SOFTWARE DEVELOPMENT FOR NATURAL GAS FIELD POTENTIAL ASSESSMENT AT CHONNABOT PROSPECT, NORTHEASTERN THAILAND

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Abstract

The objectives of this research are (1) to develop the computer program called PPA (Petroleum Potential Assessment) using Microsoft Visual Basic version 6.0 for determining for natural gas field potential assessment, (2) to compare the commercial petroleum potential assessment software, including FASPU (Fast Appraisal System for Petroleum Universal Version) and GeoX (Geometry Experiments) with PPA (Petroleum Potential Assessment), and (3) to evaluate economic returns in terms of Internal Rate of Return (IRR) and Profit to Investment Ratio (PIR). The PPA software has been developed for natural gas potential assessment in the northeastern Thailand and design support of input parameter under various geological and engineering parameters including area of closure, porosity, thickness, gas saturation, gas formation volume factor, and recovery factor. PPA software uses the Monte Carlo simulation and probability of success theory, and is developed on Microsoft Visual Basic version 6.0. The software includes a main page and three modules: technical considerations, gas production forecast considerations and economic considerations. In terms of technical consideration, the estimated gas in place resources are 147.49 Bcf (billion cubic feet) at 90%, 405.71 Bcf at 50% and 926.74 Bcf at 10% of fractile, respectively. The estimated gas recoverable resources are 132.74 Bcf at 90%, 365.14 Bcf at 50% and 834.07 Bcf at 10% of fractile, respectively. In terms of economic consideration, the Internal Rate of Return (IRR) and Profit to Investment Ratio (PIR) for natural gas field at Chonnabot prospect are 20.03% and 1.10, respectively.

Keywords: Northeastern Thailand, software development, Chonnabot prospect

Introduction

Due to petroleum prices, the world has an economic problem. Energy is vital to both the economy and population since it is one of the main powers driving the growth of economics and the prosperity of people. The energy consumption has developed in various functions such as industry, agriculture, and transportation. Thailand spends a large amount of money importing oil because reserves of petroleum in Thailand are limited. Therefore, we should be searching for new petroleum fields and increasing recovery from the existing petroleum fields.

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As in the 2007 annual report, the Department of Mineral Fuels Strategic plan is to promote petroleum assessment through greater data security, update, and organize annual technical seminars to share views with concessionaries in northeastern Thailand, academics and the interested public to add further insight and ease exploration success. Exploration and production of petroleum in northeastern Thailand has been going on for more than four decades. Currently, only two natural gas fields, namely Nam Phong and Sinphuhorm, are on production. The petroleum provinces in northeastern Thailand have a high potential for exploration and development. The reservoir rocks in this vast region are Permian carbonates, which contain anticlines resulting from transversing fault lines, creating fractures, and adding porosity to the carbonates. More than 30 wells drilled have confirmed this fact, but to date only the Nam Phong and the Sinphuhorm gas fields have production (Department of Mineral Fuels, 2007). It is expected that more gas fields will be developed in the carbonate reservoir rock Chonnabot prospect.

Methods

For this study, we used three computer softwares consisting of FASPU (Fast Appraisal System for Petroleum Universal Version), GeoX (Geometry Experiments) and PPA (Petroleum Potential Assessment). The required data for the natural gas potential assessment consists of two parameters, which are geological and engineering parameters including area of closure, porosity, thickness, gas saturation, gas formation volume factor, recovery factor, trapping mechanism, effective porosity trap fill and hydrocarbon accumulation. All of the required data for this assessment have been compiled, reviewed and summarized. The Department of Mineral Fuel (DMF), the Ministry of Energy, provided these data.

The FASPU software is a prototype package of programs designed to assess the resource potential of undiscovered oil and gas resources (Crovelli and Balay, 1990). The play analysis is a general term for various geologic models and probabilistic methods of analyzing a geologic play for petroleum potential. The play analysis is a quantitative approach for estimating undiscovered oil and gas resources at a play scale including hydrocarbon source, timing, migration, and potential facies. The resource assessment is separated into individual groups that have similar geological characteristics and the same type of play attributes. Each play will, therefore, be analyzed, including hydrocarbon accumulation in forms of oil, oil with dissolved gas, and non-associated gas. The product of these three probabilities is the probability that the prospect has a petroleum accumulation, given the play is favorable, and called “Conditional deposit probability”. The hydrocarbon volume attributes consist of area of closure, thickness of reservoir rock, effective porosity, trap fill, depth to reservoir, and hydrocarbon saturation. The hydrocarbon volume attributes jointly determine the volume of the hydrocarbon accumulation within the prospect. The FASPU software is used in reservoir engineering for calculating the in place volumes of oil and non-associated gas.

