Send Orders for Reprints to reprints@benthamscience.ae

Open Access

Comparative Analysis on the Comprehensive Benefits of Unconventional Gas Fields in Sichuan Basin Between Joint Development Model and Independent Model

Shen Xilin[1,*] and Yin Ping[2]

[1]*Department of Economics Management, Southwest Petroleum University, Development Research Center for Sichuan petroleum and Natrual Gas, Chengdu, P.R. China 610500;* [2]*Department of Finance, Southwest Petroleum University, Chengdu, P.R. China 610500*

Abstract: With the rapid depletion of conventional natural gas resources in China and the increasing demand for natural gas as well as the improvement in the exploitation technologies of natural gas, the development of unconventional natural gas resources is rather urgent and feasible day by day and possible at the same time. However, the development of unconventional natural gas fields in China started rather late and slowly, lacking experience. In order to alleviate the conflict between the demand and supply, the development of unconventional natural gas is developing rather rapidly now. In this paper, the unconventional natural gas fields in Sichuan Basin were set as the research objects, with the comparison between two development models --- independent development and joint development, and a comprehensive benefit evaluation system was built with such indexes as technologies, costs, management and risks. Through the study, it showed that the benefit from independent development model outweighed that from the joint development, and the reason for it lay in that the cost indexes in independent development model were far lower than that in joint development model, which covered a rather big portion in the evaluation system. But, if the operators in joint development projects could strengthen the cost control, and cut it down equivalent to the cost level in independent development model, the benefits from joint development model would be better than those in independent development model. Such conclusion would provide references for decision making in the development and exploitation of unconventional natural gas fields.

Keywords: Comprehensive development benefits, Development costs, Development risks, Development technologies, Unconventional natural gas fields.

1. INTRODUCTION

Unconventional natural gas fields refer to the resources which can't be exploited and developed via conventional technological methods and approaches, mainly including tight sandstone gas, shale gas and coal-bed methane, characterized with large reserves, wide distribution, great difficulty in development, long-term development, high development cost, and complex development technologies. While, natural gas, as a new energy known for green, low-carbon, clean and low pollution will play a major role in the energy consumption in the future. Through developing unconventional natural gas fields, energy insufficiency resulted from rapid economic growth and improvement of people's living standard can be bridged up, further to safeguard national energy security, meanwhile, it is of great importance in reducing air pollution, strengthening environment protection, and realizing the goal of energy saving and emissions reduction.

2. STATUS QUO OF EXPLOITATION AND DEVELOPMENT OF UNCONVENTIONAL NATURAL GAS FIELDS

China is rich in unconventional natural gas fields, widely distributed almost all over all the big basins, with a reserve of around $320\times1012m^3$, covering about 2/5 of the national total proven reserves. In 2011, the yield of tight sandstone gas reached up to $256\times108m^3$, covering 25% of the national total natural gas yield, which is a major field of exploitation and development of unconventional natural gas. And China is also rich in coal-bed methane, ranking the third in the world as regard to the reserves, which is equivalent to 66% of the total reserves of conventional natural gas; in 2012, the yield of coal-bed methane reached up to $125\times108m^3$. At the same time, the reserves of shale gas in China also rank the front row. According to the survey issued by the Ministry of Land and Resources in March, 2012, the terrestrial potential of shale gas in China would be $134.42\times1012m^3$, with exploitable potential of $25.08\times1012m^3$, and its construction is underway to increase its yield.

3. PROBLEMS IN THE EXPLOITATION AND DEVELOPMENT OF UNCONVENTIONAL NATURAL GAS FIELDS

The reservoir of unconventional natural gas fields is mainly a fracture reservoir with a low pore and low osmosis, characterized with unevenness, and different types of resources feature different geological complexities and uniqueness, which increased the difficulty in the exploitation and development of unconventional natural gas fields [1]. The major problems lied in the following 3 aspects. I). The problems of

*Address correspondence to this author at the 8 Xindu Avenue, Xindu District, Chengdu, Sichuan, P.R. China; Postcard: 610500; Tel: 13730664451; E-mail: shenxilin@vip.sina.com

