Estimation of net oil and gas reserves and sensitivity analysis of influencing factors for net present value under royalty & tax contracts – a case study on X project, Kazakhstan

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Abstract. The Royalty & Tax Contract is one of the most common cooperation modes in the international petroleum industry. Under this mode, contractors take the share of net oil and gas reserves in kind, and pay royalties, income taxes and other taxes/fees to the landowner. The net reserves owned by a contractor refer to the remaining economical recoverable reserves that the contractor can obtain during the remaining contract period, and represent the contractor’s actual revenue. Taking the XX project in Kazakhstan as an example, this paper presented the method for estimating net oil and gas reserves under the Royalty & Tax Contract, discussed how the production, decline rate, development plan, oil prices, costs and taxes affect net reserves from the technical, economic, commercial and engineering perspective, and made sensitivity analysis of the most critical influence factors like oil production, oil prices, operation expenditure and investment. Finally, some development optimization and evaluation strategies were proposed to maximize the contractors’ economic benefits.

1. Introduction
The petroleum resources are decreasing in a global context, while the demand for oil and gas is increasing. Under this context, the producing countries and the consuming countries contact more and more frequently in the petroleum-based economy. Nowadays, such kind of communication and cooperation plays an important role in the international petroleum activities. As a traditional and common mode of international petroleum cooperation, the Royalty & Tax Contract is widely used in Australia, Canada, Norway, Saudi Arabia, the United States, Kazakhstan, Peru, Ecuador, Tunisia, Chad, and other countries/regions [1-2]. Taking the X project in Kazakhstan as an example, and based on the practices of SEC reserves assessment in recent years, the content and features of the Royalty & Tax Contract are presented. Then, the net reserves estimation method and influencing factors are discussed, and the sensitivity analysis is performed on the most significant factors. Finally, some development optimization and evaluation strategies are proposed. The results are expected to be guiding significance for professionals engaged in international petroleum cooperation and related economic evaluation.

2. Content and features of the royalty & tax contract
The Royalty & Tax Contract, also known as the License Agreement, evolved from the traditional concession contract. As a typical feature of this contract mode, the contractor, with the license awarded by the host country, is allowed to explore, develop and produce oil and gas resources in the...
designated block(s) during the contract period, alone or in conjunction with the government or national oil company (NOC) of the host country. The contractor shall assume the risks and operation costs thereof, meanwhile the equipment and devices purchased by the contractor and the surface facilities built by the contractor shall be owned by the oil company \[3-4\]. The contractor takes the share of crude oil and natural gas in kind and pays the royalty (in kind or cash) and taxes to the host country, with the recovery of investment and operation expenditure. Essentially, for the Royalty & Tax Contract, the oil company controls the operations, while the government controls the oil company through legislation and taxation.

The Royalty & Tax Contract also has other features as follows:

1. There are three operation models under this contract mode. First, the contractor carries out the operation solely. Second, the contractor and the host country carries out the operation in form of joint venture, where the host country can participate in the entire exploration, development and production process of the project, or hold some dry shares in the exploration phase and participate selectively in certain phases after the project is proved economic for development. Third, the contractor and the host country manages and operates the project jointly, by a newly established project company according to a certain proportion of contributions to assume all risks and liabilities occurred during the project development and production. And the two sides share the profit accrued from the project according to the contract terms and their respective contributions \[5-6\].

2. The Royalty & Tax Contract has no limit on the percentage of cost recovery. The contractor and the host country splits the profit mainly in three manners. First, the contractor pays the royalty to the host country. The total income of oil and gas production should first exclude the royalty, which varies greatly from country to country and from contract to contract. Second, the oil company’s expenses are deducted, including production costs, depreciation, depletion and amortization (DDA), and intangible capital costs (or deposits, in some countries). Third, the oil and gas income is taxable after deducting royalty and costs. The type and rate of taxes are different across countries \[7-10\].

3. The total cost of oil and gas production and the contractor’s after-tax profit share are closely related to changes in project output and oil prices. The Royalty & Tax Contract mode reflects a coexistence of risks and benefits. In other words, the contractor must assume the risks of project loss due to low output and low oil prices; meanwhile, it can enjoy the excess profits brought by excellent oil and gas resources.

