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Volumetric and Economy - Consideration of Gas Field Development in the Andaman Sea – Offshore Aceh

Sampe L. Purba[1], Purnomo Yusgiantoro[2],Yanif Dwi Kuntjoro[3], Rachmat Sudibyo[4]
Herlina J.R. Saragih [5]

[1,2,3,4,5] *Universitas Pertahanan Indonesia (Indonesia Defense University)*
[1] *sampepurba@gmail.com,*[2]*purnomoys@gmail.com,*[3]*yanifdkuntjoro@gmail.com,*
[4]*rsudibjo@gmail.com,*[5] *herlinsara897@gmail.com*

Abstract

This modeling is a simulation study bridging the prespective of the micro-corporate aspect vis a vis the government's macro interests in monetizing gas in the Andaman Sea border region of Aceh. The yardstick hurdle for investors in the upstream Production Sharing Contract (PSC) to go or not for a project is the Internal Rate of Return (IRR), or Minimum Accepted Rate of Return (MARR). However, the government's interests are beyond that. The macro and long-term comprehensive objectives are justified on cost benefit analysis. Among other things, the Government instrument in public policy of PSC are fiscal terms contracts, taxes and gas pricing. The case study was carried out using quantitative method. The area of study is in the North Sumatra Basin (NSB), a rich basin in the Andaman Sea – offshore Aceh, in a frontier exploration area where the play concept has yet to prove. Estimated Ultimate Recoverable (EUR) volumetric is derived by Monte carlo probabilistic approach. Decision tree analysis result suggests that the development of a gas is better on partial stage when uncertainty is considerably high existed. The sensitivity analysis shows that the gas price element is the most sensitive parameter, compared to other policy instruments. Pareto efficiency is obtained at the point where the fiscal terms, gas prices and taxes are set in such a way that provides optimum compromise benefits to the stakeholder parties comprise of corporations, the government and the local economy. However, delays in taking and executing a decision will have a detrimental impact on the IRR Contractor and also to all other beneficiaries.

Keywords— estimate ultimate recoverables, reserves, economics, volumetric, montecarlo simulation, decision tree analysis, pareto efficient

INTRODUCTION

From a geostrategic and geo economic perspective, the province of Aceh - on the western and Indonesian borders, has a strategic role in the contemporary constellation of nations [1]. The unlocking of opportunity of natural resources is considered as one breakthrough to boost economic development in the region. This in turn will increase welfare and strengthen borders from a national perspective. This gas monetization modeling is a simulation study bridging and mending the interests of the micro-corporate perspective with the government's macro objective of the region.

The hurdle rate and yardstick for investor in any virtue is to pursue a project is a measurable, micro and concrete Internal Rate of Return (IRR), or Minimum Accepted Rate of Return (MARR). In terms of risk and return the IRR is a good indicator of spreads taking into account the overhead costs, risks, margins, and profits, while the discount factor reflects the cost of capital, both own corporate capital and loans (Purnomo Yusgiantoro, 2018)

On the other hands the government's interests are macro and long-term abstract based on benefit cost analysis. The government instrument in public policy to balance the interest of investor and the public are contract fiscal terms, tax and the pre set of gas price. The case study model was conducted by proxy in one PSC working area in the North Sumatra Offshore Basin of Andaman Sea – Aceh, a frontier play area where the amount of oil and gas reserves has not been proven and there is no oil and gas exploitation activity in the surrounding fields.

The modelling is carried out using a modified resource report approach, to calculate the amount of gas to commercialize. The decision tools parameters are decision tree analysis (DTA), the expected monetary value (EMV), and the internal rate of return (IRR) plug into the spreadsheet of PSC economy model.

Previous Studies

Previous research revealed that the offshore North Sumatra Basin has not been explored much (Hakim, Sibarani, & Syaiful, 2019), (Elders, 2020). In their presentation, Meckel III (Lawrence D. Meckel III, 2012) added that the Offshore North Sumatra Basin (NSB) are areas whose exploration has not yet matured. Indeed, speculatively the research claims there is a strong parallel with the mature other land area of the basin.

As of 2012, there have been 500 wildcat wells in the NSB onshore basin that were drilled. Meanwhile in the sea, which covers 75% of the area of the basin, only 42 wells have been drilled. These wells are shallow wells drilled before the 1970s. In the last ten years, only 10 wells in the sea have been drilled Meckel, III et al (Lawrence D. Meckel III, Michael Gidding, Michael Sompie, Mulyono Banukarso, Amalia Setoputri, Mayesta Gunarto, Novri Citajaya, Andre Abimanyu, 2012) .