1874-8341/15

development technologies. The development technologies of unconventional natural gas fields in China were not advanced at all, mainly of which were from the development experience of conventional natural gas fields or introduced from abroad, with low adaptability, and had not formed a unique approach to the exploitation and development of unconventional natural gas fields [2]. II) Problems in investment benefits. The unconventional natural gas resources were characterized with geological complexities and uniqueness, with rather low yield from the single well, which greatly influenced the project investment benefits from the development [3]. III) Ecological problems. In the process of exploitation of unconventional natural gas fields, hydro-fracturing technology was used for the increase in its yield, thus a large amount of water, sand and chemical additives were mixed to be filled into the well with high pressure to fracture rocks, further to release the natural gas reserved in rocks [4]. Since the water reservoir would be penetrated in the process of drilling, the filled water with chemical additives via high pressure would be of a great pollution threat. In spite of such problems in the exploitation and development of unconventional natural gas fields, because of the scarce natural resources and the increase in its social demand, together with the technological advancement, the economic value of unconventional natural gas fields would be highlighted.

4. STRENGTH AND WEAKNESS IN THE INDEPENDENT DEVELOPMENT AND JOINT DEVELOPMENT

In order to speed up the development of unconventional natural gas in China, financial preferential policies, mineral rights management policies and special funds for scientific research had been issued for the exploitation and development of unconventional natural gas fields, and the development strategy of "introducing, going out, fully using two types of capitals, resources and market at home and abroad" was encouraged to carry out.

4.1. Strength and Weakness in the Joint Development Model

Foreign petroleum companies started rather early in the exploitation and development of unconventional natural gas fields, and grasped advanced exploitation technologies and gained much development experience, while in China, it started rather late. Compared with developed countries in North America, there was a certain gap in technology and management. I) Through the cooperation with foreign petroleum companies, advanced technologies and management experience could be learned to make up the own weakness; II) The enormous investment, high costs, and high risks in the exploitation and development of unconventional natural gas fields could be shared with foreign partners, further to defend the high risks from investment, cost, yield and oil price changes; III) As for intellectual development, via the platform of joint cooperation, the characteristics of technologies and management in the exploitation and development of unconventional natural gas fields should be highlighted to develop a high-level technological team and a high-quality management team; IV) Through the practice of joint development and contracts, international operation rules for companies could be learned, further to grasp international engineering quality standard and technology qualifications, which could lay a rather solid foundation for Chinese natural gas companies to participate in international competition; V) HSE could be introduced from foreign companies, with regard to dealing with the relationship between HSE and economic benefits, HSE should be put in the first place, at the same time, HSE management process in foreign companies should be learned, and the mature HSE management experiences in the foreign companies should be learned as well [5].

However, joint development of unconventional natural gas fields could be a double-edge sword. I) There was a big difference between the joint partners in mechanism, culture, view of values, thinking ways, which could have a negative influence on the project and lead to slowing down the project. II) During the joint development, sometimes because of language barrier, misunderstanding and unsmooth communication, there would be difficulties in communication between technicians and management staff. III) There would be a conflict in treatment methods, management ideas, management methods, technological and safety standards, thus discordance in the job would appear, leading to lower management efficiency [6].

4.2. Strength and Weakness in the Independent Development

With more than 100 years' exploitation and development of conventional natural gas fields in China, abundant technologies and experiences in the exploitation and development of conventional natural gas had been accumulated. The theory, approach, technology, management and countermeasures related to conventional gas exploitation and development were basically formed, which provided a good foundation for the development of unconventional natural gas fields. I) With constant exploration of such company as SINOPEC, via independent development, a set of complete theories for the exploitation, geology, and development had been formed; II) A series of key technologies related to unconventional natural gas exploitation had been formed in China, some of which had reached advanced level in the world; III) Some demonstration zones of unconventional natural gas fields in China had been successfully set up, some typical development models had been explored, and a low-cost technology system and a low-cost management system had been formed, such as SuLiGe model (low cost, intensification, standardization, digitalization, and marketization), North Suzhou model (low cost, programming, and high-efficiency), Hancheng model (low cost, grouped horizontal wells, clustered wells, and energy saving development), demonstration zones in Yunnan and Guizhou, and southern Sichuan [7].

