Impact of Oilfield Operating Cost Splitting Ratio on the Evaluation of Listed Developed Reserves

Jixiang Yang *

Exploration and Development Research Institute of Daqing Oilfield Co Ltd., Daqing, China

*Corresponding author e-mail: yangjixiang@petrochina.com.cn

Abstract. Proven reserves of oil and gas reflect the value of the oilfield and its future development. At present, the developed reserves of Daqing oilfield play an absolutely dominant role in the proved reserves. Under the condition of certain parameters, the economic limit yield plays a decisive role in the developed reserves, and the split ratio of operation cost is one of the key factors affecting the economic limit yield. The impact of operation cost splitting ratio on the evaluation of listed developed reserves is studied to provide support for the objective and reasonable evaluation of developed reserves in the future. Based on the formula of economic limit production, the relationship between economic limit production and operating cost splitting ratio of a single well is derived, and the effect of operating cost splitting ratio on the verified developed reserves under different oil prices is obtained. The results show that the change of operation cost splitting ratio under low oil price has great influence on the proved developed reserves.

Keywords: proved developed reserves; economic limit; operation cost split ratio; impact.

1. Preface

Oil and gas reserves are an important indicator of the material basis, core assets, and market value and development potential of oil companies’ development, production and operation decisions. In 2000, PetroChina went public in the United States, and annually evaluated the proven reserves of oil and gas. As the proven reserves directly reflect the company’s value and future development, the proven reserves assessment has always been valued by leaders at all levels. In the current proven reserves structure of Daqing Oilfield, the proven reserves account for 85%, and they occupy the absolute dominant position among the proven reserves. Under certain conditions of other parameters, the economic limit output plays a decisive role in verifying the developed reserves, and the operating cost split ratio is also a key factor affecting the economic limit output. Therefore, the study of the operating cost split ratio for the evaluation of listed developed reserves The impact has a very important role in objectively and reasonably evaluating and verifying the developed reserves in the future.
2. Evaluation method to verify the developed reserves

Confirmed developed (PD) is the proven reserves that can be recovered under the following conditions [1-4]:

(1) The amount that can be recovered through existing wells and facilities using current operating methods, or the cost of equipment required is less than the cost of drilling a new well;

(2) In the case where development well mining is not adopted, the operational installed production equipment and infrastructure at the time of reserves assessment should be used. This situation is for unconventional oil and gas production activities such as oil sands, oil shale, and synthetic oil and gas.

It is confirmed that the developed reserves (PD) include the developed positive production reserves (PDP) and the developed unproduced reserves (PDNP).

PDP reserves refer to reserves under development. According to the development stage, it can be divided into:

(1) In the early stage of development, when the output is in the rising or stable period;

(2) In the middle and later stages of development, after major adjustment measures, output is in the rising stage;

(3) In the middle and later stages of development, after major adjustment measures, output is in a declining period.

PDNP reserves include shut-in and off-pipe reserves. The PDNP reserves mainly include: reserves that have been ejected but have not been produced, market or pipeline reasons have not been produced, and mechanical reasons have not yet produced reserves; the reserves of the upper succession layer or other unfired layers; the reserves that have been implemented but have not been effective. Provide future production plans and investment arrangements for PDNP reserves by type and unit to show that production is reasonably certain.

The confirmed developed reserves (PD) discussed here refer to the developed positive production reserves (PDP), and the evaluation method is mainly the dynamic method. The assessment confirmed that the commonly used methods of developed reserves (PD) are: decreasing curve method, water content and cumulative production relationship curve, oil content and cumulative production relationship curve, water-oil ratio and cumulative production relationship curve, and material balance method. Since most of Daqing Oilfield confirms that the developed reserves are in the production decline period in the middle and later stages of development, the evaluation method discussed in this paper is based on the decline curve method. According to the different values of the decreasing index \( n \), it is divided into decreasing exponential \((n = 0)\), decreasing hyperbolic \((0 < n < 1)\) and decreasing harmonic \((n = 1)\). The specific expressions are as follows:

According to the decline theory of J.J.Arps, the definition of decline rate [5-6]:

\[
d = - \frac{dq}{dqt} = kq^n
\]

(1)

The relationship between output and time of decreasing curve method:

\[
q = q_i e^{-Dt_i(n=0)} \quad (n=0)
\]

(2)

\[
q = q_i (1 + nD_t t)^{-\frac{1}{n}} \quad (0<n<1)
\]

(3)

\[
q = \frac{q_i}{(1 + nD_t t)^{(n=1)}}
\]

(4)

The calculation formula of cumulative output in the stage of decreasing curve method:

\[
N_p = \frac{q_i - q_a}{D_i} \quad (n=0)
\]

(5)

\[
N_p = \frac{q_i^n}{(1-n)D_i} [q_i^{(1-n)} - q_a^{(1-n)}] \quad (0<n<1)
\]

(6)

\[
N_p = \frac{q_i}{D_i} \ln \frac{q_i}{q_a} \quad (n=1)
\]

(7)

In the formula:

- \( q \) — Oil production at time \( t \)
- \( n \) — Decreasing index
- \( D_i \) — Initial decline rate
qi—The initial production at the beginning of the forecast
qa—economic limit output
Np—stage cumulative output

The evaluation confirms that the developed reserves need to determine the type of decline, decline index, initial decline rate and initial production. Then calculate the economic limit output based on oil and gas prices, operating costs, and various taxes.