Limited explorations accomplished in the past found only one producing basin, in addition to a number of uneconomical discoveries and several unsuccessful wells. The study also revealed that the 2-dimensional seismic interpretation revealed that there are still many oil and gas structures prospects in the North Sumatra Offshore Basin. The Aceh offshore will still attract many exploration companies to lay their virtue there.

The resource calculation approach with the 2D and 3D survey results approach was reported and presented by Fuji et al in the Offshore Technology Conference, 2008 in a paper entitled Resource Assessment of Methane Hydrate in the Eastern Nankai Through, Japan (Fujii T, Saeki T, 2008). The resource assessment in this study was for gas hydrates in the East Nankai Trough, using 2D/3D seismic data and drilling survey data from the METI exploratory well "Tokai-oki to Kumano-nada". The amount of methane gas hydrate in various layers was measured by the volumetric method in each zone. The parameters inputs are gross rock volume (GRV), net-to-gross ratio (N/G), methane hydrate saturation (Sh), porosity, cage occupancy, and volume ratio using a probabilistic Montecarlo distribution simulation using Crystal Ball 2000 software.

In the process of evaluating exploration prospects, Otis and Schneidermann (Robert M. Otis, 1997) demonstrated that based on the play concept and the hydrocarbon system, it could actually be used as a basis for planning an exploration program. In terms of priority choice (decision tree analysis), the prospect ranking, budget availability and technology management are carefully screened. Other things that are important to consider are geological risk assessment, volumetric estimation, engineer support, economic evaluation and post-drilling input as well as fiscal terms. But the main reference in the assessment is the concept of play, namely source rock, reservoir, traps including seal, as well as dynamics of migration.. This method is widely adopted in geology for screening the exploration program.

In the case of very limited data, the Montecarlo approach is one that is commonly used (Dadang Rukmana, 2012). The Montecarlo simulation approach requires random numbers and repetitions many times. Several parameters required are porosity, water

saturation, bulk volume, closure area, net pay and recovery factor. With the assistance of crystal ball software, this can be concluded better. Crystal ball is a software developed by Oracle, a spreadsheet-based application that is widely used for predictive modeling, forecasting, simulation and optimization.

One of the economic calculation modeling is reported by IHS Markit study (Markit, 2021) off the Andaman Sea – Aceh. Gas resources under that study are located in a lightly and prospective area categorized as high impact well targeting large prospects and plays in frontier and emerging basins. The development scenario model is assumed by drilling 8 designed subsea wells, piped to a submersible platform. Gas is delivered and transmitted to a gas receiving facility at Arun Facilities on land, 85 kilometers away. With a reserve range of 0.5 – 4 TCF, the modeling shows a minimum economic field size of 1.5 TCF to achieve zero NPV at a 10% discount factor.

Methodology

The economic modeling of this study uses four decision analysis tools. The first is to calculate the amount of oil and gas reserves to monetize. The second is a decision tree analysis to determine the priority of the project to be developed. The third is conducting economic exercise, and the last is considering the alternative policies to be taken.

The quantitative data in this study is a proxy dummy data on oil and gas resources in one of the Andaman Oil and Gas Working Areas. The input parameters are information regarding the structure, reservoir and volumetric, geological chance factor in each structure. The selection model approach in decision tree analysis is to rank and calculate volumetric based on the results of geological risk in each play, create a production profile, make assumptions about field development models, and develop an economic model on choices based on the results of the decision tree. There are four plays, where in each play there are a number of structures. Montecarlo simulations were carried out in each structure. Then the sum in each structure, clustered into four groups.

Volumetric reserves calculation order of steps

a. The collected results of 2 Dimensional and 3 Dimensional survey studies in the North Sumatra Basin exploration work area inputted to the software application. The input parameters include volumetric, reservoir, geological chance factor, structure and summary report Resources Initial Petroleum In Place (IPIP) and Estimate Ultimate Recoverable (EUR)

b. The volumetric for EUR is calculated using the Crystal Ball tool using the proxy dummy numbers report above. The proxies include simplification of resources as dry gas and crude oil without condensate, assuming a normal range of impurities and reservoir gas pressure.

c. The results of Montecarlo Volumetric from each structure are aggregated and grouped per cluster play. As such, please be noted that the results of this simulation are solely for study purposes, and not intended as a real picture in making investment decisions.