3. Net reserves estimation method and cash flow model under the royalty & tax contract

3.1. Net reserves estimation method

Net reserves refer to the share of gross reserves taken by the contractor base on its net economic interests specified in the contract, and it is related to various economic parameters such as the working interest, royalty, cost recovery and profit. The annual production on the production profile corresponding to the gross reserves and the net reserves is respectively called the gross production (usually “wellhead production”) and the net production.

The net reserves estimation method under the Royalty & Tax Contract is relatively simple, with the formula as follows:

\[
R_{\text{net}} = \sum_{i=1}^{n} Q_{\text{net}i} = \sum_{i=1}^{n} (Q_{\text{grossi}} \times WI)
\]

where,

- $R_{\text{net}}$ - the contractor’s net reserves,
- $Q_{\text{net}i}$ - the net production in year $i$, starting from the evaluation year,
- $n$ - the effective period for economic evaluation, no longer than the contract period,
- $Q_{\text{grossi}}$ - the gross or active production in year $i$, starting from the evaluation year,
- $WI$ - the working interest.
It can be seen from the formula that as long as the contractor can guarantee the smooth operation of the project, its share of reserves and economic benefits will be higher in case of higher production and higher oil price.

The royalty can be paid in kind or in cash. If paid in kind, the oil and gas volume corresponding to the royalty shall be deducted from the share of reserves. If paid in cash, the contractor can book this oil and gas volume, which however will not affect the contractor's cash flow.

3.2. Cash flow model
Figure 1 illustrates the cash flow model for the Royalty & Tax Contract. The total sales income of crude oil is the income excluding the pipeline tariff and the premium. The royalty and taxes are variable for different projects in different countries/regions. The rates of some taxes change depend on oil prices and production. The after-tax income is the total sales income of crude oil excluding the royalty, total production cost, income taxes and other payable taxes/fees [11]. The government's take is the sum of royalty, taxes and after-tax income. The contractor's take is the total after-tax income of the project multiplied by the share proportion of the contractor.

![Cash flow model for the royalty & tax system](image)

**Figure 1.** Cash flow model for the royalty & tax system.

4. Influence factors for evaluation of net reserves and net present value
Evaluation of net reserves is a comprehensive work. Net reserves are related to technical factors such as field plan, development and production, and also to other factors like contract terms, transportation and marketing [12-13]. Generally, the influence factors can be classified into four categories.
4.1. Technical factors

(1) Five-year plan

The five-year plan refers to the formal five-year plan for drilling, well commissioning and production resumption approved by the government and the supporting investment data, as well as the corresponding well location maps, structure maps and isopatch maps. The fidelity and credibility of data have directly impacts on the estimation of proved undeveloped (PUD) reserves and proved developed non-producing (PDNP) reserves.

(2) Initial production

The initial production is the start point for predicting the future production profile. The data of historical production in the last few months of the evaluation year have a large influence on the start point, and further the production profile in the next few years or even the entire contract period. Therefore, purposed production increase/stabilization when approaching the data cut-off point and enhancement of development and production will have positive impacts on the estimation of proved developed (PD) reserves [14].

(3) Decline rate

The decline rate is an important parameter in the performance-based reserves estimation, and it is mainly applied to the developed projects. The division of evaluation units and the determination of the decline type and curve shape directly affect the prediction of PD reserves. It is important to timely adjust the decline rate according to the actual development situation and production performance, particularly for the projects in production-rising stage or without consistent decline trend.

(4) Recovery factor

In areas that are put into production recently or soon, where the performance-based reserves estimation method cannot be used due to limited production data, the volumetric method is generally used to calculate the oil initially in place (OIIP), and the recovery factor (RF) is determined by analogy to the similar neighboring blocks or by pilot test in the area. Then, the estimated ultimate recovery (EUR) is calculated by OIIP and RF. Finally, the P1 reserves are determined. Rigorous supportive data are required to determine the RF of P1. If secondary recovery has not been implemented, the primary recovery is normally assumed [15-16].

