Selection of economic indicators for shale gas development in Sichuan Basin

Yiyu Xue, Xiaoyu Zhang

School of Economics and Management, Southwest Petroleum University, Chengdu, 610000

378006478@qq.com,919624228@qq.com

Abstract

Shale gas is an unconventional natural gas gas. It is a natural gas resource that can be mined in shale formation. Its main component is methane. It is a clean and efficient energy resource and chemical raw material. It is mainly used. It is widely used in residential gas, urban heating, power generation, automobile fuel and chemical production. The sharp increase in shale gas production in the United States has caused the international community to pay great attention to the development of shale gas. The exploration and development of shale gas has become a global hot spot. The recoverable reserves of shale gas in China are large. The exploration shows that the shale distribution basins in China include Sichuan Basin, Ordos Basin, Bohai Bay Basin, Songliao Basin, Tarim Basin, and Junggar Basin. The estimated resources are 10-30 trillion square meters.

Keywords

Shale gas, Sichuan Basin, economic indicators.

1. Introduction

The world's shale gas resources are 457 trillion square meters, which is equivalent to conventional natural gas resources. The shale gas technology recoverable resources are 187 trillion cubic meters. As early as more than 80 years ago, the United States had carried out exploration and development of shale gas, and commercial exploitation of shale gas in five basins including Michigan and Indiana. The exploitation of shale gas has also enabled the United States to achieve energy independence. Many countries are beginning to realize the importance of this unconventional gas. The development of shale gas is not only about saving energy, but also bringing huge economic benefits to the United States. As a result, many countries have begun to follow the example of the United States to explore and develop shale gas. Currently, four countries in the United States, Canada, China, and Argentina have commercialized shale gas. The top five countries in the world for shale gas technology are: China, the United States, Argentina, Mexico and South Africa. In China, the Sichuan Basin, which is the shale gas distribution basin, is the region with the most abundant shale gas resources in China, and is also the pilot test base for shale gas exploration and development in China.

2. Current status of shale gas development in China

The development of shale gas has the advantages of long mining life and long production cycle. Most of the gas-producing shale has a wide distribution range, large thickness and universal gas content, which makes the shale gas well stable gas production for a long time. Although China's shale gas reserves are abundant, the permeability of shale gas reservoirs is low, which is difficult for mining. The shale gas resources are mostly distributed in remote mountainous resources and far away from the surface; in addition, the abundance is poor, and the mining period is short; and there are many types of shale gas geological structures in China, which require different development techniques. At present, the exploration and development process of China's shale gas industry can be roughly divided into three stages. The first is the introduction stage. Before 2004, it mainly introduced and cited foreign shale gas basic theory, exploration and development experience and technology. The second is the basic research stage. From 2005 to 2008, the Chinese government, the three major oil companies and related universities began to conduct basic research on the geological characteristics of shale gas in China, providing a preliminary basis for China's shale gas resource assessment, demonstration area selection and commercial development. In the exploration and development stage of the demonstration area, since 2009, China has successively organized the national shale gas resource potential assessment, favorable zone optimization and exploration block bidding work, and made major breakthroughs in the Sichuan Basin and Ordos Basin, and initially formed the Sinopec Fuling. The four major shale gas production areas such as shale gas fields have a production capacity of more than 7 billion cubic meters per year. China's shale gas proven reserves have grown rapidly. At present, the accumulated proven geological reserves have reached 544.1 billion cubic meters, forming four major shale gas production areas in Fuling, Changning, Weiyuan and Yanchang. In 2015, China's shale gas production was 4.471 billion cubic meters, up 258.54% year-on-year; in 2016 it is expected to reach 8 billion cubic meters, an increase of about 79%. According to the “Shale Gas Development Plan (2016-2020)” issued by the National Energy Administration, China's shale gas production in 2020 will strive to reach 30 billion cubic meters, with an annual compound growth rate of over 140%; in 2030, it will reach 800-100 billion cubic meters. . With the gradual reduction of China's shale gas mining costs and the rapid release of production capacity, China's shale gas development has entered a period of rapid growth. In 2016, China's shale gas production accounted for about 6% of total natural gas production, and is expected to reach about 16% by 2020.