d. Estimate Ultimate Recoverable Resources figures, using the results from the Montecarlo simulation for the cumulative distribution function at P10, P50 and P90

e. The Initial Petroleum In Place (IPIP) figure is calculated inversely proportionally by mirroring the recovery factor in the resource report.

f. Reserves apportioned are set differently in each cluster play by taking into account the results of survey studies, geological factors and other relevant reports such as reservoirs, structural configuration, source rock, play maturity, analogues and their presence in the targeted Andaman Sea Working Area – North Sumatra basin, as well as resource reports.

g. The Reserves P50 figure is used as the basis for decision tree analysis (DTA), expected monetary value (EMV) and economic calculations (IRR)

Volumetric calculation

In this simulation, an overview of the parameters used in each structure is as follows:

	Low	Mid	High	Mean	Standard Deviation
Porosity	xx	xx	xx	xx	xx
Initial Oil/ Gas Saturation	xx	xx	xx	xx	xx
Gross Rock Volume	xx	xx	xx	xx	xx
Oil or Gas Shrinkage	xx	xx	xx	xx	xx
Recovery Factor	xx	xx	xx	xx	xx

Result

Based on the Montecarlo on P 50 simulation, the following results are obtained :

	Cluster Play A	Cluster Play B	Cluster Play C	Cluster Play D
Unit (Gas- BSCF, Oil – MMSTB)	Gas	Oil	Gas	Oil
Initial Petroleum in Place	21,349	8,041	1,480	76,143
Estimate Ultimate Recoverables	15,265	2,743	1,115	25,464
Reserves	4,580	274	223	255
% of Reserves to EUR	30%	10%	20%	1%

The recovery factor in the data above shows a normal range, where gas is around 70% while for oil it is around 30%. For simulation purposes, reserve was adjusted down from EUR with different amounts or percentages for each play. This is envisaged with conservative and intuitive critical considerations such as different geological data in each cluster with regard to reservoir type, structural configuration, source rock, play maturity, analogy with other fields and its presence in the Andaman area studied. Also by taking into account the data based on survey types and geological chance factors in each play.

Reserve figures P10, P50, P90 are used to calculate the economic simulation. The probabilities in each play are as follows.

	BCFE			MMBOE		
Play	P10	P50	P90	P10	P50	P90
A	9,995	4,580	1,685	0	0	0
B	0	0	0	775	274	60
C	500	223	79	0	0	0
D	0	0	0	417	255	141
Reserves	10,495	4,803	1,763	1,192	529	201

In the appendix, one of the results of the Montecarlo simulation using crystal ball application is shown on a structure under 10,000 iterations.