As in the 2003 CCOP Technical Secretariat Evaluation report, the GeoX software provides a stochastic assessment of resources, risk and economic value. CCOP (The Coordinating Committee for Coastal and offshore Geosciences Programmers in East and Southeast Asia), 1996 developed this software. The system was designed explicitly to support mission critical asset management decisions in oil and gas exploration projects. A distinctive model-based architecture working over the industry-standard database promotes effective use and integration of data and judgment in decision-making. The Monte Carlo simulation produced probabilistic estimates of in place resources and recoverable resources based on the estimate of the relevant various input. There are six main input parameters as follows.

1. Document: Editing documentation of the context, main attributes of the target and issues that have been considered or need to be reviewed.

2. Setup: Establishing global setting for the analysis. These setting involve what phases

are active, limits, number of trials and seed for the Monte Carlo simulation.

3. Volume: Entering estimates of the variables that are used to calculate the hydrocarbon pore volume.

4. Fluid: Entering estimates of the variables that are used to calculate in place and recoverable hydrocarbon volumes at surface conditions.

5. Correlation: Entering estimates of the relevant correlations between volume and fluid variables.

6. Risk: Entering estimates of the chance of adequacy of the different factors that control the success of the exploration target and risk.

The Monte Carlo simulation and probability of success (POS) were applied to the resources determination method. The Monte Carlo simulation, shown in Figure 1, is a powerful tool for obtaining solutions by numerical methods using random numbers and a function of the engineering (McCray, 1975). Random numbers were taken from an appropriate range of values repeatedly selected values entering into the calculations. Several hundred to several thousand random numbers, trials were generally used to obtain suitable results, which made the technique less suitable for manual calculations than to the electronic computer. Essentially, the answers could be arranged in a form that gave the fractions of total results, which fell within certain ranges in this method. Thus, it is readily adapted to solve probability problems and constructing probability distribution. Some of the types of solutions that have been obtained by simulation

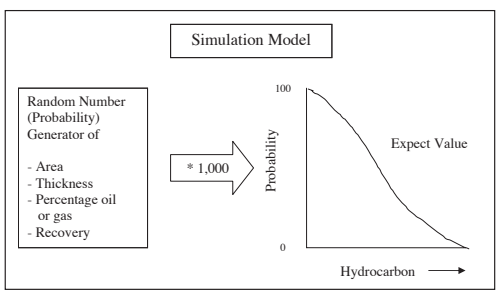

Figure 1. Monte Carlo Simulation Model (ASCOPE/ CCOP, 1982)

are as follows.

1. Estimates such as probability distributions of petroleum resources will give P90 (Proved), P50 (Proved + Probable) and P10 (Proved + Probable + Possible) reserves.

2. Estimates such as probability distributions of rates of return that might be obtained in the business venture.

3. Probability distributions of the possible "state of nature" such as the probable ultimate recovery from a petroleum reservoir.

4. Determine the most profitable number of parallel facilities.

5. Determine the probability diagram formed by combining quantities whose variation can be expressed algebraically with those whose variations can be expressed only empirically or graphically.

6. Illustrations of the validity of theorems.

7. Sensitivity analysis.

The probability of success (POS) was used for prospect evaluation (CCOP, 2000). The proportion of oil and gas in our prospect is usually one of the input parameters in the volumetric calculation. However, in some cases we wish to evaluate different cases (oil case, oil case and combination case). In these situations, we had to assess the risk associated with each case. For any given prospect, the four possible outcomes (dry, oil, gas and oil & gas) were independent. The resource distribution or range of outcomes being used in the evaluation is a function of the geological risks (including hydrocarbon resource, timing, migration, trap occurrence, potential reservoir facies, effective porosity and hydrocarbon accumulation) of the project.

The PPA software will be applied to the Monte Carlo simulation and probability of success (POS) of theoretical analysis. Ruksutjaritkul, 2010 created this software. In terms of economic evaluation for natural gas potential assessment will be performed to find the best Internal Rate of Return and Profit to Investment Ratio. The software was developed on Microsoft Visual Basic version 6.0 that is the enterprise edition with source code and utility for natural gas potential assessment. The program includes necessary command

buttons similar to the commercial software such as “Main page”, “Calculate”, “Check input, Clear” and “Save & Print”. The software is a substitution of common order such as input, output and help. This software includes a main page and three modules (including technical, gas production forecast and economic consideration) which are shown in Figure 2.

Results

Technical Consideration

In terms of Technical consideration, the natural gas potential assessment of the Chonnabot prospect were performed by PPA software are shown in Tables 1 and 2. The results can be summarized as follows:

1. The quantities of gas in place resources for the prospect are 147.49 Bcf (Billion cubic foot) at 90%, 405.71 Bcf at 50% and 926.71 Bcf at 10% of fractile, respectively.