4.2. Economic factors

(1) Operation expenditure and economic limit

Oilfield operation expenditure includes the costs of material supply, repair and maintenance of well equipment, staff compensation, maintenance of surface facilities, general administrative expenses, etc. Economic limit refers to the lowest production which able to cover the operation expenditure. After determination of the gross reserves by static, dynamic or other approaches, the economic limit needs to be measured. To be recognized as reserves, the net income obtained by the economic model should be equal to the operation expenditure. After running the economic model, the time point at which the cash flow equals to zero is referred to as the economic limit. All cash flows before the economic limit are positive, namely, the corresponding reserves are economically profitable; the cash flows after the economic limit are negative, namely, the corresponding reserves are not economically profitable, and the corresponding technically recoverable reserves should not be included in the net reserves. Therefore, optimization of operation expenditure via rational allocation and splitting can prolong the time of economic limit point, which has a positive influence on the net reserves estimation.

(2) Taxes and fees

Under the Royalty & Tax Contract, taxes and fees are also one of the important factors affecting the net reserves and profits of oil companies in addition to technical factors. The tax and royalty mainly includes mineral resource exploitation tax, export income tax, corporate income tax, excess profit tax, crude oil export tariff, dividend tax and other taxes [17]. Some taxes and fees are linked to actual production, and the incremental tax rate is applied. Some taxes and fees are subject to an incremental tax rate based on oil prices. Some taxes and fees have fixed tax rates. Different countries/regions use different types of taxes and tax rates. It is also possible to maximize the benefits
of oilfield development contractors by studying how to control taxes and fees by analysis of the impact of various taxes and fees on the economic benefits of oilfield development.

(3) Oil prices

Under the Royalty & Tax Contract, the oil price change is positively correlated with the net reserves, which directly affects the economics of the project and the final value of the reserves. Low oil prices affect the economics of reserves, shorten the economic life of reserves and decrease the value of both net reserves and gross reserves. When the oil prices rise, the economic limit point may be postponed, and the value of net reserves and gross reserves will increase accordingly.

4.3. Commercial factors

(1) Contract constraint

a. Constraint of contract period. Reserves are the sum of future predicted production values for a project within a certain contract period and economic limit. If a contract approaches expiration and no extension is considered, the quantity after the contract expires cannot be recognized as reserves, even though the production performance is very good and the resource volume is huge.

b. Constraint of the terms of the contract. For example, as stipulated by the Kazakhstan government, any oil/gas discovery through exploration shall not be put into development unless a three-year production test is conducted to further confirm the reserves, and the capacity building can only be carried out after the development plan is approved by the Kazakhstan government [18]. In the production test stage, even if the remaining recoverable reserves are large, only the P1 reserves for 3 years of development can be calculated.

(2) Contract modification

Material changes of contract terms will significantly affect the economics of reserves. The plummet of oil prices from 2014 to 2015 directly caused some projects uneconomic and downgraded their reserves to contingent resources. If some contract terms can be changed through negotiating with the host government to respond to the low oil prices, some contingent resources may be upgraded to reserves, and some projects may become economic again.

(3) Sales contract

For the assessment of gas reserves, SEC requires that there must be a sales contract. Otherwise, the reserves cannot be recognized as P1 in reserves assessment even the amount is large. If the sales contract is signed for just one year, only the production in that year will be recognized as reserves, and none of the production in other years will be included in the reserves.

4.4. Engineering Factors

Engineering factors such as the integrity and in-service time of the surface facilities, pipelines and capacity of the processing plants can also impact the oil and gas transportation and the production capacity building, which further influence the realization of the production capacity designed in the development plan and ultimately affect the reserves estimation.

5. Sensitivity analysis of key influence factors

Taking the X project in southwest Kazakhstan as example, the sensitivity analysis is made on key factors influencing net reserves and net present value (NPV). The X project is located in North Ustyurt Basin, present daily oil and gas production respectively are 7000b/d and 1 MMSCF/d, and peak oil production will be 10160b/d in 2021. The remaining contract period is 18 years. The 2019 Brent oil price assumption is 64 US$/bbl and is adopted inflated at 2% per annum thereafter, the gas price is assumed to be 0.92 US$/MCF in 2019 (Table 1). Future net income is calculated by deducting operation expenditure, investment, abandonment costs and taxes/fees from future total income. NPV is obtained by discounting the future net income at a discount rate of 10%, and the remaining revenue distribution can be seen from Table 2 and Figure 2.

