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Review paper

Hydrocarbon Reserves - Estimation, Classification and Importance in Evaluation of Exploration Projects

Zvonimir **NADJAKOVIĆ**, Josip **SEČEN** and Antun **BAUK**

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Ključne riječi: zalihe ugljikovodika, klasifikacija zaliha, vrednovanje istraživačkih projekata.

Abstract

One of the key problems encountered by oil companies from countries in transition approaching the world market is in understanding the concept of reserves, their estimation and classification. As reserves are the basic value of a company, it is imperative that business policy includes continuous replacement of reserves. The study illustrates the use of estimated reserves in the evaluation of exploration areas, and the importance of reserves in business decisions and a company's future.

Sažetak

Jedan od ključnih problema naftnih kompanija iz zemalja u tranziciji pri pristupanju svjetskom tržištu jest razumijevanje pojma zaliha, njihovog procjenjivanja i razvrstavanja. Zalihe su temeljna vrijednost naftne kompanije. Imperativ poslovne politike je stalno obnavljanje zaliha. Prikazano je kako se procijenjene zalihe koriste za vrednovanje istraživačkih lokaliteta, odnosno koliki značaj imaju pri donošenju poslovnih odluka, pa i za budućnost sâme kompanije.

1. INTRODUCTION

The concept of market economy necessarily requires the valuation of each asset held by a company. For companies registered in some of the stock markets, i.e. public companies, reporting the annual economic state is mandatory. The value of an oil company lies in the value of its oil and gas reserves. In order to make the reserves of various companies mutually comparable, a more or less similar classification system has been accepted in the world of market economy. The basic characteristic of the system is that only those quantities of hydrocarbons that can be profitably recovered using existing technology are estimated as reserves. In reserves estimation the real production behaviour is emphasised, i.e. production decline curves or mathematical modelling are used, as well as practical experience gained from similar fields. When gas fields are in question, the material balance method has been accepted as reliable. The consequence of such an approach is a conservative estimate of reserves that results in frequent upward revisions.

In the former socialist block countries, including the former Yugoslavia, a system was adopted which aimed at determination of theoretically recoverable quantities of hydrocarbons. Such an approach has resulted in more optimistic estimates, and with some exceptions it is still used in practice today. Moreover, they developed a classification system for mineral energy resources only, and not reserves. Though it gives a good insight into the mineral resource potential of a certain country, it cannot be used either in conducting the business policy of a company at an operational level or in the real estimation of its financial position.

When approaching the world market, each company should present its annual financial report. As hydrocarbon reserves represent the most important part of oil company assets, their classification and estimation should conform with international strategy rules. As the term "market" implicitly includes every market, e.g. money market, hydrocarbon reserves market or exploration areas market, the internationally acceptable reserves classification and estimation system becomes a necessity. It must be mentioned here that in the evaluation of a certain exploration prospect or one exploration well, the start point is either undiscovered potential reserves or future initial reserves, which are estimated in a similar way as for proven reserves.

2. THE CONCEPT OF RESERVES, BOTH IN CROATIA AND INTERNATIONALLY

The Croatian "By-law on data gathering, the manner of recording and establishing reserves of mineral resources as well as the preparation of balance sheet for these reserves" clearly defines what is meant by reserves. It is obvious that it refers to the volume of mineral resources found in a reservoir. Depending on the degree of certainty, these quantities are classified into the A, B, C_1, C_2, D_1 and D_2 categories but by the deterministic approach. Not all the quantities of mineral resources in a reservoir can be produced, and only some

INA-Naftaplin, Šubićeva 29, HR-10000 Zagreb, Croatia.

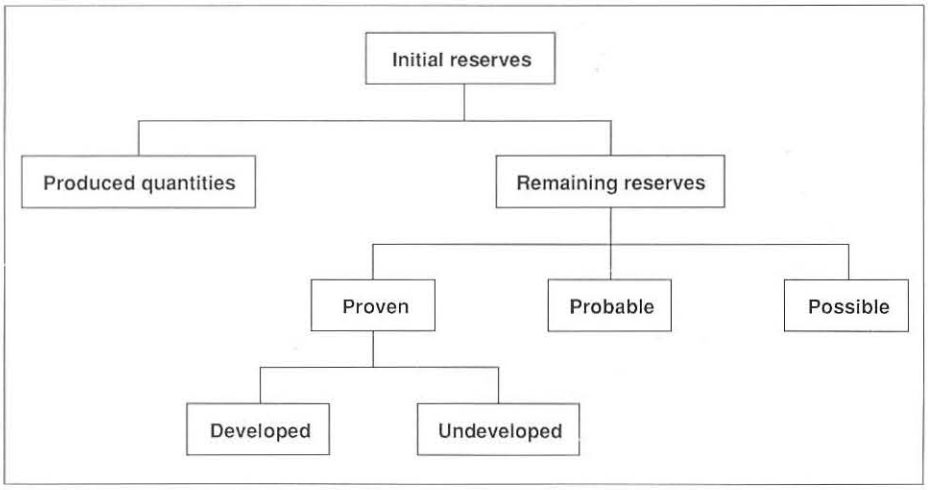

Fig. 1 A classification of reserves.

can be profitably produced. It seems, therefore, that the term "reserves" is inadequate. However, in order to report volumes that can be profitably produced the A, B and C_1 categories are classified into economically and uneconomically recoverable reserves. The economically recoverable reserves are oil and gas volumes that can be profitably recovered, and they, in fact, represent the reserves.