2. The quantities of gas recoverable resources for prospect are 132.76 Bcf at 90%, 365.14 Bcf at 50% and 834.07 Bcf at 10% of fractile, respectively are shown in Table 3.

Economic Consideration

In terms of economic consideration, the determination of the Internal Rate of Return (IRR) and Profit to Investment Ratio (PIR) are analyzed and estimated in all case studies. The exploration and production periods under the Petroleum Acts “Thailand III” are divided into

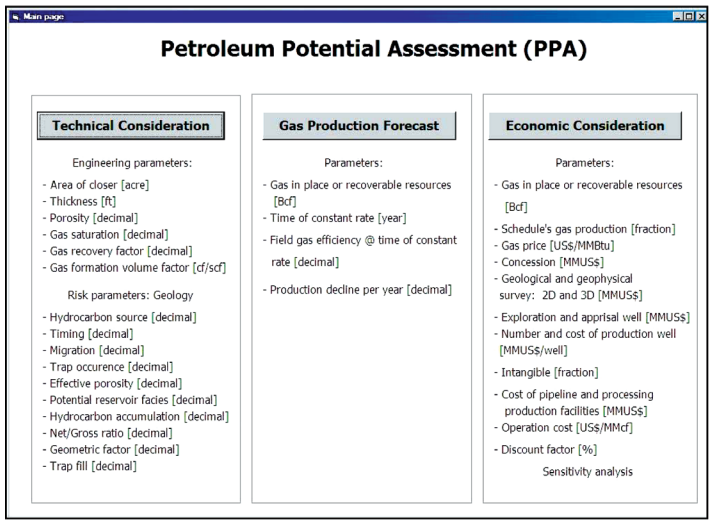

Figure 2. The main page of PPA software

Table 1. Input parameters of Technical consideration (CCOP, 2006)

Parameter: Engineering	Units	Value		
		Min	Mean	Max
Area of closer	acer	2020	none	12530
Thickness	ft	107	240	374
Porosity	%	3	none	18
Gas saturation	%	53	none	86
Gas recovery factor	%	90	none	90
Gas formation volume factor	-	0.0032	none	0.0034

3 years of exploration period and 20 years of production period. This study production is currently in its 4th year of investment. The total exploration period is 3 years and then production period is 23 years, which are divided in this study. The following is the work plan schedule:

1st year @ 2010: Petroleum concession

2nd year @ 2010: Geological and geophysical surveys

3rd year @ 2010: Drill exploration, appraisal and production wells

4th year @ 2010: Production

Table 2. Input parameters of Technical consideration (CCOP, 2006)

Parameters: Geology	Units	Value
Hydrocarbon source	%	100
Timing	%	100
Migration	%	100
Trap occurrence	%	80
Potential reservoir facies	%	90
Effective porosity	%	100
Hydrocarbon accumulation	%	100
Net/Gross ratio	%	68
Geometry factor	%	86
Trap fill	%	48

Table 3. Result of Technical consideration for natural gas potential assessment of Chonnabot Prospect

Softwares	In place resources/Recoverable resources (Bcf)		
	(P95*)/P90	P50	(P5*)/P10
FASPU (*)	139.78 / 132.79	554.20 / 498.80	2081.87 / 1873.68
GeoX	124.20 / 111.80	351.90 / 316.80	942.00 / 847.80
PPA	147.49 / 132.74	405.71 / 365.14	926.74 / 834.07

Table 4. The basic and other assumption cost at the reserves 365.14 Bcf

Type:	Value	Unit
Gas price	4.4	US$/MMBtu
Operation expense	1000	MMUS$
Facility cost	145	MMUS$
Capital cost - Geological and geophysical survey - Drilling explorations well - Drilling production well - Pipe line	276.41	MMUS$
Income tax	50	%
Discount rate	10	%
Tangible cost	20	%
Intangible cost	80	%

The petroleum economic study under the concession system and petroleum economic evaluation of Thailand III (ASCOPE/CCOP, 1982) has detailed basic assumptions and other assumption costs, which are shown in Table 4 and the economic results are shown in Table 5.

