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Economic Evaluation For Oil and Gas Exploration Drilling Project

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Abstract

The mechanism of selecting and evaluating exploration prospects for oil and gas exploration drilling projects is usually done individually with considerations on the technical and economical aspects. The technical aspect of the prospect is focused on to how far a chance of oil and gas exists, and this aspect is also referred to as risk aspect of the prospect. On the other side, economic evaluation is done based on predicted resource recovery, an evaluation of the level of prospect using general investment indicators.
Technical aspects used to be assessed as a standard procedure in the exploration projects, but economic aspects will still need to be intensively explored.

In the condition where the availability of drilling sites are getting scarcer as well as the very limited budget, this research proposes the tools of analyses for optimizing the selection and planning of exploration projects, namely the Discounted Cash Flow and the Decision Tree of Timing Option. Analyses have been conducted in this research, by inputting a three-year REPA (Region Risk Factors) Index.

The result from those analyses is an index of investment called the RI3 index. Comparing it with the application of Zero-One Programming method in portfolio analyses, it was shown that the ranks of investment from both analyses are different.

Key words: investment portfolio, risk factors, risk assessment, discounted cash flow, decision tree of timing option

I. Introduction

PT. Pertamina DOH JBB (Daerah Operasi Hulu Jawa Bagian Barat) is one of the actors of the oil and gas upstream industries in Indonesia. The company's main task is to find and produce crude oil and gas available in its working area, which covers the provinces of Banten, DKI, northern part of West Java to a part of Central Java. Special studies and expertise in technical and economic aspects are therefore necessary for carrying out this task.

There are in general, four main stages in the oil and gas upstream industry, namely exploration stage, development stage, production stage, and abandonment stage. The exploration stage is aimed at finding and accumulating crude oil and natural gas. This is indeed the fundamental stage in the oil and gas upstream industrial activities, as it would continuously increase the company's values through additions of commercial hydrocarbon reserves (Chimblo dan Chimblo, 2004). The reserve will then be further evaluated in the development stage, that is, to look at its prospective and commercial levels when the new reserve from the new field is going to be developed for production. Using the field development and production scenarios obtained from evaluations at the earlier stages, which are contained in the POD (Plan of Development), the new reserve will then be ready for production. Naturally, the oil and gas production will be decreasing to arrive at a stage where the field has to be abandoned. The four stages are interrelated, forming a life cycle of oil and gas as seen in Figure 2 (Ong, 2005).

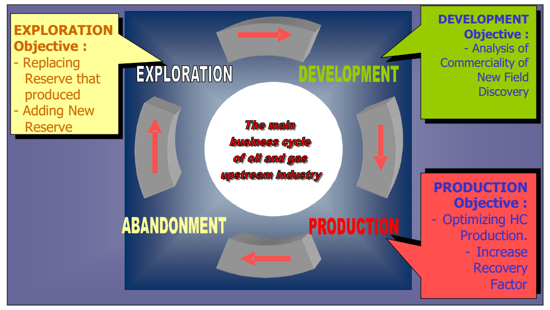

Figure 1. The four main stages of oil and gas upstream processing sector

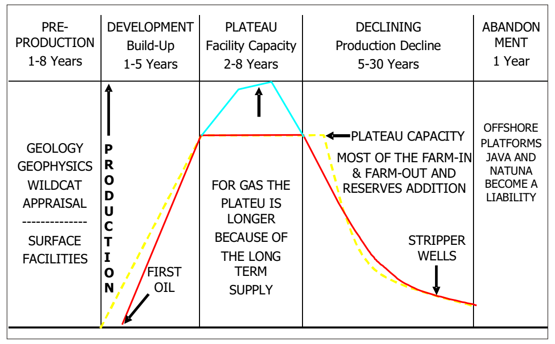

Figure 2. Life cycle of an oil and gas field (Ong, 2005)

II. Evaluation and Operation of The Exploration Drilling Project

There are several important matters worth considering in connection with exploration drilling projects, namely:

1. The exploration drilling project, as one of the main components in the oil and gas business such as shown in Figure 3, plays an important role in sustaining the oil and gas business.
2. The exploration and drilling project is a project of investment in the upstream oil and gas business.
3. In general, like any other projects of investment, factors of risks are inseparable from exploration drilling projects.
4. Exploration drilling projects are selected and planned based on evaluation results of drilling prospects.

Based on the above considerations (especially point 4), prospect evaluation and studies are very decisive for a successful selection and planning of exploration drilling projects.

2.1 Evaluation Process of Exploration Prospects

The evaluation process started with appraising the available geological and geophysical data, both manually as well as by using the existing technologies. Otis and Schneidermann (1997) illustrated the flow for the evaluation process of exploration prospects in general, such as shown in Figure 4. It started with the development of a play concept, comprising of assessments on the four main elements, source rocks, reservoirs, type of traps, and the dynamic process of hydrocarbon timing and migration.

From descriptions of the play concept, one could estimate the geological risk level or probability of finding hydrocarbons for production. Besides, one could also appraise the volume of hydrocarbons that could possibly be recovered. The appraised hydrocarbon volume will be made the base for estimation of engineering plans, concerning plans for production profiles, production facilities, as well as transportation plans.

Based on risk analyses, estimation of hydrocarbon volume, as well as the calculated engineering plans, the next process is economic analyses, which will be used as reference for appraising feasibility of the proposed drilling prospect.

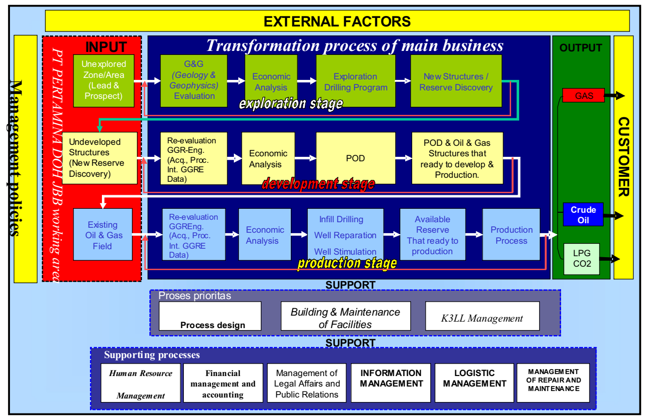

Figure 3. Processes in the upstream oil and gas business

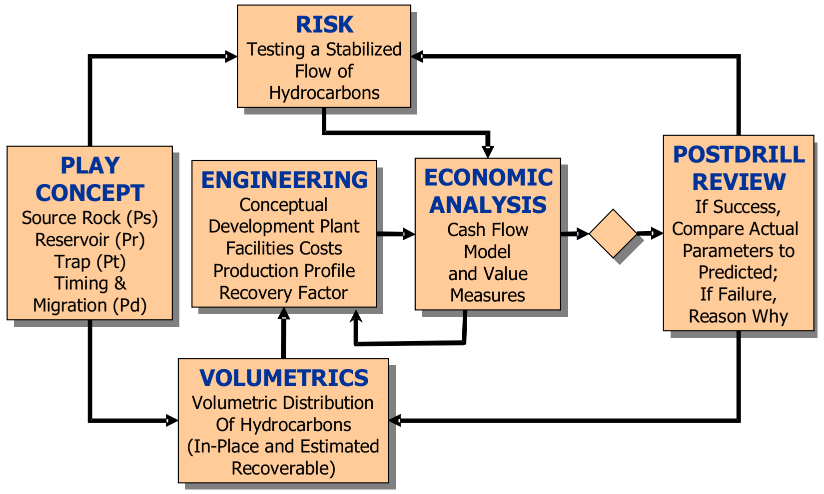

Figure 4. Evaluation Process of Exploration Prospects (Otis and Schneidermann, 1997)