As the By-law does not define the method for estimating the profitability of reserves, a static method is most frequently used for these estimates, in contrast to the rules applied in market economies that require cash flow calculation, i.e. discounted cash flow analysis. Besides, the degree of certainty of so determined reserves, is not unique.

In the majority of countries with market economies, mineral resources are divided into discovered and undiscovered, and those discovered are further divided into reserves (initial) and unrecoverable quantities. We shall focus our attention on the reserves. A classification of reserves is presented on Fig. 1.

The remaining reserves are classified according to the degree of certainty which indicates the technical and economic probability of recovering the classified volumes of reserves. In the deterministic approach to reserve estimation, the degree of certainty is reported descriptively. The evaluator, according to his professional judgement, classifies the reserves in compliance with the criteria accepted by the Society of Petroleum Engineers (e.g. SOCIETY OF PETROLEUM EVALUATION ENGINEERS, 1988, and THE PETROLEUM SOCIETY OF THE CANADIAN INSTITUTE OF MINING, METALLURGY AND PETROLEUM, 1994). Some authors consider the certainty of proven reserves to be almost 100%, probable 50% and possible 10%. In the probability approach to reserve estimates, the degree of certainty will be assigned numerical values and, depending on the country and company, proven reserves would be those determined with a reliability greater than 80% or 90%, probable from 40% or 50% to 80% or 90% and possible from 10% to 40% or 50% (CALDWELL et al., 1993).

The basic characteristic of proven developed reserves is that they are those quantities of hydrocarbons that can be recovered from existing wells and supplied to the market by existing gathering and transportation systems. Undeveloped reserves are the reserves the production of which requires significant investment, but projects or studies confirming their economic justification are already available. In contrast to this, the recoverable reserves in Croatia, in addition to a different level of technical reliability, are only roughly estimated. Concerning old fields with completed projects and proven profitability, those reserves are close or identical with proven reserves. In new fields, for which the project or study has yet to be prepared, the reserves might be categorised as probable or possible, depending on the degree of certainty. In other words, additional wells should sometimes be drilled and completed in these new fields and all the necessary infrastructure, as well as the gathering and transportation system, constructed. All this requires large investment that has to be justified in order to classify hydrocarbon quantities to be recovered from these fields into proven, but undeveloped reserves. Therefore, the reserves of non-producing fields categorised according to the By-law as recoverable reserves, should be considered probable or possible, depending on the degree of certainty.

Let us emphasise once more the difference in categorising the hydrocarbon reserves in market oriented and socialist economies. In market economies the term reserves applies to those volumes that can actually be supplied to the market. It means that all the real problems of production are taken into consideration, from a damaged near well bore zone, through the imperfections of fluid lifting and transportation systems to the untimely and sometimes ineffectiveness of workover operations. All these are theoretically unpredictable. This is why, for reserve estimates, a real field performance is used or so called "production decline curve" or analogy with a similar field. Contrary to this, in former socialist countries emphasis was placed on theoretically recoverable volumes at reservoir level. It means that in predicting the future behaviour very sophisticat-

ed calculations are sometimes used, to calculate theoretically recoverable volumes, but they cannot reflect all the complexities of real production.

3. ECONOMIC EVALUATION

In this study, discussion of economic evaluation is separated although in the market economy it is an inseparable part of the estimation of both the degree of certainty and quantity of reserves. This is due to the fact that only the quantities that can be profitably produced and supplied to the market under definite technical and economic conditions are considered as reserves. The By-law of the reserves classification issued by the Republic of Croatia requests only a rough economic evaluation. Such evaluation cannot be used either as a basis of investment or for estimating the profitably recoverable quantities of hydrocarbons, i.e. reserves.

The economic evaluation in the market economy is based upon criteria accepted by the Stock Exchange Commission, and the same criteria are incorporated into International Accounting Standards. The economic value is determined by applying the method of cash flow calculation at constant prices and costs at the end of the previous year and a 10% discount rate (FINANCIAL ACCOUNTING STANDARDS BOARD, 1982). The result of such an approach are various indices of the project efficiency and reserves estimation. Among the indices are payout time, return on investment, rate of return and net present value. With a correct prediction of future field performance and all future costs, one can obtain an evaluation which is a good basis for making business decisions. There is no need to describe in detail the calculation methods, as they are already well known. When making the economic evaluation it is very important to properly determine the investment risks. In the process of establishing the risk, the evaluation of geological and technical uncertainty is, in principle, less problematic than that of political and economic uncertainty, but they have to be evaluated too, as they can substantially affect the final result.

