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# Economic evaluation on tight sandstone gas development projects in China and recommendation on fiscal and taxation support policies

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**Abstract**

China is rich in tight sandstone gas resources ("tight gas" for short). For example, the Sulige Gasfield in the Ordos Basin and the Upper Triassic Xujiahe Fm gas reservoir in the Sichuan Basin are typical tight gas reservoirs. In the past decade, tight gas reserve and production both have increased rapidly in China, but tight gas reservoirs are always managed as conventional gas reservoirs without effective fiscal, taxation and policy supports. The potential of sustainable tight gas production increase is obviously restricted. The tight gas development projects represented by the Sulige Gasfield have failed to make profit for a long period, and especially tight gas production has presented a slight decline since 2015. In this paper, a new economic evaluation method was proposed for tight gas development projects. The new method was designed to verify the key parameters (e.g. production decline rate and single-well economic service life) depending on tight gas development and production characteristics, and perform the depreciation by using the production method. Furthermore, the possibility that the operation cost may rise due to pressure-boosting production and intermittent opening of gas wells is considered. The method was used for the tight gas development project of Sulige Gasfield, showing that its profit level is much lower than the enterprise's cost level of capital. In order to support a sustainable development of tight gas industry in China, it is recommended that relevant authorities issue value-added tax (VAT) refund policy as soon as possible. It is necessary to restore the non-resident gas gate price of the provinces where tight gas is produced to the fair and reasonable level in addition to the fiscal subsidy of CNY0.24/m$^3$, or offer the fiscal subsidy of CNY0.32/m$^3$ directly based on the on-going gate price. With these support policies, tax income is expected to rise directly, fiscal expenditure will not increase, and gas consumption cost in China will be significantly cut down.



*Keywords:* China; Tight sandstone gas; Development project; Economic evaluation; Sulige Gasfield; Gate price; Cost of capital; Value-added tax (VAT) refund; Fiscal subsidy

In China, tight sandstone gas, or tight gas, is defined as natural gas contained in sandstone reservoirs with matrix permeability of 0.1 mD or less [1]. Tight gas is characterized by low quality, high development costs, and low and fast-declining production in a single well, making its production increase and stabilization difficult. Moreover, natural gas price in China has long been regulated, and the actual economic efficiency of tight gas development projects is much lower than that of conventional gas development projects. Currently, most of the tight gas "sweet spots" with high-level reserves have been developed, with a large production capacity formed. The large quantity of remaining reserves is low in quality, and they are not qualified for technical and economical scale development, almost attracting no investors. Thus, the industry is facing huge pressure to realize production stabilization and increase. If tight gas is still managed as a conventional resource without effective fiscal, taxation and policy supports,

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it is extremely challenging to further increase its production. Currently, the relevant authorities are actively working to develop the supporting policies for tight gas. In this paper, the technical and economic limits of tight gas development projects are discussed. Through case studies, the methods and parameters for the economic evaluation of tight gas projects are improved, and the benefits of these projects are evaluated objectively, so as to provide a quantitative basis for the introduction of support policies in tight gas industry.

## 1. Current tight gas exploration and development in China

### *1.1. Fast increases in tight gas reserves and production during 2006–2014*

According to the latest estimates, the technically recoverable tight gas resources are $9 \times 10^{12}$–$13 \times 10^{12}$ $m^3$ [2], accounting for about 29–48% of technically recoverable conventional gas resources [3]. Over the past decade, the robust demand in natural gas market, sustained progress in key engineering technologies for exploration and development, and expected price hikes driven by persistently high oil prices triggered the rapid increases in tight gas reserves and production in China. The newly-discovered proven gas in place accounted for about 45% of the total newly-discovered proven gas in place within the same period. In 2014, tight gas contributed 27% to China's total gas production, close to 40% of conventional gas production.