2.2 Exploration Risks

Bailey, *et al.* (2000) mentioned that the oil and gas upstream industry is full of risks and uncertaintaies. According to De'Ath (1997), the risks of the upstream oil and gas business could be grouped into three main aspects (Figure 5), as follows:

a. *Country and Industry Environmental Risks*. This risk aspect is closely related to the business condition in a particular country, externalities or the surrounding environment, as well as characteristics of the respective business. Included in the aspect of risks are: country risk, country economy, environment, general issues, petroleum legislation, energy balance, competition, and activities. All these risk aspects are necessary for the evaluation relating to business strategies, such as to oil and gas upstream business that just entered a country to start the business.
b. *Geotechnical Risks*. Geotechnical risk is an aspect of upstream business risks related to geology and operational techniques. This risk aspect is closely related to conditions of the earth as the main object of the oil and gas upstream industry.
c. *Economic Risks*. Economic risk is related to economic aspects, particularly the opportunity to obtain a certain level of profit as the ultimate goal of the upstream business process. The aspect of economic risks in general covers: economic indicators, commercial types, taxes, and production options. This aspect of risks is necessary for evaluations that are directly connected to financial profit calculations as end goal of the business process.

In the overall evaluation of the profit seeking upstream business process, the three risk aspects are weighted differently, such as shown in Figure 5. The aspect of geology and geotechnical risks is weighted 50%, whereas the two other aspects of risks are weighted 25%. In general, the aspect of geotechnicak risks is made the main focus in upstream business investment studies, nevertheless, the two other aspects of risks are also important, considering both aspects are weighted 50% of the total weighted risks.

Mapping the three aspects of risks on the drilling prospect, the three aspects of risks are actually present at the stages before and after evaluation of the drilling prospects, such as seen in Figure 6. At the early stage, after studying and evaluating the prospect, *Drilling Prospect I* is produced, which has already included geotechnical risks in the calculation of prospects. Many oil companies conduct drilling based on results of drilling prospects at this stage, especially the national oil companies operating in the company's country of origin.

Nevertheless, the other two risks, respectively the Country Risk and Economic Risk or a combination of both risks, could basically be included in the calculation for optimizing the investment portfolio to produce the *Drilling Prospect II*. Multinational oil companies have made it a standard procedure to include the two respective risks in the calculation of investment, considering the fact that multinational oil companies are usually operating in many different countries. Thus, the three risk factors should be considered in investment portfolio planning to ensure the investment of gaining optimal values.

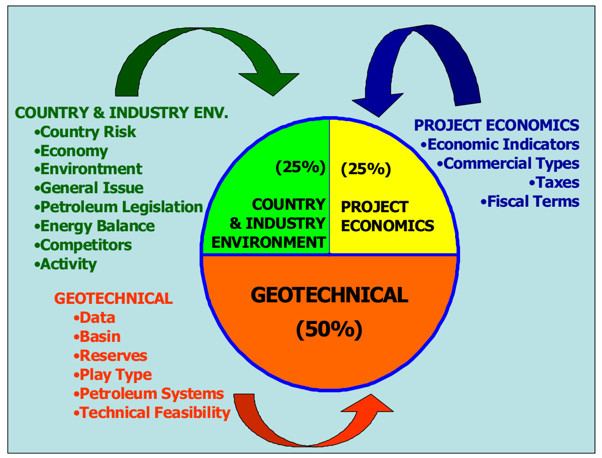

Figure 5. Three aspects of risks in the upstream business (De Ath, 1997)

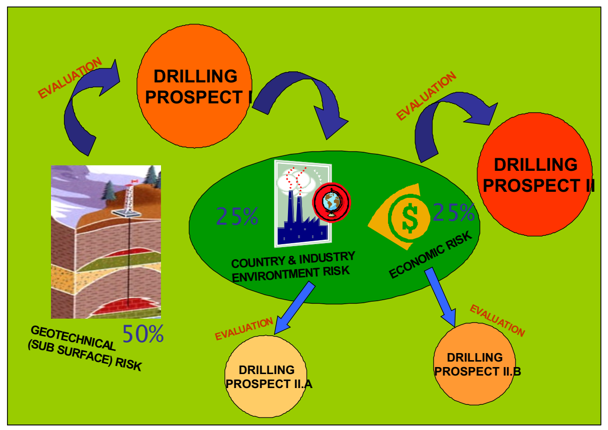

Figure 6. Positions of the three aspects of risks towards Drilling Prospects

In this final project, both risks, the country-industry environmental risk and economic risk, which comprises 50% of the total risks, will be made the main factor for further discussion. Determination on the two risks will be discussed in the following section.

2.3 Measuring Country-Industry Environmental Risks and Economic Risks

Besides the geotechnical risks such as explained above, it is imperative to consider the country-environment risk and economic risk related to the other weighted 50% of the risk factors. Harvey, C.R. (1996) explained that there are several methodologies usually used for measuring country risks, among others, *Institutional Investor and International Country Risk Guide* (ICRG).

Institutional Investors are used to measuring risks based on credit risks, surveyed from international bankers operating in a particular country. The risk scale is made from 0 to 100, where 100 shows the minimum credit risk. Surveys are carried out for each of the countries, the data are then processed by the International Investor to determine its rating. The rating relies greatly on experiences of the surveyed object in the respective country, even the most experienced surveyors will have different assessments regarding the risk rating of a particular country. The other methodology for risk rating of a particular country, namely the International Country Risk Guide (ICRG), conducts measurements through monthly data collection. ICRG uses four measurements for risk rating, namely Political Risks, Economic Risks, Financial Risks, and Composite Risk Rating, the latter is calculated based on the three above mentioned risk factors. Each of the risk factor, such as Political Risk, comprises of 13 risk factors, Economic Risk and Finacial Risk consist of 6 and 5 risk factors respectively (see Table 1). Each factor has its own rating, the higher the score, the lower the risk. The score for political risks is obtained from data analysis, and is of subjective nature. The score for economic risks is based on objective data of quantitative analyses and the score for financial risks is based on a combination of both qualitative and quantitative data. ICRG categorized country risks based on two main components, namely ability to pay and willingness to pay. Political risks are associated with willingness to pay, financial and economic risks are associated with ability to pay. The point for political risks (100 points) is determined to be greater than both financial risks and economic risks (50 points).