If the decline type, decline index, initial decline rate and initial production are fixed, then the economic limit production determines the size of the proven reserves. Considering that listing confirms that most of the developed reserves are evaluated using index declines, this article focuses on the study of the index declines.

3. Calculation method of economic limit output

The economic limit output refers to the minimum output for recovering operating costs and taxes. The calculation of the economic limit output is an important part of the assessment and verification of the developed reserves. The formula for calculating the economic limit is as follows:

$$q_{a} = \frac{C_{T} + (12 \times \text{Wells}) \times \text{Solution Gas}}{(P_{o} \times \text{po} - \text{TAX}_{o}) - CV}$$  (8)

Solution Gas = $$\frac{q_{g} (\text{year})}{q_{o} (\text{year})} (1 - G_{s})$$  (9)

$$\text{TAX}_{o} = \text{Special oil revenue per ton} + P_{o} \times T_{r} + P_{o} \times \text{VAT}_{o} \times (T_{e} + T_{t})$$  (10)

$$\text{TAX}_{g} = P_{g} \times T_{r} + P_{g} \times \text{VAT}_{g} \times (T_{e} + T_{t})$$  (11)

The special income tax threshold is 65 USD / barrel.

Special oil revenue per ton = [(excluding tax oil price (USD / barrel) − starting point) × collection rate − quick calculation deduction] × ton − barrel ratio × exchange rate  (12)

| Crude oil price (USD / barrel) | Collection rate (%) | Quick calculation deduction (USD/barrel) |
|-------------------------------|---------------------|-----------------------------------------|
| 65~70                         | 20                  | 0                                       |
| 70~75                         | 25                  | 0.25                                    |
| 75~80                         | 30                  | 0.75                                    |
| 80~85                         | 35                  | 1.5                                     |
| >85                           | 40                  | 2.5                                     |

In the formula:
qa (single well) — the economic limit production of a single well, unit: ton / month / well
CT—Fixed cost, unit: Yuan / year
CV—variable cost per unit, unit: yuan / ton
Wells—number of wells opened, unit: mouth
Po—oil price without tax, unit: Yuan / ton
Pg—excluding tax gas price, unit: yuan / square
TAX—ton oil tax, unit: yuan / ton
TAXg—Fangqi taxes and fees, unit: yuan / square
Solution Gas—Dissolved gas item, unit: Yuan / ton
qq (year) —annual gas production, unit: Wanfäng
qo (year) —annual oil production, unit: ten thousand tons
Gs—natural gas shrinkage, unit: decimal
Tr—Resource tax rate, unit:%
VATo—VAT rate of oil, unit:%
VATg—Gas VAT rate, unit:%
Te—Additional education fees, unit:%
Ti—urban construction tax, unit:%
Ts-Ton oil special income

According to the practice of the listed reserve evaluation work, the operating cost split method is: fixed cost accounts for 70% of the total cost, and variable cost is divided by 30% of the total cost by the estimated annual oil production.

From the economic limit production formula, it can be concluded that the economic limit is mainly affected by oil and gas prices and operating costs [8-10].

4. The relationship between economic limit and operating cost split ratio

Literature [7] conducted a qualitative study on the operating cost split ratio and evaluation results, without quantitatively studying the impact of oil prices and operating costs on reserves assessment. In this paper, by simplifying the calculation formula of single-well economic limit production, the relationship between the single-well economic limit production, oil price, operating cost, and operating cost split ratio is obtained to quantitatively study the impact of oil price and operating cost on reserves assessment. The simplified steps are as follows:

After replacing the operating cost in the calculation formula for the economic limit production of a single well with the total operating cost, the fixed cost ratio is x (0 < x < 1) and the annual oil production, we get:

\[q_a \text{(well)} = \frac{C \times (12 \times \text{Wells})}{\text{Solution Gas} \times (P_o - \text{TAX}_o) - \frac{C}{q_o \text{(year)}}(1-x)}\]  

(13)

The formula can be obtained: When " \( \text{Solution Gas} \times (P_o - \text{TAX}_o) + \frac{C}{q_o \text{(year)}} \) " , that is, the income generated by the current output just offsets the operating costs and taxes, and the current output is the economic limit output. Therefore, when calculating the economic limit output, it should be guaranteed that " \( \text{Solution Gas} \times (P_o - \text{TAX}_o) > \frac{C}{q_o \text{(year)}} \) " , that is: the income generated by the current output still has surplus after offsetting the operating costs and taxes, otherwise It is directly judged that the block is not economical.