In China, large-scale exploration and development of tight gas was firstly carried out in the Sulige Gasfield, Ordos Basin. The Sulige Gasfield, discovered in 2000, revealed unsatisfactory performance in early production test. For instance, small well-controlled reserves, and low and fast-declining production, which were mainly attributed to low permeability, low pressure, and low abundance. It was not developed intensively until 2006. Since 2008, with the application of vertical well layered fracturing and horizontal well staged fracturing, the Sulige Gasfield has realized a rapid increase in both reserves and production. In the same period, breakthroughs were made in the exploration and development of tight gas reservoirs in Upper Triassic Xujiahe Fm in the Sichuan Basin, Jurassic in the Junggar Basin and Tarim Basin, and deep formations in the Songliao Basin and Bohai Bay Basin [4]. In 2011, the concept of tight gas was introduced to China to formally distinguish it from low-permeability conventional gas. By the end of 2014, China's accumulated proven tight gas in place had exceeded $4 \times 10^{12}$ $m^3$. In 2014, China's total tight gas production reached $360 \times 10^8$ $m^3$. Tight gas production in the Ordos Basin was about $280 \times 10^8$ $m^3$, making it a major contributor to the increase in tight gas reserves and production in recent years.

### *1.2. Traditional management of tight gas as conventional gas in China*

The national standard promulgated in 2014 specifies the conditions for recognizing tight gas wells and tight gas reservoirs: ① the median of matrix permeability under overburden pressure (excluding fracture permeability) of the rock samples of all cored wells in the target interval is less than or equal to 0.1 mD; and ② the ratio of all tight sandstone gas wells to all gas wells in the target interval is greater than or equal to 80%. In China, the oil and gas industry has recognized the Sulige Gasfield and the Xujiahe Fm gas reservoirs in the Sichuan Basin as typical tight sandstone gas reservoirs [4–8]. However, there are high-yield wells in the "sweet spots" of tight gas. Therefore, the Chinese energy authorities still question "sweet spots" as tight gas, and thus do not manage tight gas as unconventional gas. In fact, adequate specialized research has been conducted on the relationship between the matrix permeability under overburden pressure and air permeability under atmospheric pressure for tight gas reservoirs, high-yield factors in "sweet spots", and specific conditions for recognizing tight sandstone gas reservoirs, which are not in professional dispute.

In China, core matrix permeability under original overburden pressure is seldom measured in the laboratory; instead, air permeability under atmospheric pressure is generally used to evaluate reservoirs. Studies show a value of sandstone permeability under overburden pressure approximately lower than a magnitude of air permeability under atmospheric pressure [8–13]. The development degree of fractures contributes significantly to sandstone permeability [14,15], making it a key high-yield factor in "sweet spots". Without excluding fracture permeability, the permeability under overburden pressure in Sulige Gasfield, Daniudi Gasfield and Xujiahe Fm gas reservoir in the Sichuan Basin is less than 0.1 mD, with a sample ratio of over 80% [5,8,16,17] and a median of permeability under overburden pressure of less than 0.1 mD [15–19], meeting the Chinese standard for tight gas reservoirs and belonging to tight sandstone gas reservoirs.

### *1.3. Signs of slight decreases in tight gas production since 2015*

Since 2004, the natural gas market in China has ushered in a phase of rapid development. However, the prices of natural gas are far below its value, as they have long been subject to government-prescribed pricing. The persistently high international crude oil prices have significantly driven the demand for natural gas, and promoted the exploration and development of tight gas, coalbed methane and other high-cost unconventional gas resources. In this case, exploitation enterprises barely use crude oil profits to make up gas losses. It was not until June 2013 that China gradually raised gas prices [20]. China planed to unify the prices of stock gas and incremental gas by the end of 2015. Since June 2014, however, with rapid declines in international oil prices, the actual settlement prices of natural gas in China have not been timely adjusted. Thus, the relevant authority rapidly and substantially reduced non-resident natural gas prices twice in February and November 2015 [21,22], further lowering gas market price expectations and putting huge pressure on tight gas development.

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