The formula for calculating Country Risk, according to ICRG, is as follows

$$PR = Sum_i\ PR_i \quad (1)$$

$$ER = Sum_i\ ER_i \quad (2)$$

$$FR = Sum_i\ Fr_i \quad (3)$$

$$CRR = 0.5 \times (PR+ER+FR) \quad (4)$$

where :

PR = Political Risk

ER = Economic Risk

FR = Financial Risk

CRR = Composite Risk Rating

As explained earlier, the three risk factors have their own risk factor criteria. Political risk comprises of 13 risk factor criteria, economic risk and financial risk comprise of six and five risk factor criteria respectively, as shown in Table 1. Country risks are to be in effect when the company is going to invest in

a certain country. This paper will further explore the case of Pertamina, which is a national company, when it is going to invest in certain working areas with different industrial environment characteristics.

2.4 Exploration Well Drilling Operation Process

Once a proposal for exploration drilling is declared as feasible, the next step is the drilling operation process. The process involves programming for drilling as a follow-up of Evaluation, Pre-construction, Construction, and Operation Drilling and up to Post-operation processes, such as shown in Figure 7. Each work stage will involve certain fields of expertise. In the evaluation process, for example, a geoscientist will propose a ready for drilling prospect, the drilling engineer will design the drilling program, and logistics will be in charge of material planning. The pre-construction stage will involve experts in topography, lawyers for land registration, and public relations officers.

Civil and mechanical engineers will be engaged in the construction stage. The drilling operation stage will involve various fields of expertise until the post-operation stage, and indeed, the work will also get the support from auxiliary experts like in finance and human resources development. Experts in health, work-safety, and environment protection will monitor all the activities related to these aspects. Thus, the oil and gas well drilling operation is an integrated activity of various scientific disciplines and inter-disciplinary approaches will be imperative for the Head of the drilling project to consider.

The operation cost of the exploration drilling includes costs for conducting all the above mentioned activities, like expenditures for surveys, licensing, land acquisition, and construction. The costs for drilling also include costs for materials and for services, and later on also the post-operation costs.

Country risks, namely the risk factors of industrial externalities, will have effects during the drilling operation stage. A drilling operation activity might be delayed if environmental risks in the area are not carefully computed beforehand. The following section will discuss this matter in detail.

Table 1. Country Risk Factors according to ICRO Rating System (Harvey, C.R., 1996)

Political, Economic and Financial Risk of Country	**% of Composite**
Political	
Economic expectations versus reality	6%
Economic planning failures	6%
Political leadership	6%
External conflict	5%
Corruption in government	3%
Military in politics	3%
Organized religion in politics	3%
Law and order tradition	3%
Racial and nationality tensions	3%
Political terrorism	3%
Civil war	3%
Political party development	3%
Quality of bureaucracy	3%
Total Political Points	*50%*
Financial	
Loan default or unfavorable loan restructuring	5%
Delayed payment of suppliers' credits	5%
Repudiation of contracts by government	5%
Losses from exchange controls	5%
Expropriation of private investments	5%
Total Financial Points	*25%*
Economic	
Inflation	5%
Debt service as a % of exports of goods and services	5%
International liquidity ratios	3%
Foreign trade collection experience	3%
Current account balance as % of goods and services	8%
Parallel foreign exchange rate market indicators	3%
Total Economic Points	*25%*
Overall Points	**100%**

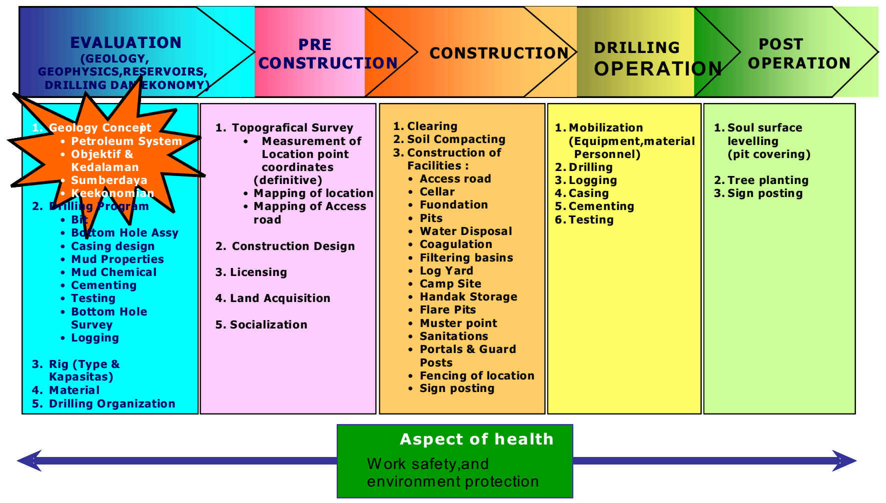

Figure 7. Flow of Activities of Exploration Drilling Operation

III. Issues of Investment in The DOH JBB Exploration Drilling Project

With the imposition of the *UU Migas* (Oil & Gas Law) No. 22 Year 2001, particularly in Indonesia, the oil and gas industries have been continuously changing. The application of the *UU Otonomi Daerah* (Law pertaining to Local Area Autonomy) had caused local area governments to have more freedom in enacting regulations related to increasing local area income. The other effect is rapid development of local areas as well as increased sensitivity of communities especially towards environmental impacts of industries, such as the oil and gas industry, and this development has become a special risk of concern to investment. The impacts had indeed affected PT. PERTAMINA DOH JBB, operating in the most densely populated area of Indonesia. Considering the condition, investments should be more selective and carefully planned. Figure 8 presents a simple illustration of the issues.

