and shale gas in China have been systematically analyzed and forecasted using multiple methods. The following conclusions are drawn: first, the cumulative gas production in China will reach 280−330 bcm by 2035 and 330−410 bcm by 2050; second, the conventional gas production peaks will be easily predicable during the forecast period, while the peaks of CBM and shale gas production need to be further forecasted and tracked continuously; third, with the possible breakthrough of gas hydrate exploration and development being considered, gas production in China has a great potential and bright future. In order to achieve a strategic goal of energy transformation and conservation and to guarantee a safe and stable gas supply, a timely profound analysis and study will be necessary on the international political, economic and energy development situation for a global gas strategic layout. In view of this, based on the analysis of domestic natural gas supply and demand situation, the following proposals are put forward: to speed up the domestic tapping and commercial production of those deep-strata, deep-water and unconventional gas resources to consolidate the dominant position of domestic natural gas supply; to attach great importance to a strategic layout of overseas gas resources utilization and to adopt various ways to ensure the security of domestic gas market; to accelerate the evaluation of gas hydrate development in order to enlarge and consolidate the gas resource basis; and to strengthen a dynamic forecast on the peaks of gas production in order to continuously enhance the soft power in international competition.

Over a decade of rapid development, China has ranked among the world's leading producers and consumers of natural gas. At present, the pressure of climate change and the development of new technologies in the energy sector drive the global energy revolution. "More clean energy and less carbon dioxide" has become the main theme of energy revolution. Increasing the proportion of natural gas consumption represents China's best realistic choice for controlling air pollution and smog. Therefore, there is great potential for the development of China's natural gas market in the future. Scientific research and judgment on gas production peaks are of great significance to the formulation of national energy strategies, the overall arrangement of domestic gas and imported gas resources, and the rational planning of natural gas business development. The study on production peak is a complex and systematic task involving many factors such as resource base, economic level, geopolitics, technological progress, and environmental protection, and involves great difficulties in accurate evaluation; thus, comprehensive multi-disciplinary research is required. In this paper, based on the knowledge and experience of natural gas strategic research of

many years, the authors assessed gas production peak in China by resource types with a variety of methods and multiple scenarios, in order to provide a basis for the deployment of national energy strategy and the development planning of natural gas industry.

1. Knowledge of gas production peak

1.1. Basic concept

The rise and evolution of the study on "Peak Oil" originated from the "Bell Curve" law of mineral resources discovered by Hubbert (a famous American petroleum geologist) in 1949 [1]. He believed that the production of oil, as a non-renewable resource, in any region, will reach a peak and then inevitably begin to decline [1]. In 1956, Hubbert boldly predicted, in spite of the continuous growth of oil production in the United States, that oil production in the country would decline after reaching a peak in 1967−1971. Truly, the US oil production reached its peak in 1970. This "precise" prediction made Hubbert's Peak Oil Theory cause a sensation, which pushed the peak oil research to a climax.

With the deepening of research, the concept of "peak oil" has been supplemented and improved. Campbell, an Irish geologist, defined the peak oil as the peak value and its arrival period for oil and gas production in an oil region or country [2]. Skrebowski, the former U.S. energy consultant, defined the peak oil as a point after which oil production will no longer increase; however, this point does not mean that oil is depleted, but that oil production will not increase [3].

The first medium-/long-term forecasting model for oil and gas reserves and production in China was proposed by Academician Weng Wenbo, a famous geophysicist. He pointed out in his book *Theory of Forecasting* [4]published in 1984 that any finite body experiences a natural process of rising−growing−flourishing−declining, so does oil and gas exploitation. On this basis, the Weng's Model for oil/gas reserves and production forecasting was established. Later, Chen Yuanqian and other scholars also made a lot of analysis and research on oil and gas production forecasting [5,6].

Natural gas was initially developed and utilized later than oil and it had always been taken as a product associated to oil. The production peak of gas is far less concerned than oil, and no report has been found on the systematic study of global gas production peak. The authors believe that the gas production peak should be studied with a full consideration to the upstream, midstream and downstream integration of the natural gas industrial chain, and both the consumer market and transmission & distribution network construction require a long stable period of gas supply. Therefore, the gas production peak is defined as the production at the time when the gas production in a country or basin reaches the maximum (with the fluctuation not more than 5%) and keeps continuous and stable for not less than 20 years. In other words, the arrival of gas production peak does not mean that natural gas production is about to be depleted, but it will experience a longer plateau period.

1.2. Significance

The study on gas production peak is of urgent and realistic significance to energy transformation and CO_2 emission reduction, promoting sustainable socio-economic development, and raising people's awareness of scientific utilization of natural gas resources. In terms of a nation, a reasonable assessment of gas production peak is conducive to its formulation of energy security strategy, proactive planning for the utilization of overseas gas resources, and scientific deployment of national gas development. In terms of an oil company, understanding gas production peak is beneficial for a company to scientifically prepare its development strategy, make oil/gas field development planning, and rationally allocate its assets, in order to maximize its economic returns and ensure its sustainable development. In terms of the gas industry chain, the production peak is the key to the coordinated development of the industry chain, and also the foundation for the construction of the transmission & distribution networks in the midstream and the market development in the downstream.

1.3. Uncertainties

As mentioned above, the study on production peak is a complex and systematic task that involves many factors. Research institutes and scholars often have their respective conditions for determining the production peak. Once the conditions change, the peak will change. Even the same institute or scholar may have its/his recognition on the peak changing with the conditions. Therefore, there are uncertainties in the determination on the production peak. The oil peak has been argued for years in the industry, mainly because people paid too much attention only to the outcome of the peak, but ignored the conditions for it.

It is certain that oil and gas, which are limited in quantities, are subject to a peak objectively. The focus of research should be on the size of the peak and arrival of the peak. As oil and gas resources expand from onshore conventional and unconventional resources, to offshore, and to polar, the scale of resources is increasing continuously. Meanwhile, the factors such as technological breakthroughs, incentive policies, and energy structure adjustment, are changing. All these drive us to consistently investigate and correct the recognition on peak.

2. Gas production peak in China

2.1. Gas production forecasting method

At present, gas production forecasting methods mainly include analogy method (e.g. gas recovery rate method), life model method (e.g. Hubbert model and Weng's model), combination model method (e.g. gray-Hubbert method), reserve/production ratio controlling method, production composition method, reservoir engineering method, and supply-demand integration forecast method (Table 1). Each method corresponds to specific characteristics and application conditions. In the early stage of basin exploration and