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A SIMULATION MODEL FOR ANALYSIS OF LONG TERM NATURAL GAS COMMITMENT

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ABSTRACT

A simulation model is developed in this paper to estimate the number and timing of the exploratory attempts required to fulfill a company's long term gas commitment. The model simulates that company's production, exploration, and discovery in the given sedimentary basin. The model also considers exploration by other companies in the same area, and uses a field distribution to estimate the size of the discovery. With this simulation tool, natural gas producers and users can evaluate different scenarios and decide how the risks and costs of fulfilling long term gas commitments should be shared.

1 INTRODUCTION

The natural gas is near its lowest price in fifteen years, but its use is not increasing as quickly as it might. The reason for this underutilization is that many potential users of natural gas are hesitant to commit to this fuel due to long and short term price and delivery problems. Each aspect of the risks associated with commitment to natural gas must be studied by potential users, transporters, and producers. Reliable transportation, contingencies for short term delivery problems, equitable pricing, and the location and type of long term supply are just a few of the issues which must be addressed by those involved with the natural gas industry.

Most of the sedimentary basins onshore and offshore of the continental United States are sufficiently mature and explored so that undiscovered resource estimates can be made for each sedimentary basin. An article in Oil and Gas Journal (1991) indicates that the United States has up to sixty years or more of natural gas supply yet to be produced. Although some medium to long term supply commitments (seven-fifteen year) can be made by predicting the decline curves of existing fields, longer commitments with higher volumes will depend on production from yet undiscovered fields (Vidas and Hugman, 1991). It is believed that the use of undiscovered resource estimates in a computer simulation can help producers, transporters, and end users quantify the timing and level of the exploration effort necessary to convert the undiscovered resources into reserves and fill the needs of the end users.

This paper addresses the development of a simulation model to determine the number and timing of the exploratory attempts required to fulfill a company's long term gas commitment. The model simulates that company's production, exploration, and discovery in the given sedimentary basin. With this simulation tool, natural gas producers and users can evaluate different scenarios and decide how the risks and costs of fulfilling long term gas commitments should be shared.

2 THE SIMULATION MODEL

The simulation model is composed of five components: production, exploration, discovery, exploration by others, and statistics collection. The model starts in the production component, it initialize with the producer's current rate of gas production and the fraction of the current rate which is committed in the long term. The current rate declines at a mean constant percentage (which is the reciprocal of the reserve to production ratio) to simulate annual production decline due to depletion.

In the exploration component, a random number is generated for each exploration attempt. Since each exploratory attempt has an independent chance of success, the chance of success remains stationary (Megill, 1984). An unsuccessful attempt is tallied if the random number is less than the failure rate. The program returns to exploration until the random number generated is greater than the failure rate (Newendorp, 1975).

When a successful exploratory attempt (a discovery) is made, the program moves into the discovery component and selects a field size from the undiscovered field array. The probability of the discovery for a given size i, P_i, is equal to the product of the number of fields in a given class size (X_i) and the reserves of that class size (C_i) divided by the sum of the products of all of the field numbers and class sizes. Thus the larger fields then have a higher probability of being discovered first (Kaufman, 1975).

Since there will be many other companies operating in the sedimentary basin or the area of the field distribution during the years to be studied, the simulation model considers the depletion of the resource base by others. The annual drilling rate by others and its standard deviation is input at the beginning of the simulation. This annual drilling rate can be increased or decreased at a constant annual percentage.

At the end of each simulation run the gas sales rate, the number of exploratory attempts (if any) and size of the discovery (if any) for each year are stored along with the squares of the values. At the end of all of the simulation runs (the experiment) the mean and standard deviation of each parameter are calculated for each year and for the period as a whole.

3 CONCLUSIONS

The United States has several existing and potential sources of natural gas. There is also a large existing infrastructure of producers and transporters. It is also apparent that there is a significant market for gas now and its demand is expected to grow. One of the fastest growing uses of natural gas will be for electrical generation. Natural gas is attractive to electrical producers because it is an efficient fuel to use and has no environmental drawbacks. Market and regulatory factors are moving toward making the use of natural gas more simplified and stable.

While some existing fuel supply models have investigated the cost and outcome of future drilling, the models have not investigated the natural gas delivery by a single entity or company. A simulation model was designed to be used as a tool to investigate the effect of different resource demands and constraints upon a supplier of a long term gas commitment.

In the experiments tested in this research, the proposed simulation model appears to be able to identify the key elements which would cause a potential long term supplier the most exposure to commitment of resources. The amount of gas committed and the production profile or acceleration of production have the most effect upon the level of exploratory and discovery effort required to fulfill the long term gas commitment. The experiments also showed that the factor over which an operator has the least control, the exploration rate in the basin, is relatively insignificant at a wide range of levels.

REFERENCES

Kaufman, G.M., Balcer, Y., and Kruyt, D. "A Probablistic Model of Oil and Gas Discovery." *Methods of Estimating the Volume of Undiscovered Oil and Gas Reserves*, Tulsa: American Association of Petroleum Geologists, 1975, pp. 113-142.

Megill, Robert E. *An Introduction to Risk Analysis*. Tulsa: PennWell, 1984.

Newendorp, Paul D. *Decision Analysis for Petroleum Exploration*. Tulsa: Pennwell, 1975.

Oil and Gas Journal, "U.S. Natural Gas Resource Base Increases." Aug. 1991, p.23.

Vidas, E.H. and Hugman, Robert H. *Find Rate Methodology and Resource Base Estimates of the Resource Supply Model*. Washington: Gas Research Institute, Feb. 1991.

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