4. EVALUATION OF EXPLORATION AREAS AND WELLS

Every enterprise, regardless of type and size must, for the sake of survival and development, continuously evaluate business efficiency. For oil companies there is an additional imperative, i.e. the replacement of produced quantities of hydrocarbons by newly discovered reserves. Both requirements have to be compatible regardless of the exploration and production conditions.

The basic principle of successful business is that income must exceed expenditure. The success of any business can be expressed by the simple equation:

$$\text{PROFIT} = \text{VOLUME} \times (\text{PRICE} - \text{VARIABLE / UNIT COSTS}) - \text{FIXED COSTS} - \text{TAXES}$$

The volume of hydrocarbons is difficult to quantify. It is estimated by means of various methods at different stages of exploration or development. The accuracy of estimation increases with the number and reliability of the available data on the reservoir geological model, fluid and rock properties as well as the recovered fluid volumes.

The price of hydrocarbons is beyond company control and prediction of future prices represents a large unknown when defining basic long term objectives.

Costs, including overheads, can and must be controlled by the business policy of the company and individuals.

Taxes are also beyond the control of a company as they are controlled by the state depending on its interests and needs.

Accordingly, this equation indicates that making profit involves several unfavourable factors and may be controlled mainly by costs.

Geologists and petroleum engineers can contribute to this business in two ways:

- increasing and maintaining volumes;
- reducing or controlling costs per unit volume produced.

While the other indices from this equation depend on the economic, political and social conditions of a certain country, the explorationist should also take into account and direct the activities toward conditions which are more favourable for the company. These are general principles of profitable hydrocarbon reserves exploration, and their elements will be discussed later in more details.

The procedure for estimating the value of any given exploration area commences with determination of the undiscovered potential reserves value. This is determined by calculating the cash flow. Costs of failure should also be estimated, e.g. those of a dry well. Of particular importance is determination of the probability of a success. By these means a predicted cash value is calculated, which may be simply represented as:

$$\text{EMV} = [\text{VR} \times \text{PS}] - [\text{CF} \times (1-\text{PS})]$$

where VR is value of reserves, PS probability of success, CF costs of failure and EMV expected money value.

An exploration well can be evaluated in a similar way. There is also the possibility for comparing the exploration well results in a ratio obtained by dividing the expected cash flow value by the dry well cost. Another index, which can be used in project ranking, is obtained by dividing the expected cash flow value by current investment value. This index gives an expected income per unit of investment. The approach, methodologically identical to this, applied in the proven reserves estimate, facilitates the evaluation of the exploration projects. This evaluation is to be made not only at the very start of the process, but also during

each phase when changes occur due to either new technical perceptions or new economic conditions. In this manner conditions will be created which would make it possible to conduct the exploration operations in an extremely profitable way, and to achieve the optimum results by investing into hydrocarbon exploration.

Various methods and rules are used in the determination of the effects of investments, which are applied by oil companies when making decisions on investing into exploration projects. Some of the simple criteria frequently used in world practice in exploration area evaluation (JONES, 1992) may be considered:

1. If the undiscounted gross value of total production from the hydrocarbon accumulation does not exceed at least 40 times the discovery costs (land purchasing and drilling costs) the project is not cost effective and should be abandoned. There is a suggestion for the ratio to be even 50:1 (HARDIN, 1958).

2. A project must not be started in any case when the rate of return is not greater than certain values established in advance:

- For a high risk area 30-40%
- For a medium risk area 20-30%
- For a low risk area 15-25%

Unfortunately practical experience indicates the fact that explorationists have a poor perception of risk, i.e. low-risk projects fail more often than expected. In spite of this imperfection, some evaluators of exploration areas find this approach very viable.

3. If the project will not payout in less than "x" years, it should not be started.

- Individual wells in 2-2.5 years
- New field in 4-5 years, depending on size

This rule is particularly applicable to smaller fields near large ones, where pipelines and other facilities already exist. However, discounted payout may be a more realistic measure.

4. The average discovery costs (including development) in 1989 in the USA were approximately:

- 31.5 USD/m^3 (5 USD/bbl) for oil,
- 27 USD/1000 m^3 (0.75 USD /Mcf) for gas.

Similar figures are given in Herold's Annual Reserve Replacement Cost Analysis for world wide operations, 1993. Higher costs make the project unprofitable. Costs of discovery include all dry hole costs, and should be divided by the probability of success to adjust the risk and allow valid comparison with other projects.