3. Status of shale gas development in the Sichuan Basin

The shale gas reserves in the Sichuan Basin are abundant, and shale gas is also one of the five high-end growth industries in Sichuan Province. The shale gas resources in Sichuan Province is about 27.5 trillion cubic meters, accounting for 21% of the country; the recoverable resources are about 4.42 trillion cubic meters, accounting for 18% of the country, and the resources and recoverable quantities rank first in the country. . In 2009, Sichuan Shale Gas owned China's first shale gas straight well Wei 201 well, and signed two evaluation agreements with Shell Company on Fushun-Yongchuan block; in 2010, Sichuan shale gas resource Dioha was initially completed. And assessment and shale gas horizontal well drilling, volume fracturing and other core technologies made breakthroughs; in 2011, China's first shale gas level Weijing 201-H1 well, carried out well chemical operations, has a group of shale Gas horizontal wells; in 2012, Sichuan shale gas stratum development plan could not be issued, and Changning-Weiyuan national shale gas demonstration zone was approved. In 2013, it signed a product sharing agreement with Shell Company on Fushun-Yongchuan area, and ConocoPhillips. The company signed a joint research agreement on the Neijiang-Dazu block; in 2014, the Changning-Weiyuan block realized industrial production of shale gas and formulated a development plan for the development of shale gas industry. The shale gas in Sichuan Province is mainly developed and explored by PetroChina Southwest Oil and Gas Field Company, mainly distributed in the southern part of the Sichuan Basin. The main production area is the Changning-Weiyuan block. The block is the first national shale gas demonstration area of PetroChina. In 2006, the southwest oil and gas field took the lead in conducting shale gas geological evaluation in China. In 2009, it took the lead in conducting pilot tests. In 2012, the Changning-Weiyuan national demonstration zone was started. In 2014, the scale construction was implemented. In 2016, the deepening evaluation and scale production were started. It has created a number of domestic shale gas exploration and development projects. It has built a production capacity of 2.5 billion cubic meters per year in the Changning-Weiyuan demonstration area, successfully completed various demonstration tasks in the national demonstration zone, and guided and demonstrated domestic shale gas. Exploration and development. By the end of 2017, Changning-Weiyuan Block has put into operation 163 shale gas wells, with 158 production wells, 8 million cubic meters of shale gas per day, and an annual output of 2.473 billion cubic meters, accounting for the total output of shale gas of PetroChina Southwest Oil and Gas Field Company. 98.9%. In addition, the shale gas production of PetroChina Zhejiang Oilfield in Sichuan has reached more than 500 million cubic meters. In 2017, CNPC's annual production of shale gas in Sichuan reached 3.021 billion cubic meters, which is 200 million cubic meters more than planned, and its output accounts for about one-third of the country's shale gas production. This has played a positive role in improving the energy structure of Sichuan Province, accelerating energy conservation and emission reduction and air pollution prevention, and promoted regional economic and social development.

4. Income and expenses

Revenue includes shale gas sales revenue, fixed residual value of recovery, liquidity and government subsidy income.

4.1 Sales revenue

Shale gas sales revenue calculation formula

R=Q*F*P

R represents the income of shale gas sales in the year; Q represents the output of shale gas in the year; F represents the commodity rate of shale gas; P represents the wellhead price of shale gas.

4.2 Recovered residual value of fixed assets and working capital

For the residual value of fixed assets, due to China's emphasis on environmental protection, shale gas development needs to adopt certain environmental protection measures. Considering the cost of environmental protection and learning from the economic evaluation of foreign shale gas, it can be ignored when forecasting cash inflows. Residual value recovery. Liquidity recovery is consistent with other projects and has no special features.

4.3 Government subsidy income

In 2012, the Ministry of Finance and the National Energy Administration jointly issued a notice, the central government will arrange special funds to support the development and utilization of shale gas, and subsidize shale gas mining enterprises. The subsidy standard for shale gas mining enterprises from 2012 to 2015 is RMB 0.4 yuan / m3. With the advancement of mining technology, the cost of mining is also reduced, and policy subsidies are lowered. The subsidy standard for shale gas from 2016 to 2018 is 0.3 yuan/m3, and the subsidy standard is 0.2/m3 from 2019 to 2020. In addition, the Ministry of Finance also stipulates that local finance can provide appropriate subsidies according to local conditions.