Since the exploitation and development of unconventional natural gas fields in China was still at a developing stage, there were some difficulties in independent development, such as weakness in geological work, lack of key technologies, insufficient policy support, etc.

5. A COMPREHENSIVE BENEFIT EVALUATION OF UNCONVENTIONAL NATURAL GAS FIELDS IN SICHUAN BASIN FROM JOINT DEVELOPMENT AND INDEPENDENT DEVELOPMENT

The development of unconventional natural gas field in Sichuan Basin is a major natural gas product base in China.

In order to conduct the comprehensive benefit evaluation of unconventional natural gas fields from joint development and independent development, three big natural gas mines independently developed by PetroChina Southwest Oil & Gaefiled Company and 2 joint projects in Sichuan Basin were selected as research objects. Twelve experts from Sichuan Province in technology, economy and management with a long-term experience in the exploitation and development of natural gas were invited to provide intellectual support in this study from the perspective of the choice of evaluation indexes, the determination of index portion, and index value.

5.1. Principles for the Choice of Evaluation Indexes

1) Systematic principle. A comprehensive benefit evaluation should be based on the analysis of all kinds of factors from multi-levels and multi-angles to establish a comprehensive evaluation index system with the systematic approach.

2) Simple principle. Index numbers should be reduced as many as possible if it will not impact the evaluation effect, and cross connection and chaos should be avoided, to make it easy for analysis.

3) Objective principle. The development characteristics of oil & natural gas industry should be fully illustrated during a comprehensive benefit evaluation, and the evaluation should be estimated as a whole according to national industrial standard or international industry standard, to judge the operational benefits objectively.

4) Principle of importance. The choice of evaluation indexes should highlight and grasp the key point, to choose the typical and representative indexes to evaluate.

5) Comparable principle. The comparable principle that refers to the choice of indexes should be comparable horizontally and vertically, to illustrate the difference between indexes in different time and space.

5.2. Evaluation Index System

The evaluation index system consists of technological indexes, cost indexes, management indexes, and risk indexes.

1) Technological level indexes consist of exploitation evaluation technology, well drilling technology, well completing technology, gas production technology, and collection & transportation and purification technology.

2) Cost level indexes consist of well drilling cost, well completing cost, ground project cost, and other costs.

3) Management level indexes consist of the establishment of institutions, management methods, management institutions, and management efficiency.

4) Risk level indexes refer to resource risks, HSE risks, and political risk.

5.3. The Determination of Index Portion

In order to guarantee the science and effectiveness of the approach to the determination of index portion, the process of "to establish structural model, to construct judge matrix, to conduct unification test, to order the total structure" should be strictly abided by, and the portion for each technological level index, cost level index, management level index and risk level index mentioned above respectively is calculated as follows:

ω = (0.08674, 0.030898, 0.042369, 0.031373, 0.01548, 0.208658, 0.11337, 0.079838, 0.046309, 0.04266, 0.034703, 0.05269, 0.062945, 0.073604, 0.043519, 0.032277).

Among the 4 types of indexes mentioned above, the influence of cost indexes, was the biggest, followed by technological indexes, management indexes, and risk indexes. In the technological indexes, the exploitation evaluation technology had the biggest influence, followed by well completing technology, gas production technology, well drilling technology, and collection & transportation and purification technology. Among cost indexes, drilling cost had the biggest influence, followed by well completing cost, ground project cost and other costs. Among management cost, the biggest influence lay in management efficiency, followed by management institution, the establishment of institutions, and management methods. And among risk indexes, the influence of resource risks was the biggest, followed by HSE risks, and political risk.

5.4. The Value of Evaluation Indexes

Experts were invited to conduct researches on materials of related unconventional gas field companies in Sichuan Basin, either in joint development model or in independent development model, and scored the 16 indexes on a 1-100 scale, P1 was obtained for the indexes value of the joint development model, p2 for the indexes value of the independent development model.