5. Any gas exploration and production project should not be started if it will not return at least 35 USD/1000 m^3 (1 mil. USD/billion cuft). This also includes development drilling costs.

6. The first well should "earn" enough to pay for land, seismic surveys and drilling.

7. No new field wildcat venture should be taken if, after the wildcat which proves to be successful, drilling of at least three offset development wells is not feasible.

This represents "some rules of thumb" used mostly in the USA in evaluating exploration areas.

A realistic approach to the valuation of exploration prospects, for the Croatian oil company, becomes a necessity under conditions of fairly stable prices and in a highly explored operational area. Evaluation of the exploration area as much objectively as possible becomes imperative under conditions of comparatively stable prices of hydrocarbons in an area previously highly explored. Today one cannot rely on either a significant price increase or large discoveries. For these reasons it is necessary to evaluate the exploration projects as rationally as possible.

In the foreseeable future hydrocarbons remain the inevitable energy resource and mineral reserve to be used in the chemical industry. This means that the process of exploring, discovering and putting into production new reserves is continuous, but under considerably more difficult technical and economic conditions, as is constantly reiterated by the leading people of big oil companies. This could also be applied to the oil companies in the former socialist countries, in the majority of which exploration operations were rather extensive, and during transition into the market economy the rationalisation of the exploration processes, as well as other activities of oil companies was more strongly emphasised.

5. INA-NAFTAPLIN AND THE TREND OF THE MARKET ECONOMY

Analysis of the reserves management at INA-Naftaplin encounters all the problems indicated in this study.

The remaining oil reserves are contained in old fields with high production costs. When estimating the remaining reserves according to standards common to western countries, it has become certain that production costs will considerably reduce the remaining economic production life of the fields. It is also certain that recoverable (technical) reserves, due to a long productive life, will generally meet the criteria introduced by the new evaluation approach.

In order to increase the remaining reserves production costs must be reduced, i.e. to make detailed analyses of each item loading these costs. Another method of improving the cost effectiveness of each field is to increase the well productivity by introducing new technologies adequate to the field conditions.

The world price of oil products and an aspiration to enter the petroleum business world presumes that all the costs of our activities are brought as soon as possible to the world level. It requires not only the definition of the company from the organisational point of view, but also it's streamlining.

In this process, the non strategic, financially marginal and other undesirable investments should be elim-

inated, with a parallel restructuring and reorganisation performed while planning the strategic growth of the company.

In contrast to this there is an option for the company to downsize by reducing all activities by a certain percentage, without any clear plan of growth.

If the first option is to be applied, i.e. the concept of growth, regular replacement of reserves should be achieved through careful planning of all activities in accordance with the company potential.

The reserves can be restored by continuing exploration in the country and abroad, by acquisition of reserves and introducing the additional recovery methods aimed at increasing the recovery of the remaining reserves in old oil fields.

There is a high probability that the remaining potential of the Pannonian exploration area in Croatia can ensure discoveries and new reserves for replacement of only a fraction of current production.

Exploration operations abroad must be the basis of long term reserves replacement. The results achieved so far are encouraging, but future activities should involve all the human resources in order to select the most prospective prospects.

There is no possibility for the short term stabilisation of reserves without purchasing already discovered reserves or fields in production on the open market. It is a new activity for the company and many difficulties are expected, but if we wish to initiate a new cycle of company growth, it is more imperative than optional. All these activities assume co-operation with foreign oil companies as well as the application of the most recent technical achievements in all stages of the oil and gas exploration and production process.

6. CONCLUSION

The hydrocarbon reserves of the Republic of Croatia, defined according to the By-law, are not directly comparable with the proven, probable and possible, classification used internationally, due to a different approach to the estimation from the technical and economic point of view. Therefore, a new estimation and classification scheme should be implemented in order to establish the financial position of an oil company in Croatia according to international standards. A new By-law (at least internal) about classification of reserves should be prepared, which would take into consideration international standards, i.e. be based upon the market approach. The reserves estimated and classified in this manner would be the basis for approaching the world market. It does not mean that mineral energy resources should not be reported. On the contrary, they should be assigned to localities, i.e. concession blocks, and the potential reserves estimated according to the adopted rules but taking into consideration the risk. A continuous revaluation of potential reserves should be performed during exploration, as all changes in costs or prices of hydrocarbons could affect their required volume, and by this could directly affect the continuation of works or their termination in case of unprofitability.

INA Naftaplin is facing the necessity of the optimisation of the exploration and the rationalisation of development on the basis of the described valuation of reserves. Applying criteria accepted worldwide and methods of valuation of prospects, more efficient exploration at home and abroad should be achieved, which, together with the acquisition of new reserves, should result in a higher reserves replacement ratio. A replacement ratio of 1 must be achived as soon as possible.

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