4.4 Shale gas development costs

Shale gas will have continuous cash outflow from exploration of shale gas resources to proven reserves, from proven reserves to completion of production capacity until shale gas mining, including exploration engineering investment, development engineering investment, and working capital investment. , operating costs and taxes.

4.4.1 Exploration investment

When the shale gas exploration project is evaluated as an independent project, its exploration investment must be estimated separately; when evaluating the shale gas development project, the exploration investment that has already occurred is not included in the development investment of the development project, but the oil and gas assets are formed, and the provision is made. The depletion is included in the cash flow statement as the cash outflow for the first year of the construction period.

4.4.2 Development investment

Development investment in shale gas refers to the cost incurred in developing proven reserves for shale gas and constructing facilities for mining, gathering, and storage of shale gas. It mainly includes the following parts:

Development Investment = Development Well Investment + Fracturing and Completion Investment + Ground Construction Support Investment

At present, China has initially mastered the shale gas exploration and development technology, and most of the drilling and fracturing test mining projects are completed by domestic enterprises themselves, but the core technology is not mastered, and foreign companies are required to provide services, resulting in high costs. The data shows that Sinopec's average cost of developing single wells in shale gas is about 80 million yuan, and the lowest is 50 million yuan. Therefore, although China has already mastered the technology of shale gas development, the completion effect may not be high, and there is room for further improvement. It is necessary to further improve shale gas exploration and development technology and increase scientific and technological innovation to achieve development. The improvement in cost is reduced, the output is further increased, the production is deferred, and the economic benefit is increased.

4.4.3 Liquidity investment and construction period interest

Liquidity refers to the working capital required for the development of shale gas reserves. The shale gas project development generally adopts the detailed item estimation method. In the initial stage of shale gas development, the preliminary economic evaluation stage is carried out, and the expanded index estimation method can be used for rough estimation.

Construction period interest refers to the loan interest payable by the shale gas development project during the construction period. Taking into account the time value of funds, the calculation of loan interest during the construction period of shale gas development projects should be based on compound interest.

4.4.4 Operating costs

The production and operation costs and expenses of shale gas mainly include the production cost of shale gas, sales expenses, other expenses, etc., mainly including materials, fuel, power, wages for workers, employee welfare, depreciation, operation, and repair. , processing fees, etc.; sales expenses are the various expenses that will occur during the sales process. In order to simplify the calculation, it can be calculated from 0.2% to 0.5% of the annual sales income, and other expenses include management fees.

4.4.5 Tax

There is no difference between the tax payable for shale gas development and conventional oil and gas development. There are mainly the following types: income tax VAT, urban and rural construction maintenance tax education surcharge and resource tax.

As a national key support and encourage the development of specific projects, shale gas is levied at a flat rate of 15% on income tax.

The calculation of value-added tax does not affect the economic effects of shale gas development, but the value-added tax should be used as the basis for the calculation of other taxes and fees. The shale gas value-added tax is also applicable to the 13% tax rate for the development of oil and natural gas.

Urban and rural construction maintenance tax and education surcharge are based on VAT, urban construction tax is 7% of value-added tax, and education surtax rate is 3%. According to the "Detailed Regulations on the Provisional Regulations on the Sub-resource Tax of the People's Republic of China" promulgated on October 31, 2011, oil and natural gas are levied at an ad valorem rate nationwide at a rate of 5%.

5. Economic indicator selection

The static evaluation method and the dynamic evaluation method are economic evaluation methods according to whether or not the time value of funds is considered. The static evaluation method means that the time value of funds is not considered in the whole project development cycle. The commonly used indicators are: static investment recovery period, investment profit rate, investment profit and tax rate. The dynamic evaluation method is also called the discount method. That is, according to a certain discount rate, the income and expenses obtained in each year after the project development are converted to the present value of the evaluation starting point to evaluate the economic value and economic benefit of the project development. The basic indicators of the dynamic evaluation method include net present value, internal rate of return, and dynamic investment payback period.

5.1 Static evaluation

5.1.1 Investment profit rate

It is used to investigate the static indicators of the investment profitability of shale gas project units. Its expression is:

Investment profit rate = total annual profit / total project investment x 100%

Total annual profit = annual sales income - annual sales tax and additional - annual value added tax total annual cost

Among them: annual sales tax and surcharge = annual city maintenance and construction tax + annual education fee plus + annual resource tax

Total investment of the project = construction investment + construction period interest + working capital

Calculate the investment profit rate of the project based on the relevant data of the financial information, and compare it with the average profit rate of the shale gas industry to determine the profitability of the project unit investment.