Now suppose that the remainder is a constant b, " \( b = \text{Solution Gas} \times (P_o - \text{TAX}_o) - \frac{C}{q_o \text{(year)}} \) " (b> 0), and the parameter b is introduced into the calculation formula of the economic limit production of single well:

\[q_a \text{(well)} = \frac{C \times (12 \times \text{Wells})}{b \times \frac{C}{q_o \text{(year)}}} = \frac{(q_o \text{(year)} - \frac{b q_o \text{(year)}}{c})}{b \times \frac{C}{q_o \text{(year)}}} \div (12 \times \text{Wells})\]  

(14)

Since b is greater than 0, the economic limit production of a single well increases as the fixed cost ratio increases. When the evaluation unit is effective, reducing the proportion of fixed costs to the total operating cost can achieve the purpose of reducing the economic limit of production and increasing the proven reserves.

In the formula:

C—Total operating cost, unit: ten thousand yuan

x—Proportion of fixed costs, %
5. Case analysis
Taking an oil field in Daqing as an example, the impact of different oil prices and different fixed cost ratios on the economic limit of a single well was calculated. The basic parameters are as follows:

**Table 2. Basic parameters of an oil field**

| Price without tax | 1.46 | Yuan / square |
| Total operating cost | 169657000 | yuan |
| exchange rate | 6.7686 | Yuan / USD |
| Ton to barrel ratio | 7.293 | Barrel / ton |
| Air shrinkage | 55.5% |
| Oil VAT rate | 17% |
| Gas VAT rate | 11% |
| Resource tax rate | 5.22% |
| Building tax | 7% |
| Educational surcharge | 3% |
| Annual oil production | 188494.5 | Ton |
| Annual gas production | 8237220 | square |
| Number of wells opened | 4.95 | Well |

Six different oil prices were selected from the oil price from 938.40 yuan / ton to 5000 yuan / ton. When the initial average single-well production is 31.73 tons / month / well and the initial decline rate is 10%, the proven developed reserves in each case are calculated, see the following table:

From the results:
1. When \( b = 0 \), the economic limit of a single well will not change with the change of fixed cost ratio, and the evaluation unit is not economical at this time;
2. When \( b > 0 \), under the same oil price, the lower the fixed cost ratio, the lower the economic limit of a single well, confirming that the developed reserves increase as the fixed cost ratio decreases;
3. When \( b > 0 \), the lower the oil price, the greater the change in the economic limit of a single well due to the change in fixed cost ratio, which proves that the developed reserves are greatly affected.

6. Conclusion and understanding
(1) In the assessment of verified reserves, the rationality of economic limit production calculation is related to whether the assessment is objective and reasonable, whether the reserves that should be evaluated are not missed, and the reserves that should not be evaluated are not commented on.
(2) When the income generated by the current production is just enough or not enough to offset the operating costs and taxes, the evaluation unit is not economical, confirming that the developed reserves are zero;
(3) If the revenue generated by the current production offsets operating costs and taxes, the lower the fixed cost ratio, the lower the economic limit of a single well, and the higher the verified proven reserves; when the oil price is lower The fixed cost ratio has a great influence on the proven reserves.

References
[1] Wang Yongxiang, Duan Xiaowen, Xu Xiaolin, Wang Jingrong, Yuan Zixue. Determination criterion and the estimation methods for the proved reserves under the US.SEC regulation[J]. ACTA PETROLEI SINICA.2016.37(9):1137-1144.
[2] BI Haibin, LI Jianzhong, ZHANG Junfeng, ZHOU Mingqing. Applications of reliable techniques to reserves estimation proved by the SEC standard. [J] ACTA PETROLEI SINICA.2013,34(6): 1212-1217.
[3] SUN Qiufen, XIE Jinlong, MENG Haiyan, CAO Chongjun, WANG Baili. Current SEC reserve evaluation methods in China [J]. INTERNATIONAL PETROLEUM ECONOMICS. 2015 (1):72-75.
[4] Jiang Xin, Sun Qiufen, Zhao Qiyang. Main impact of the new SEC reserve rules on estimation and disclosure of oil and gas reserves by oil companies listed on the New York Stock Exchange. International Petroleum Economics, 2010(10), 20-23.

[5] ARPS J J. Analysis of Decline Curves. Society of Petroleum Engineers. 1945, 160(1): 228-247.

[6] JIA Chengzao. SEC estimation approach for oil & gas reservoirs. Beijing: Petroleum Industry Press, 2004: 102-104

[7] Li Xianlu, Long Weijiang, Yu iaohong, Yang Fei, Yu Qiang, Liu Junhong. Economic factors of SEC reserve evaluation in Henan Oil Field. PETROLEUM GEOLOGY & EXPERIMENT. 2012, 34(5), S18-526

[8] Zhang Fuxing. Analysis on influencing factors of SEC reserves evaluation. PGRE, 2013, 20(3): 95-97

[9] Meng Haiyan, Sun Qiufen, Cao Chongjun. Impact of the New SEC Reserve Rules on Estimation and Disclosure of Oil and Gas Reserves. Petroleum Planning & Engineering, 2012, 23(2): 19-22.

[10] Wang Xiaoyu, Luo Dongkun, Guo Ru. Influence of Relationship between Operational Cost and Oil Price on Evaluation of Oil and Gas Development Project. Technology Economics. 2016, 35(2): 88-93.