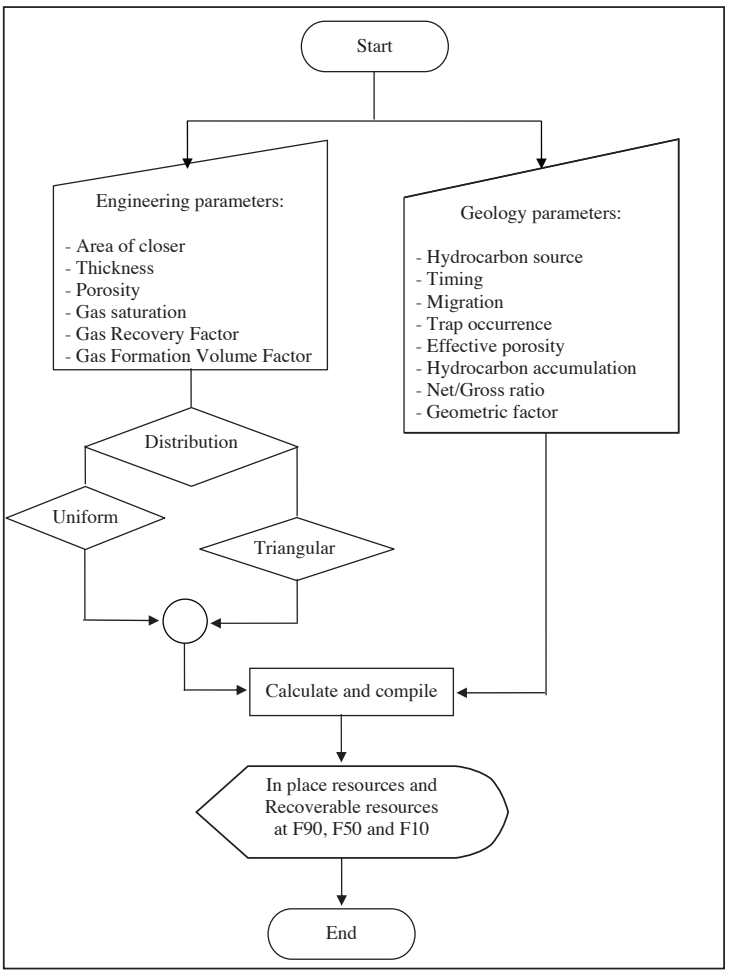

Figure 3. Flow chart for technical consideration

Table 5. Result of Economic consideration

Results	Value
Gross revenue	1423.46 MMUS$
Royalty	149.53 MMUS$
Income tax	314.27 MMUS$
Operation cost	378.89 MMUS$
IRR (Internal Rate of Return)	20.03%
DIRR (Discount Internal Rate of Return)	9.12%
PIR (Profit to Investment Ratio)	1.10

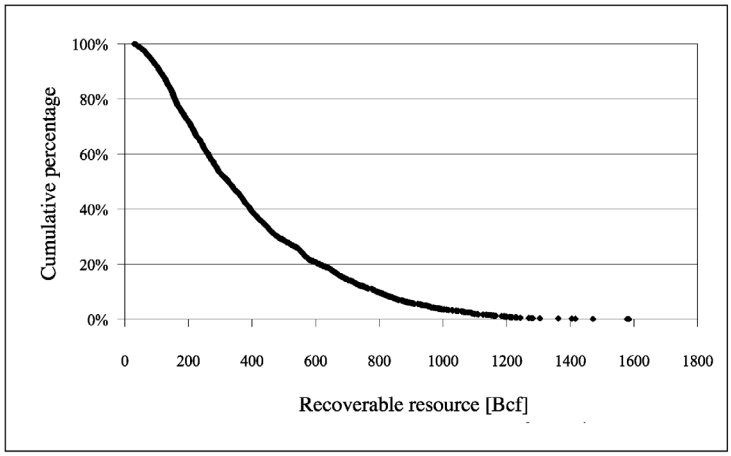

Figure 4. Natural gas potential assessment of Chonnabot Prospect by PPA software

Conclusions

Technical consideration, the quantities of gas in place resources are 147.49 Bcf at 90%, 405.71 Bcf at 50% and 926.74 Bcf at 10%of fractile, respectively. The quantities of gas recoverable resources are 132.74 Bcf at 90%, 365.14 Bcf at 50%and 834.07 Bcf at 10% of fractile, respectively.

The comparison between PPA and FASPU software show that PPA software had an error difference from FASPU software of approximately 26.7% because the PPA software had been considered in geological parameters, which are net to gross ratio and geometric factor. The comparison between PPA and GeoX software, PPA software had an error difference from GeoX software of approximately 15.3%.

Economic consideration, the Internal Rate of Return (IRR) and Profit to Investment Ratio (PIR) for natural gas in northeastern Thailand are 20.03% and 1.10. The economic results are the best estimate in this case.

Recommendations

The research methodology completed and developed by this program is useful but some data that were used in the case studies are not proper such as thickness and geometric factor data. The gas production forecast module of PPA software was developed for planning gas production of each project. The input parameter consists of in place or recoverable resource, field gas production rate, efficiency at time of constant rate, time of constant rate and production rate decline per year. The number of years it is produced and the production rate per year calculates the results of gas production forecast module.

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