5.1.2 Static investment payback period

Refers to the time required for net income to cover all investments. It is an evaluation indicator that reflects the project's investment recovery capacity. Generally counted from the beginning of the construction period. Its expression is:

$$\sum_{t=1}^{Pt}(CI - CO)_t = 0$$

Where: Pt is the static investment payback period; CI is the total cash inflow of shale gas exploration and development; CO is the total cash outflow of shale gas exploration and development; (CI-CO)t is the net cash flow of the first year; i is the page Rock gas industry benchmark yield.

5.2 Static investment payback period

5.2.1 Internal Rate of Return

Refers to the discount rate (NPV =0) when the present value of the net cash flow of the project is cumulatively foggy throughout the calculation period. It reflects the profitability of the funds occupied by the project and is the main dynamic indicator for examining the profitability of the project. Its expression is

$$\sum_{t=1}^{n}(CI - CO)_t(1+IRR)^{-t} = 0$$

Where: IRR is the internal rate of return; C1 is the total cash inflow for shale gas exploration and development; CO is the total cash outflow for shale gas exploration and development; (CI-C0), the net cash flow for the first year; n is the calculation period .

The internal rate of return is an indicator of the efficiency of capital utilization. The calculation of the internal rate of return implies a basic assumption that the net income obtained during the life of the project can all be used for reinvestment, and the rate of return of the reinvestment is equal to the internal income of the project. rate. Because the geological conditions are very complicated and there are many factors influencing, the return rate when the investment is used for reinvestment cannot be exactly equal to the internal rate of return of the project. Therefore, the internal rate of return should be used as an auxiliary indicator for the evaluation of shale gas projects.

5.2.2 Dynamic investment payback period

The shale gas project has a long development time, so it is easy to adopt a dynamic investment payback period. Its expression is

$$\sum_{t=1}^{pt}(CI-CO)_t(1+i)^{-t}=0$$

Where: Pt is the dynamic investment payback period; i is the shale gas industry benchmark yield.

CI is the total cash inflow from shale gas exploration and development; CO is the total cash outflow from shale gas exploration and development; (CI - CO) t is the net cash flow in year t.

The investment recovery period can reflect the risk degree and economy of the project to a certain extent, but only pay attention to the speed of the project's recovery investment, which cannot directly reflect the profitability of the project and the profitability of the project throughout its life. The investment cycle of shale gas development is long, the exploration process is extremely complicated, and it is staged and repetitive. The investment may also have discontinuity. There is not much decision-making value in calculating the investment recovery period in the exploration stage. Therefore, this indicator can only be used as an auxiliary indicator.

5.2.3 Net present value

According to the benchmark rate of return of the shale gas industry or the set discount rate, the net cash flow of each year in the project calculation period is discounted to the sum of the present values at the beginning of the construction period. It is the main dynamic indicator to examine the profitability of the project during the calculation period. The expression is

$$NPV=\sum_{t=1}^{n}(CI-CO)_t(1+i)^{-t}$$

Where: NPV is the net present value; CI is the total cash inflow of shale gas exploration and development; CO is the total cash outflow of shale gas exploration and development; (CI-C0), which is the net present value of the t-year; i is the discount rate ;n is the number of years of the entire project. The net present value method has a discount factor, and the earlier the shale gas is produced, the larger the NPV.Compared with other economic indicators, the net present value method is more reliable in terms of rationality and operability. It is still the most commonly used method for shale gas economic evaluation. The internal rate of return and the payback period can be used as auxiliary indicators.

Table 1 Shale gas production layer table in shale gas production area of Sichuan Basin

area	thickness /m	TOC	R_o	Porosity	Gas content /m³
ChangNing	30~60	1.9%~5.3%	2.5%~3.0%	2.9%~6.5%	2.4~5.5
WeiYuan	20~40	1.1%~6.3%	2.1%~2.8%	2.8%~5.5%	1.9~4.8

The shale gas depth in the Sichuan Basin is about 1500~4500m, the shale thickness is 60m, the porosity is 3.5%, and the organic carbon content is 3.65%. It is expected to form an annual output of shale gas 300~600*10^8m3. This paper selects economic evaluation parameters: capital expenditure is 17 million yuan per gas well, operating cost is calculated based on sales income 0.5%, income tax rate is 15%, resource tax rate is 5%, discount rate is 5%, fixed assets depreciation rate is 10%, natural gas The price is 3 yuan / cubic meter.