Since the X project is a purchased project in the middle and late development stages, all taxes/fees are relatively fixed and have little impact on the NPV. According to the analysis of the indicators
affecting the economic benefits of the project, six variable parameters are selected for scenario analysis with single factor (oil production, gas production, oil price, gas price, Opex (excl. tariffs) and Capex) change of 10% and 20% under the assumption that other factors are unchanged.

**Table 1. X project summary.**

| Project Size | Daily oil and gas production in 2019 respectively are 7000b/d and 1 MMSCF/d. |
|--------------|--------------------------------------------------------------------------------------------------|
| Oil Production During RT Term (since 2020.1.1) | 35.51 MMB |
| Gas Production during RT Term (since 2020.1.1) | 7.96 BCF |
| Oil Price | 65 US$/bbl from 2020 onward, inflated at 2% per annum thereafter. |
| Gas Price | 0.92 US$/MCF from 2020 onward. |
| Capex in 2019 | 22 US$ million |
| Opex in 2019 | 31 US$ million |

**Table 2. Net reserves calculation of X project.**

| Year | Gross Oil Reserves | Gross Gas Reserves | Net Oil Reserves | Net Gas Reserves | Future Gross Revenue | Operation Costs | Capital Costs | NET | Export | Export Duty | Income Tax | Excess Profits Tax | Other Taxes | Company Cash Flow | Total Field Cash Flow |
|------|--------------------|--------------------|-----------------|-----------------|-------------------|-------------------|---------------|-----|-------|-------------|-----------|-------------------|-------------|-------------------|---------------------|
| 1    | 3139.0             | 657.0              | 3130.0          | 657.0           | 102.9             | 40.8              | 19.6          | 6.7 | 0.0   | 10.1        | 3.6       | 0.0               | 2.2         | 19.9             | 19.9               |
| 2    | 3723.0             | 803.0              | 3720.0          | 803.0           | 139.9             | 48.2              | 20.0          | 9.7 | 7.0   | 13.6        | 4.7       | 0.0               | 2.2         | 32.8             | 22.8               |
| 3    | 3723.0             | 803.0              | 3720.0          | 803.0           | 139.2             | 48.8              | 17.3          | 10.4 | 9.4   | 15.3        | 8.0       | 0.0               | 2.1         | 29.5             | 29.5               |
| 4    | 3540.5             | 766.5              | 3540.5          | 766.5           | 142.9             | 47.4              | 17.0          | 9.4  | 13.6  | 14.5        | 6.8       | 0.7               | 2.0         | 31.5             | 31.5               |
| 5    | 3558.0             | 730.0              | 3558.0          | 730.0           | 148.8             | 48.0              | 18.7          | 9.6  | 14.0  | 15.3        | 7.7       | 1.4               | 2.0         | 34.1             | 34.1               |
| 6    | 3029.5             | 657.0              | 3029.5          | 657.0           | 134.8             | 42.5              | 13.9          | 8.9  | 12.0  | 13.8        | 7.0       | 1.7               | 1.9         | 32.5             | 32.5               |
| 7    | 2701.0             | 602.5              | 2701.0          | 602.5           | 123.7             | 39.2              | 9.6           | 8.1  | 11.8  | 13.7        | 6.1       | 2.0               | 1.7         | 31.3             | 31.3               |
| 8    | 2445.5             | 547.5              | 2445.5          | 547.5           | 103.6             | 36.2              | 6.9           | 7.5  | 10.8  | 12.3        | 5.7       | 2.7               | 1.6         | 30.1             | 30.1               |
| 9    | 2090.5             | 474.5              | 2090.5          | 474.5           | 83.5              | 31.3              | 6.8           | 6.5  | 8.4   | 10.5        | 4.8       | 2.7               | 1.4         | 28.6             | 28.6               |
| 10   | 1752.0             | 401.5              | 1752.0          | 401.5           | 65.3              | 20.2              | 4.2           | 4.0  | 8.9   | 4.3         | 2.8       | 1.2               | 3.7         | 23.7             | 23.7               |
| 11   | 1495.6             | 360.0              | 1495.6          | 360.0           | 73.9              | 24.9              | 2.3           | 3.5  | 8.9   | 8.2         | 3.1       | 1.9               | 1.1         | 20.0             | 20.0               |
| 12   | 1204.5             | 292.0              | 1204.5          | 292.0           | 50.5              | 21.1              | 1.9           | 2.8  | 7.3   | 6.6         | 2.3       | 1.4               | 0.9         | 16.2             | 16.2               |
| 13   | 949.0              | 219.0              | 949.0           | 219.0           | 49.3              | 17.9              | 3.0           | 2.3  | 6.0   | 5.3         | 1.6       | 0.6               | 0.8         | 11.9             | 11.9               |
| 14   | 730.0              | 162.5              | 730.0           | 162.5           | 37.7              | 14.6              | 1.2           | 1.8  | 4.6   | 4.0         | 0.8       | 0.5               | 0.5         | 9.5              | 9.5                |
| 15   | 547.5              | 145.6              | 547.6           | 146.0           | 28.7              | 12.2              | 1.0           | 1.4  | 3.5   | 3.2         | 0.2       | 0.6               | 0.6         | 6.6              | 6.6                |
| 16   | 401.5              | 109.5              | 401.5           | 109.5           | 22.1              | 10.1              | 0.8           | 1.0  | 2.7   | 2.4         | 0.0       | 0.0               | 0.0         | 4.5              | 4.5                |
| 17   | 292.0              | 73.0               | 292.0           | 73.0            | 16.8              | 8.6               | 0.4           | 0.8  | 2.0   | 1.8         | 1.0       | 0.0               | 0.0         | 5.8              | 5.8                |
| 18   | 191.9              | 73.0               | 191.9           | 73.0            | 13.0              | 7.4               | 0.2           | 0.6  | 1.8   | 1.4         | 0.0       | 0.0               | 0.0         | 1.3              | 1.3                |
| 19   | 182.5              | 73.0               | 182.5           | 73.0            | 10.0              | 6.8               | 0.1           | 0.5  | 1.1   | 1.1         | 0.0       | 0.0               | 0.0         | 0.5              | 0.5                |
| Total | 35514.5            | 7957.0             | 35514.5         | 7957.0          | 1527.6            | 532.3             | 141.1          | 95.5 | 134.9 | 162.0       | 64.7      | 19.0              | 23.8        | 355.3            | 355.3               |