P1 = (87.5, 87.5, 87.5, 75, 75, 25, 25, 25, 25, 66.7, 66.7, 66.7, 70.8, 20.8, 45.8, 33.3)

P2 = (62.5, 62.5, 45.8, 79.2, 58.3, 50, 75, 75, 50, 62.5, 50, 50, 54.2, 66.7, 41.7, 91.67)

5.5. The Calculation of Comprehensive Benefits

The value of the comprehensive benefit evaluation in the joint development model was:

$V1 = \omega * P_1^T = 46.45$

While the value of the comprehensive benefit evaluation in the independent model was:

$V2 = \omega * P_2^T = 60.05$

6. THE COMPARATIVE ANALYSIS ON COMPREHENSIVE BENEFITS OF UNCONVENTIONAL GAS FIELDS IN SICHUAN BASIN BETWEEN JOINT DEVELOPMENT MODEL AND INDEPENDENT DEVELOPMENT MODEL

Through the calculation of comprehensive benefits of unconventional gas fields in Sichuan Basin between joint development model and independent development model respectively, the comprehensive benefit from joint development was 46.45, while the comprehensive benefit from independent development was 60.05, showing the comprehensive benefit from independent model outweighed that from joint development model.

Comparative analysis on benefits: the comprehensive benefit of unconventional natural gas fields in Sichuan Basin from joint development model was lower than that from independent development model. The reason for it lay in that the cost level in independent development was much lower than that in joint development, and that the cost level played a rather important role in the comprehensive benefit evaluation, though joint development model was superior to independent development model in technology level and management level, which covered a small portion in the comprehensive benefit evaluation.

Analysis on dynamic benefits: if cost level in the joint development model could be controlled and cut down equivalent to that in the independent development model, the evaluation values of the comprehensive benefits from two development model could be obtained as follows: the comprehensive benefit of independent development model was 60.05, while that of joint development model was 62.48, which meant the comprehensive evaluation benefit from joint development model was superior to that from independent model.

From the comparative analysis, it showed that cost management should be strengthened in the development of unconventional gas field in Sichuan Basin in the joint development model, especially the control over well drilling cost and well completing cost. While in the independent development model, advanced exploitation technologies and management experience should be learned from the foreign companies, to improve technological and management level.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Sichuan Provincial Planned Projects on philosophical, social science during the Twelfth-Five Plan for the year of 2014NO: SC14E073).

REFERENCES

[1] Y. Ma, J. Feng, and Z. Mou, "The potential and exploring progress of unconventional hydrocarbon resources in SINOPEC", *Engineering Sciences*, vol. 14, no. 6, pp. 22-30, 2012.

[2] N. Ning, H. Wang, H. Yong, H. Liu, X. Hu, Q. Zhao, and D. Liu, "The unconventional natural gas resources and exploitation technologies in China", *Natural Gas Industry*, vol. 9, pp. 9-12, 2009.

[3] G. Tian, "The yield of unconventional natural gas is expected to reach up to 1.6×10~(12)m~3 in 2035", *Natural Gas Industry*, vol. 7, pp. 58, 2012.

[4] X. Zhou, and Z. Hu, "The eco-environment destruction from the development of oil & natural gas and its treatment", *Resources & Industries*, vol. 7, pp. 32-34, 2000.

[5] L. Zhou, and D. Zheng, "Development contract model of international oil exploitation and development and its latest trends", *International Petroleum Economics*, vol. 9, pp. 23-25, 2006.

[6] X. Liu, Y. Zhang, and X. Jiang, "Suggestions on speeding up the joint development of unconventional natural gas in China," *Natural Gas Industry*, vol. 10, pp. 1-5, 2011.

[7] W. Hu, "Development and utilization of nonconventional natural gas resources in China", *Journal of Daqing Petroleum Institute*, no. 5, pp. 9-16, 2010.

Received: December 15, 2014 Revised: January 04, 2015 Accepted: February 25, 2015