In the economic evaluation of the project, the economic parameters should be fully considered, and the annual cash flow NCF can be expressed by the following formula.

NCF=Natural gas price* gas production-capital expenditure-operating cost-resource tax rate* natural gas price* gas production-income tax rate* income

The cumulative net cash flow of the project is:

$$NPV=\sum\frac{NCFt}{(1+k)^t}$$

Using the above economic parameters, the net cash flow and accumulated net cash flow during the project operation period can be known.

Table 2 Cash flow statment of project

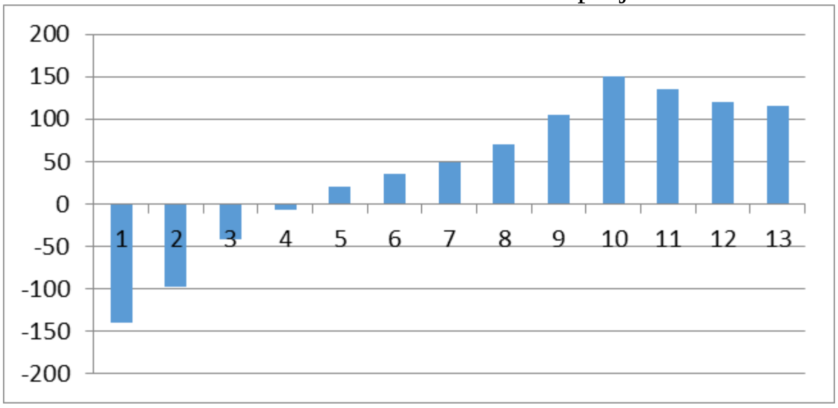
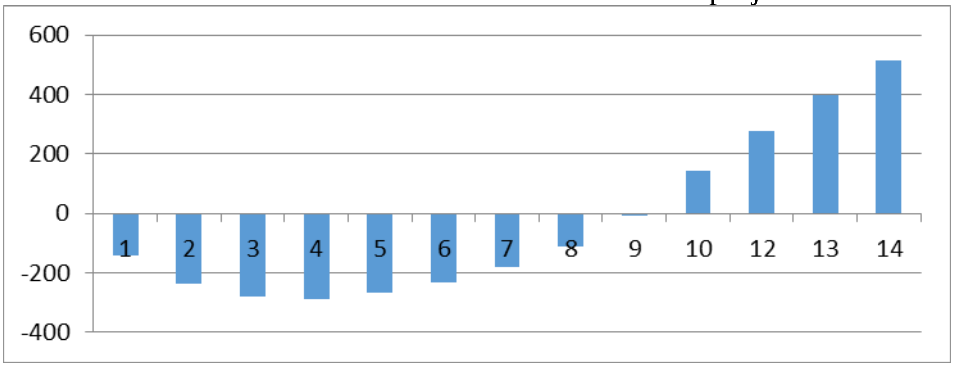


Table 3 Accumulate cash flow statment of project



From Figure 1, it is concluded that the cash flow begins to be positive in the fifth year of operation, and the cash flow reaches the maximum in 10 years. In Figure 2, the project reached its maximum negative value in the fourth year after the start of operation. At this time, the accumulated investment amount reached the maximum. With the recovery of funds, in the 10th year, the cash flow became positive, and profit began to be realized.

6. Conclusion

The economic evaluation of shale gas investment projects is a dynamic process, and the targets of different stages of evaluation are also different. Based on the economic evaluation parameters of shale gas investment projects, this paper selects and studies the main economic indicators, and studies the adaptability of NCF, NPV, investment recovery period and other indicators in shale gas investment projects, and is a shale gas project. The selection of economic evaluation indicators provides ideas, uses the net present value to establish an economic evaluation model, and provides a quantitative model for the economic benefit evaluation of shale gas investment projects, providing a basis for investment decisions of shale gas projects.

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