**Figure 2.** Remaining revenue distribution (discounted at 10% from 01/01/2020) for the X project.
In Figure 3, variations in oil production and oil prices have significant impacts on the NPV of the X project, showing a positive correlation. When the oil price changes by ±10% and ±20% respectively, the NPV changes by 240-380 MM$ and 150-420 MM$ respectively. The difference of the variation range is 140 MM$ and 270 MM$ respectively. When the oil production changes by ±10% and ±20% respectively, the NPV varies in the range of 270-350 MM$ and 230-390 MM$ respectively, with a variation of 80 MM$ and 60 MM$ respectively. The Capex and Opex changes have a relatively small impact on the NPV, showing a negative correlation.

![Figure 3. Sensitivity analysis for the X project.](image)

6. Conclusions

(1) The Royalty & Tax Contract is one of the most common cooperation modes in the international petroleum industry. Under this mode, contractors take the share of net oil and gas reserves in kind, and pay royalties, income taxes and other taxes/fees to the government of the host government. The specific taxes are controlled by the government of the host country through legislative provisions, and the tax types and rates vary from country to country.

(2) The estimation of net reserves is a comprehensive work that integrates the factors in technical, economic, commercial and engineering aspects. It is influenced by technical factors such as reservoir parameters, development plan and recovery factor, and other non-technical factors such as contract period, investment, operation expenditure, oil prices, taxes/fees, transportation and marketing. The net reserves estimation can be objective and reliable only when such factors are clarified accurately.

(3) Under the Royalty & Tax Contract, production, oil prices, operation expenditure, investment, taxes/fees, and pipe tariff influence the contractor’s NPV and net reserves to different extents. The oil prices and production are the most weighted factors. The task of annual net reserves estimation is faced with various difficulties and challenges because of the changes in international oil prices, host country’s policies, and the geographical conditions, local environment and production/development level of the project concerned. To optimize the net reserves and NPV of a project, effective analysis should be made before estimation, and appropriate development and evaluation strategies should be developed.
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