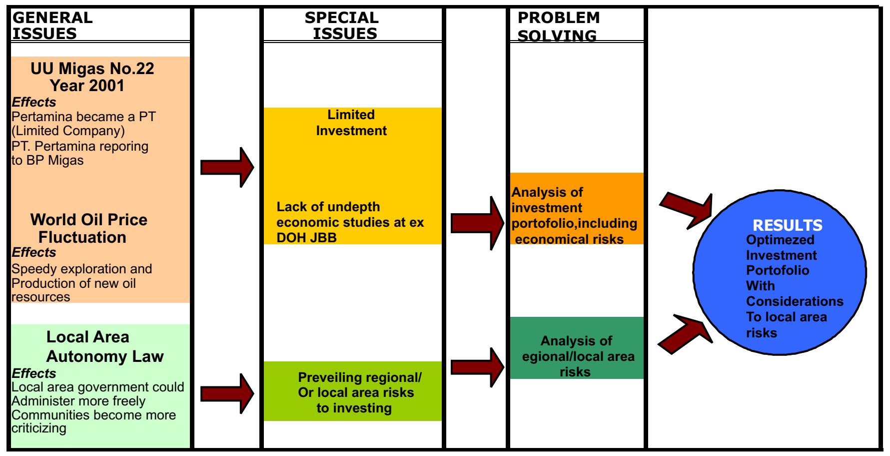

Figure 8. Outline of Issues

Exploration activities at DOH JBB, which is now managed by the Exploration Function, stretch over areas of all the regions and cities in the northern part of West Java to the northern part of Central Java, from Bekasi in West Java to Kabupaten Batang in Central Java. Considering the great stretch of the working area of PT Pertamina DOH JBB, the company is facing unexplored areas or zones with different risk levels, depending on characteristics of the local governments, communities, and environments. Meanwhile, the company's demand is to obtain maximum rate of return and sustainability of the oil and gas business at DOH JBB through the discovery of a new, commercially viable oil and gas reserve to replace the earlier oil and gas reserve already in production. The issues are, among others:

a. *Prevailing risk factors due to local area condition*

   Due to the imposition of the Law pertaining to Local Area Autonomy, local area governments have more freedom to control investments in their areas. At present, the selection of areas for exploration drilling will greatly depend on developments in the area, condition of the people, as well as the local area government. The drilling conducted this year in the area of Bekasi will have different rate of risks when carried out several years later.

b. *Lack of in-depth economic studies*

   So far, the DOH JBB Exploration Function had not yet conducted an in-depth economic evaluation on certain matters related to the project, for example, matters related to risk factors, not only sub-surface risks, like industrial environmental risks and economic risks. The evaluation process for the proposed DOH JBB exploration drilling is illustrated in Figure 9.

c. *Availability of investment funds*

   The change of Pertamina's status to become a corporation had made every spending of the investment budget to follow standard business principles. Thus, each investment for drilling should be based, not only on technical reasons, but also on available funding and therefore, investment drilling might be based on 'limited budget region' where every function will have a budget limit for investment. The DOH JBB Exploration Function should be able to produce a ranking of drilling investment activities based on the limited budget available.

As explained earlier, the above mentioned general issues (Oil and Gas Law No. 22 year 2001, world oil price fluctuations, Law pertaining to Local Area Autonomy) have great effects and at the same time, create problems for the Pertamina DOH JBB Exploration Function in particular. The problems are mainly related to three issues, namely, *limited investment funds, lack of in-depth economic studies*, and the *prevailing region/local area risks for investment*. The first and second problem will be approached using portfolio analyses and the third problem will be approached using the *region/area risk analysis*. The expected result from these analyses will be an *optimized investment portfolio with the inclusion of region/area risks*.

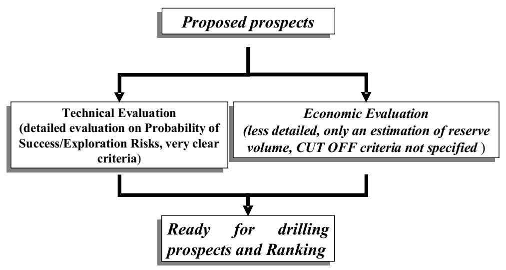

Figure 9. Evaluation Process of Proposed Drilling at DOH JBB Exploration

Table 2. Seven Exploration Drilling Projects that are going to be analyzed

NO	Wells	Location	Reserves	
			Oil (MMBO)	Gas (BCFG)
1	SGN	Cikarang	0	30
2	RKM	Karawang Tengah	18	0
3	BRK	Indramayu Timur	35	9
4	PGT	Bekasi Utara Timur	75	84
5	PCC	Indramayu Selatan	0	140
6	LNG	Karawang Barat	22	0
7	TDC	Karawang Utara	31	0

In this case study, the approach taken for problem solving is through taking seven proposed exploration wells, each located in different areas and with different reserve volumes, as well as different planned locations, as shown in Table 2.

IV. Problem Solving

4.1 Methodologies for Problem Solving

Two methods are used as an approach for Portofolio Analyses, *DCF Analysis* and *Decision Tree Timing Option* (with the inclusion of Economic Risk and Region Risk Factors). Meanwhile, analysis of *Region/Area Risks* is approached using a combination of modified Institutional Investor method and simplified ICRG. The final result of this problem solving methodology is the ability to rank the prospects of projects using DCF Análysis and Timing Option Analysis and to compare the results of both analyses. Figure 10 presents a flow diagram for problem solving.

The steps for problem solving in accordance with the flow chart is as follows:

1. Selection of prospective exploration projects for investments in the first year (in this case, seven drilling prospects are selected as case studies, such as listed in Table 2).
2. Calculation of estimated volume of oil and gas resources from each of the selected prospects (in this case the volume of resources have already been measured by the DOH JBB Exploration Function).
3. Determination of the economic level of the entire Project in general, the main outputs will be some Standard economic parameters such as NPV, IRR, PI, etc. The method for measuring will be in accordance to the standard formats already available at the DOH JBB Exploration Function.
4. Calculation of the Expected NPVdr, which is the output of Option I, using the Decisión Tree Análysis. The input data comprises of 12%, 16%, and 18% Discount Rate (dr), each with a probability of 0.25, 0.5 and 0.25 respectively, based on assumptions. For PI (Profitability Index) < 1.5, the assumption will be that Exploration will not make any investments.
5. Calculation of Expected NPVri3, which is the output of Option 2, using the Decisión Tree Análysis. The input data is the RI3 Index, which is a multiplication of the Region and Environment Probability Average (REPA) Index and the Investment Index for a time period of three years in the Project area.

6. Calculation of each ranked investment using the investment funds limited to USD 400 million using the DCF Standard method. In this case, PI is used, whereas outputs of Option 1 and Option 2 will use Zero-One Programming for the Decisión Tree Análysis.
7. Portfolio Análisis alter using both methods.
8. Recommendations for planning.

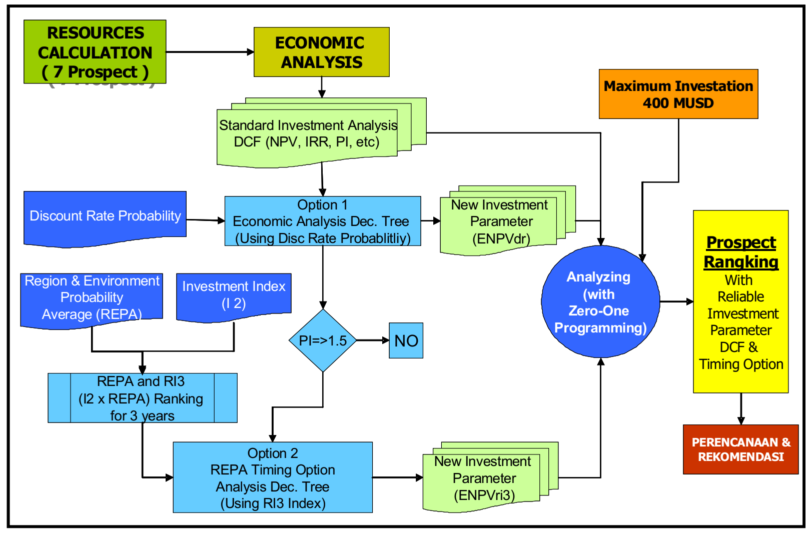

Figure 10. Flow chart for Problem Solving

4.2 Economic Evaluation of Projects

In this article, the economic factors for evaluation of the seven selected projects (such as listed in Table 2) are basic investment factors, such as NPV, IRR, POT and PI, measured and evaluated using the usual spreadsheet of the JBB Exploration Function. Table 3 presents the results of the economic calculation of the seven reserve wells.

Table 3. Data and Economic Calculation Results of Reserves at Seven Exploration Wells

Data and economic calculatation results of reserves at seven DOH JBB exploration wells Reseves

Cadangan	SGN	RKM	BRK	PGT	PCC	LNG	TDC
Oil Reserves (MMBO)	0	18	34.8	75	0	22.1	30.9
Gas Reserves (BCFG)	30	0	0	84	140	0	0
Operational Life	12	14	19	14	15	37	13
Ave. Production Oil (BOPD)	0	700	2300	1500	0	1200	2500
Ave. Production Gas (MCFD)	7000	0	0	10000	16000	0	0

Data and economic calculatation results of seven DOH JBB exploration wells economic appraisal

Keekonomian	SGN	RKM	BRK	PGT	PCC	LNG	TDC
Oil Price (US $/bbl)	35	35	35	35	35	35	35
Gas Price Perbarel (US/MCF)	2	2	2	2	2	2	2
Avg. Oil Cost (US$/bbl)	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Avg.Gas Cost (US$/MCF)	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Investment (MMUS$)	9,250.0	61,650.0	83,600.0	227,625.0	44,900.0	30,900.0	45,900.0
NPV (US$) @ 16%	3,373.7	21,360.8	51,426.7	151,672.6	12,829.4	35,938.6	77,884.3
IRR(%)	33.98	31.97	40.77	71.36	34.35	60.38	91.2
NPV/I	0.36	0.35	0.62	0.67	0.29	1.16	1.70
PI	1.55	1.61	2.06	2.5	1.54	2.93	3.82
POT	5.27	6.34	6.12	5.25	6.49	4.93	4.24
Sensitivitas NPV thd Disc. Rate							
12%	5,053.4	34,014.1	77,000.9	210,837.9	19,928.1	51,420.3	102,878.4
PI pd 12%	1.8	1.97	2.58	3.09	1.83	3.77	4.73
16%	3,373.7	21,360.8	51,426.7	151,672.6	12,829.4	35,938.6	77,884.3
PI pd 16%	1.55	1.61	2.06	2.50	1.54	2.93	3.82
18%	2,720.8	16,654.6	41,904.8	129,121.2	10,180.0	30,238.8	68,024.1
PI pd 18%	1.44	1.47	1.86	2.28	1.43	2.63	3.46

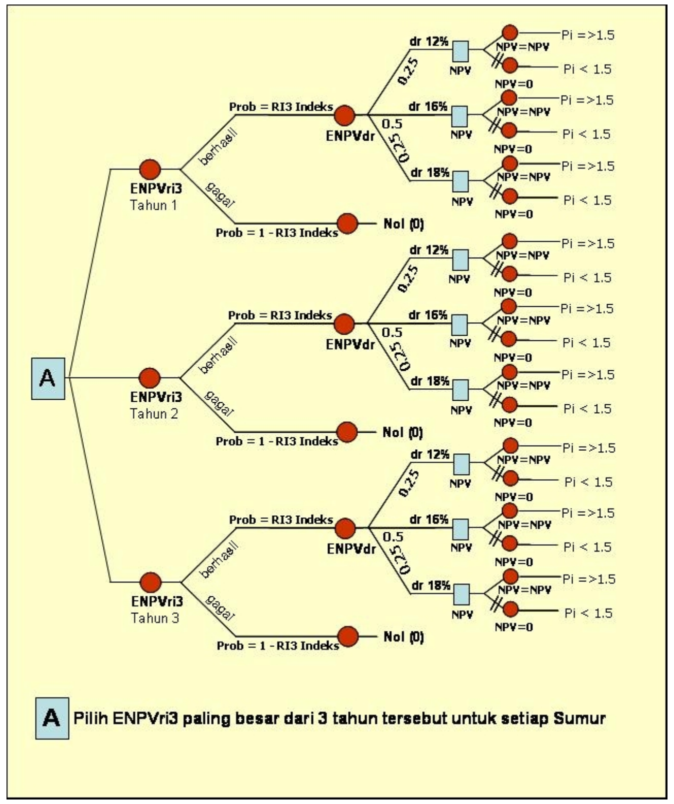

Figure 11. Flow Chart Decision Tree of Timing Option Analysis

4.3 Evaluation of Investment Portfolio

Two approaches are used for evaluating investment portfolio of the seven exploration wells related to the above mentioned issues, namely *DCF Analysis* and *Decision Tree Timing Option Analysis*.

4.3.1 DCF Analysis

The dynamically occurring changes are affecting all decisions, selections, and methodologies or procedures in oil and gas companies, such as the case with PT PERTAMINA (PERSERO) DOH JBB. The dynamic changes have encouraged the managers or decision makers to be more flexible in observing and appraising all the available opportunities and options comprehensively. One of the adjusted methodologies is project analysis and calculation as well as production of portfolios.

Today's frequently used methodology is the discount cash flow (DCF) method. This method appears to be less dynamic and not adequately flexible for being adjusted to the increasingly dynamic changes. Some research, such as brought forward by Bailey, W. et al. (2004), confirmed several limitations of the DCF method:

1. The DCF method is a static method as it assumes that a certain planned project is 'rigid' and could not be changed so that the management becomes passive and follows the original plan without paying attention to changes of situations.

2. The DCF method assumes rigid predictions and determinations. In practice however, it is often hard to estimate cash-flows and DCF often give too high or too low valuations on a project.
3. Almost all DCF analyses have been using WACC (Weight Average Cost of Capital) discount factor. Besides WACC, several companies use some 'hurdle rate' which might not represent actual the risks that are inherent in projects.

John Bridge (1994) mentioned that in the DCF analysis, the parameters usually used are NPV, IRR and PI. Ranking could be achieved through putting in the right order the highest scores of each of the respective parameters. Selection of investment is based on the highest rank. Nevertheless, this way could only be effective when it deals with single parameters. When more than one parameter is observed, ranking could still be obtained through the use of the *Incremental Analysis* approach (Arsegianto, 2005). In this case, the DCF Analysis uses the single approach, namely PI.

4.3.2 Real Option-Decision Tree of Timing Option

Almost every project is conducted within a certain period of time. Changes of situations would possibly provide some options or opportunities which might take place within the time period when the project is carried out.

Real options, also referred as managerial options or strategic options (Brigham & Enhardt, 2002) could be defined as opportunities to deal with changes of situations so that the managers would have some options (as rights, and not as duties) to control the running of a project to get better results. In the evaluation of a project or real assets (physical assets), the real options method is used, and as implied by its name, the method uses the well-established options theory provisions (Chimblo and Chimblo, 2004).

In general, the evaluation of a project as well as a business opportunity, using DCF or Real Option, will be based on cost-benefit analysis. The difference here lies on matters of risk handling (Lima & Suslick, 2002). One of the main components in the project evaluation (using the DCF method) is the Net Present Value (NPV). Gitman, L.J. (2003:446) differentiated the NPV obtained from DCF calculation with the NPV obtained from adding the value of real options to the traditional NPV, such as shown in the following equation:

$$NPV_{strategic} = NPV_{traditional} + Value\ of\ real\ options \qquad (5)$$

There are four important kinds of real options for investment, namely timing option, growth option, abandonment option, and flexibility option (Gitman, L.J., 2003:445; Brigham & Ehrhardt, 2002:596-597). Investment Timing Options are measurable using five different approaches, namely DCF Analysis Ignoring the Timing Option, DCF with a Qualitative Consideration of The Timing Option, Decision Tree Analysis of The Timing Option, Valuing the Timing Option with the Black-Scholes Model, and Financial Engineering

The issues in this case is the possible changes of discount rates and changes of government policies as well as sensitivity of communities in the drilling location surroundings, represented by the REPA (Region Environment Probability Average) Index. In this case, the REPA Index is designed for three years, thus, the Decision Tree Analysis of The Timing Option will be applied, using the approach as illustrated in the flowchart (Figure 11). The same will be done for the 2nd and 3rd year, and the best of the three years will be chosen.

Investment Timing Option is the conventional NPV analysis which implicitly assumes the projects that are to be accepted or rejected, implicating that the projects will be or not be taken for the moment. In practice however, the companies sometimes have a third option, namely to postpone the project until some later time when more information is available. With this option, certain projects could dramatically influence the estimation of probabilities and risks.

4.4 Region and Environment Probability Average Index (REPA Index)

De Ath (1997) explained earlier that Country and Environment Risk will have effects on 25% of the three risk factors (Geotechnical: 50%, Economic: 25%). ICRG interprets country risk into three kinds of risks (PR, ER, and FR). Indeed, this holds true for companies who are going to invest in a certain country, the values are the same for all areas/regions in that particular country.

With regards to Indonesia, particularly the areas of Java as the working area of PT Pertamina DOH JBB with all the earlier mentioned issues, it turns out that Regional or Local Area Risks, hereinafter referred as Region Risks, become the main issue related to dynamic developments in the area, as well as the communities and environments of the area. Region risks are especially due to the enactment of the Law pertaining to Local Area Autonomy, as local area governments and communities are having the opportunity to be more actively involved in economic development undertakings in their areas. Considering that there is yet no research carried out concerning this matter, especially in the DOH JBB exploration areas, informal discussions with the actors who are involved in DOH JBB exploration activities are conducted to obtain the risk index.

The discussions have produced five qualitative descriptions of region risks, namely Local Area Governments, Population, Environmental Issues, Community's Sensitivity, and Local Area Developments (see Figure 12). The higher the score (maximum score is 1) of the five respective categories of risks, the lower the Investment Risk Rate in the area. The figures for each of the wells are obtained from experiences of the writers and the exploration team while working at DOH JBB Exploration. Like *Institutional Investor* this approach is very subjective for the determination of *Country Risk,* nevertheless, through weighting of each of the respective criteria factors, this approach is basically a modified ICRG and Institutional Investor methods already discussed earlier.

Risk assessments are conducted on each of the respective wells for the five risk categories within a period of three years to produce the weighted average. The weighted average will then be called the *Region and Environment Probability Average Index (REPA Index)*. (See Table 4).

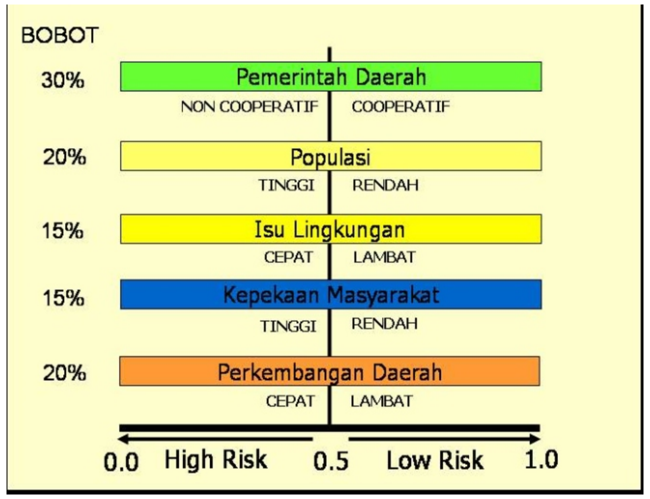

Figure 12. Five Issues of "Region Risk" at DOH JBB Exploration

REPA results indicated that investment risks are different from one area to the other area during the three successive years, as shown in the spider diagram (Figure 13). The diagram clearly shows that the PCC and BRK wells have an average REPA Index value of over 0.75 in three years, indicating that the region is still safe for investments from year 1 until year 3. The REPA Indexes for the PGT, RKM, and SGN wells decrease in year 2 and year 3. The SGN, RKM, and PGT have even shown a REPA Index to reach 0.5 after year 3, meaning that the areas have a growing risk for investments. Meanwhile, the LNG well is showing an increase REPA in year 2 when compared to the first year. This might be due to the assumption that in the early year there were some rejections from the local community, however, when investment was postponed until the second year, the community might demand for a the project to speed up, thus, increasing the REPA Index.

Table.4. REPA dan RI3 Indexes at Seven Exploration Wells

Results of REPA Index and RI-3 index (REPA index X investment index) within 3 years at seven exploration wells

Wells	Region	Year 1			Year 2			Year 3		
		REPA Index (RI)	Inv. Index (II)	RI 3 Index (RI x II)	REPA Index (RI)	Inv. Index (II)	RI 3 Index (RI x II)	REPA Index (RI)	Inv. Index (II)	RI 3 Index (RI x II)
SGN	Cikarang	0.76	1	0.76	0.50	0	0.00	0.46	0	0.00
RKM	Karawang Tengah	0.77	1	0.77	0.50	0	0.00	0.48	0	0.00
BRK	Indramayu Timur	0.84	1	0.84	0.82	1	0.82	0.77	1	0.77
PGT	Bekasi UtaraTimur	0.78	1	0.78	0.69	0.5	0.35	0.50	0	0.00
PCC	Indramayu Selatan	0.86	1	0.86	0.83	1	0.83	0.73	0.5	0.36
LNG	Karawang Barat	0.79	1	0.79	0.83	1	0.83	0.74	0.5	0.37
TDC	Karawang Utara	0.83	1	0.83	0.79	1	0.79	0.73	0.5	0.37

notes :
When REPA > 0.75, investment index = 1 (great probability for investment)
When REPA 0.50 - 0.75, investment index = 0.5 (investment probability = 50%)
When REPA < 0.50, Investment index = 0 (not good for investment)

The REPA Index is precisely indicating the probability for input in the calculation of the Expected NPVrepa, managerially however, it is for the management to decide for not investing when the region risk is high. To facilitate the calculation of Expected NPV, the Investment Index is supplied with certain limiting requirements, such as explained in the following section.

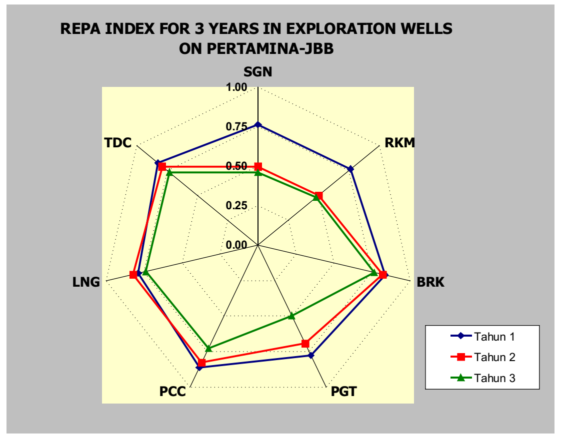

Figure13. Spider Diagram REPA Index of 7 DOH JBB Exploration Wells

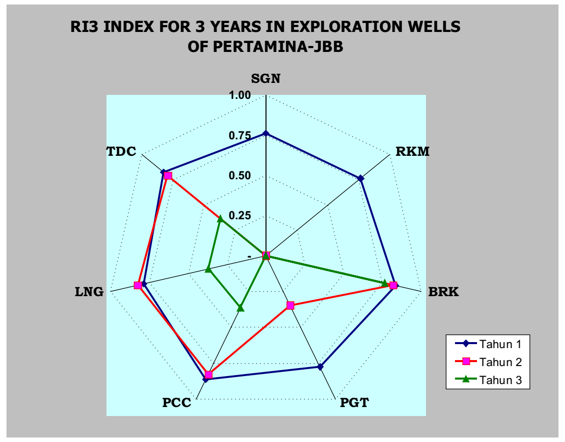

Figure 14. Spider Diagram RI3 Index of 7 DOH JBB Exploration Wells

4.5 Investment Index and RI3 Index

After obtaining the REPA Index, it will then be defined that for REPA scores of < 0.5, there will be no investment, for REPA scores between 0.51 and 0.75, the probability for investment will be 50%, and investments will certainly be conducted when the REPA score is greater than 0.75. The quantitative approach of the above qualitative investment is by deciding on the Investment Index (I2), where

REPA <= 0.5, then I2 = 0
REPA 0.5-0.75, then I2 = 0.5
REPA => 0.75, then I2 = 1

Multiplication of the REPA Index (RI) and the Investment Index (I2) will produce the Investment Probability based on Region Risk, referred to as RI3, where

$$RI3 = RI \times I2 \qquad (6)$$

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This Index is very effective for indicating investment probabilities in an area for a certain year, as illustrated for this case in Figure 14. After inclusion of the Investment Index (I2), the RI3 could then be obtained. With regards to the seven wells, the RI3 for the SGN and RKM wells in the 2nd and 3rd years is Nil (0), and therefore, investment for the SGN and RKM wells should be made in the first year, that is, if the company expects of not losing the investment opportunity in the area. The RI3 index for PGT well in year 3 is nil, thus, invesment should be made either in the first year or the second year. The RI3 index become an input for calculating the Expected NPVri3. Complete data of the obtained RI3 Indexk is presented in Table 4.

4.6 Calculation of Ecpected NPV through Inclusion of Sensitivity, Discount Rate, REPA Index and Ri3 Index (ENPVdr, ENPVrepa, ENPVri3)

Calculation of the Expected NPVdr (ENPVdr) is by multiplying the NPV discount rate (12%, 16%, 18%) and the probability of risks. The Expected NPVrepa (ENPVrepa) is obtained from using the decision tree method for three successive years by calculating the REPA probability REPA for each year and multiplying it with the ENPVdr.

Using the same method, the Expected NPVri3 (ENPVri3) is obtained from using decison tree for 3 years, calculating the RI3 probability RI3 of each year and multiplying them with ENPVdr. Table 5 presents the data processing results.

Table. 5. Calculation Results of ENPVrepa dan ENPVri3 for 3 sucessive years

SUMMARY
Expected NPV from repa index (ENPVrepa) and Expected NPV from ri3 index (ENPVri3)
(Calculated for Three Years)

Wells	Region	Year 1		Year 2		Year 3	
		ENPVrepa	ENPVri3	ENPVrepa	ENPVri3	ENPVrepa	ENPVri3
SGN	Cikarang	2,249.52	**2,249.52**	1,467.72	**0.00**	1,357.09	**0.00**
RKM	Karawang Tengah	14675.68	14,675.68	9,591.95	**0.00**	9,208.27	**0.00**
BRK	Indramayu Timur	46,292.20	46,292.20	45,460.60	45,460.60	42,411.42	42,411.42
PGT	Bekasi UtaraTimur	124,640.21	124,640.21	111,372.06	55,686.03	79,608.91	**0.00**
PCC	Indramayu Selatan	11,989.88	11,989.88	11,501.92	11,501.92	10,107.75	5,053.87
LNG	Karawang Barat	30,227.46	**30,227.46**	31,666.86	**31,666.86**	28,404.22	**14,202.11**
TDC	Karawang Utara	67,375.91	67,375.91	64,721.71	64,721.71	59,821.64	29,910.82

4.7 Use of Zero One Programming for Investment Portfolio Ranking Index

After calculating the Expected NPV for each of the respective indexes, each of the methods will then be ranked. Table 5 presents the complete data processing results. Through the inclusion of investment index, it becomes easier to produce the ENPVri3, as the ENPV will become nil in the first and second year. Therefore, it is clear that the management should definitely decide to invest on the SGN well in the first year. The same holds true for the RKM well, investment should be made in the first year.

In line with the explanation about the methodology, investment for all the wells is limited to only 400 Milion USD. For the Ranking of Indexes in the selection of portfolios, Gabriel.A.C. (2002) introduced several methods. The standard method is by using the Index Ranking of DCF, however, the weakness is that such ranking is of single nature. In this case, the Index Ranking used is the *Profitability Indeks* (PI).

4.7.1 Data Processing with Zero One Programming

Gabriel A.C. further explained another method for selection of portfolios, namely by using Zero-One Programming. Zero-one programming is a simple method for calculating the maximum return of an investment portfolio with a limited budget. The *Maximum Investment Portfolio Investasi* is expressed by

$$NPV\,max = \Sigma\, NPVi\, Xi \qquad (7)$$

Investments that become constraints are expressed by

$$\Sigma\, Ii\, Xi <= I \qquad (8)$$

The Xi value is a binary number (0 and 1), where, when Xi = 1, investment should be made and it will be the other way around when Xi = 0. I stands for Investment. This method is used for obtaining the ranking of wells where investments are going to be made, namely for the DCF and the Decision Tree Timing Option methods, after inclusion of Discount Rate Probability (ENPVdr) and ri3 index (ENPVri3). Table 6 presents a summary of data processing results using Zero-One Programming.

4.7.2. Analisa Hasil Pengolahan Data dengan Zero-One Programming

Results of using Zero-One Programming in DCF Analysis indicate that the SGN, BRK, PGT, LNG, TDC wells are worth for investments with a maximum NPV of US $ 320 Million and Investment of US $ 397 Million, and this is below the Maximum Investment of US $ 400 Million.

Concurrently, results of the Decison Tree Timing Option using ENPdr also indicate the same wells as the Zero-One Programming in DCF Analysis, however, with an ENPVdr of 339 M USD, which is greater than the DCF. Considering the results of Zero One Decison Tree Timing Option using ENPVri3, thus, investments will be made for SGN, RKM, PGT and TDC wells with a maximum ENPVri3 of 209 M USD and investment of 344 M USD.

Table 6. Data processing results using zero-one programming

SUMMARY OF ZERO-ONE PROGRAMMING
DCF ANALYSIS AND DECISION TREE ANALYSIS OF TIMING OPTION
FOR 7 EXPLORATION WELLS (WITH MAX. INVESTING 400 MUSD)

	DCF ANALISYS				DECISION TREE ANALYSIS TIMING OPTION					
Wells	Invesment (000)	NPV (000)	Zero-One	Investment decisions based on zero-one programming	ENPVdr (000)	Zero-One	Investment decisions based on zero-one Programming	ENPVri3 (000)	Zero-One	Investment decisions based on zero-one Programming
SGN	9,250.00	3,373.69	1	OK	2,950.19	1	OK	2,249.52	take	OK
RKM	61,650.00	21,360.75	0	NO	19,183.90	0	NO	14,675.68	take	OK
BRK	83,600.00	51,426.67	1	OK	55,439.76	1	OK	46,292.20	0	NO
PGT	227,625.00	151,672.60	1	OK	160,826.08	1	OK	124,640.21	1	OK
PCC	44,900.00	12,829.40	0	NO	13,941.72	0	NO	11,989.88	0	NO
LNG	30,900.00	35,938.60	1	OK	38,384.08	1	OK	30,227.46	postpone	NO
TDC	45,900.00	77,884.31	1	OK	81,667.77	1	OK	67,375.91	1	OK
			I =	397,275.00		I =	397,275.00		I =	344,425.00
			NPV =	320,295.87		ENPVdr	339,267.88		ENPVri3	208,941.33

Total investment fund USD 400.000.000

4.8 Portfolio Analysis using DCF Analysis dan Decison Tree of Timing Option Analysis

Observing the data processing summary of portfolio analysis presented in Table 7, using the DCF Analysis one could explain about the decision making analysis using the PI index. Based on the highest PI ranking, there are four wells prospective for investment, TDC, LNG, PGT, and BRK with a total investment of US $ 388 Million with NPV of US $ 317 Million. Using the Zero-One Programming such as shown in Table 6, the prospective wells become five, namely SGN, BRK, PGT LNG, and TDC with a total investment of US $ 397 Million (still below the maximum investment of US $ 400 Million) with NPV of US $ 320 Million.

Table 7. Ranking of Investments using DCF Analysis and DT of Timing Option

SUMMARY
DCF ANALYSIS AND DECISION TREE ANALYSIS OF TIMING OPTION
FOR 7 EXPLORATION WELL (WITH MAX. INVESTING 400 MUSD)

		DCF ANALYSIS				DEC. TREE TIMING OPTION ANALYSIS	
Wells/ Prospects	PI	Investment Decision based on P1 ranking	Invested Wells In year 1	Investment decisions based on zero-one programming	Invested Wells In year 1	Investment decisions based on zero-one programming	Invested Wells In year 1
SGN	1.55	NO		OK	SGN (5)	OK	SGN (1)
RKM	1.61	NO		NO		OK	RKM (2)
BRK	2.06	OK	BRK (4)	OK	BRK (4)	NO	
PGT	2.5	OK	PGT (3)	OK	PGT (3)	OK	PGT (4)
PCC	1.54	NO		NO		NO	
LNG	2.93	OK	LNG (2)	OK	LNG (2)	NO	
TDC	3.82	OK	TDC (1)	OK	TDC (1)	OK	TDC (3)

After the inclusion of Economic Risk (ENPVdr) and Region Risk (ENPVri3), the rank of investment options will also change. Using the Decison Tree of Timing Option Analysis, the investment decision with considerations on region risk such as explained earlier will be SGN, RKM, PGT and TDC with a maximum ENPVri3 of US $ 209 Million and an investment amounting to US $ 344 Million.

It could then be concluded that when the company would like to invest and based on considerations of region or local area risks in accordance with requirements already explaiend earlier, the investment should be carried out in the respective sequence, namely the SGN, RKM, TDC, and PGT wells, such as shown in Table 7.

V. Conclusions and Recommendations

5.1 Conclusions

1. The Investment Portfolio Analysis approach using the Decision Tree of Timing Option proves to present different results when only the DCF Analysis approach is being used.
2. The gist of one of the Timing Option method is the inclusion of risk factors that are always changing every time.
3. Appraisal of the region/area risks as an input for calculating the Timing Option value. In this case, the DOH JBB had never appraised the risks, qualitatively nor quantitatively, in the economic calculations.

5.2 Recommendations

1. The methodological approach in Appraising Region/Area Risks discussed in this paper would still need further improvements through a special research to be conducted by a Team with competence in risk analysis.
2. The other effect of this surface risk appraisal is that besides for optimizing investments, it could also be used as initial inputs in cost estimation, with the assumption that the risk could be minimized through additions in the cost components.
3. To be able to observe further the economic appraisal, it is suggested for DOH JBB to establish the Investment Portfolio Team for exploration undertakings.

Hopefully, the findings could benefit the decision makers as an introductory analysis for investing in connection with the problems facing DOH JBB.

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