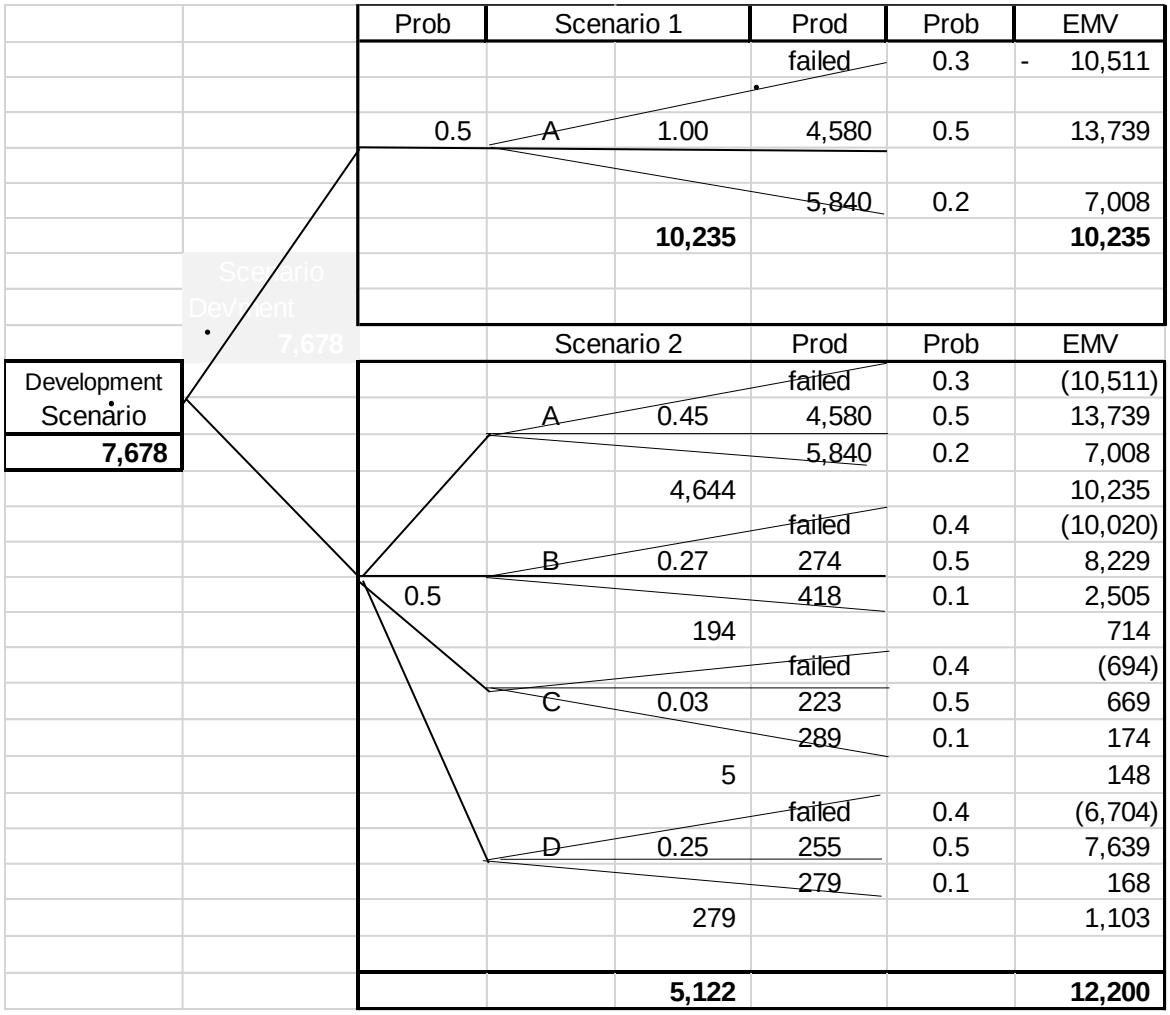
Decision Tree Analysis

Decision tree analysis (DTA) is one of the models used in decision making under uncertainty in various possibilities (probability) (Mian, 2002). In this study, DTA is used for decision making related to the scenario modeling of the oil and gas structure development that will be carried out.

Based on the best value from the various scenario options, it will be determined which model is then simulated/exercised for the IRR (Internal Rate of Return) economic test.

For the calculation of decision tree analysis, the results of the Montecarlo P50 are used. To get the monetary value, the gas price is assumed to be $6 per mmbtu and the crude oil price is $60 per barrel. The gas price of $6 per mmbtu for domestic use has long been the Government's favorable target[2]

The results of the decision tree analysis are as follows:



[2] https://jakartaglobe.id/multimedia/jokowi-asks-ministers-lower-gas-price-6-per-mmbtu

In this decision tree analysis, there are two scenarios. The first scenario is to develop Play A only. Subject to the Play A satisfactory results, then Play B, C and D will be developed accordingly. While the second scenario is to develop all four plays at once. Decision tree analysis demonstrates that scenario one that develops Play A as first stage option provides a better Expected Monetary Value, which is 10,235. Meanwhile, if it is developed concurrently, the project will yield 5,122 . The overall development of this scenario gave a positive result of 7,678 to the portfolio. This is a strong interpreted message that the overall play is indeed very promising.

The data collected under the study is still very limited. The available data is from the record and the interpretation of 2 D and 3 D seismic survey along with the analogue with the adjacent similar geological properties. In accordance with the rule of thumb calculation of reserves as referred to in the guidelines on the framework classification of resources issued by the world petroleum council, regarding the Petroleum Resources Management System (SPE, AAPG, WPC, SPEE, 2011), there are wide range of uncertainties ranging from prospective resources, contingent resources, reserves to production).

Based on these considerations, and by studying at the contemporary average gas field in Indonesia at average of average of 0.5 TCF field size, for economic calculations, the EUR resulted from montecarlo is highly discounted for simulation. The assumption of a development of 2 TCF will be used. Size 2 TCF generally is categorized as medium-sized field, while size 5 TCF has been classified as a giant field with a more complex development scenario, including the possibility of converting it into LNG (Hyne, 2001). By taking proportionally the Reserves figures P90, P50 and P10 from the above calculation, what if scenario of Expected Monetary Value is calculated, with the following results:

EMV Calculation				
Reserves		NPV Contr@10%	Prob.	EMV
740	P90	(263.16)	0.25	- 65.79
2,000	Base	577.08	0.50	288.54
4,364	P10	1,488.77	0.25	372.19
	Outcome	1,802.69	1.00	**594.94**

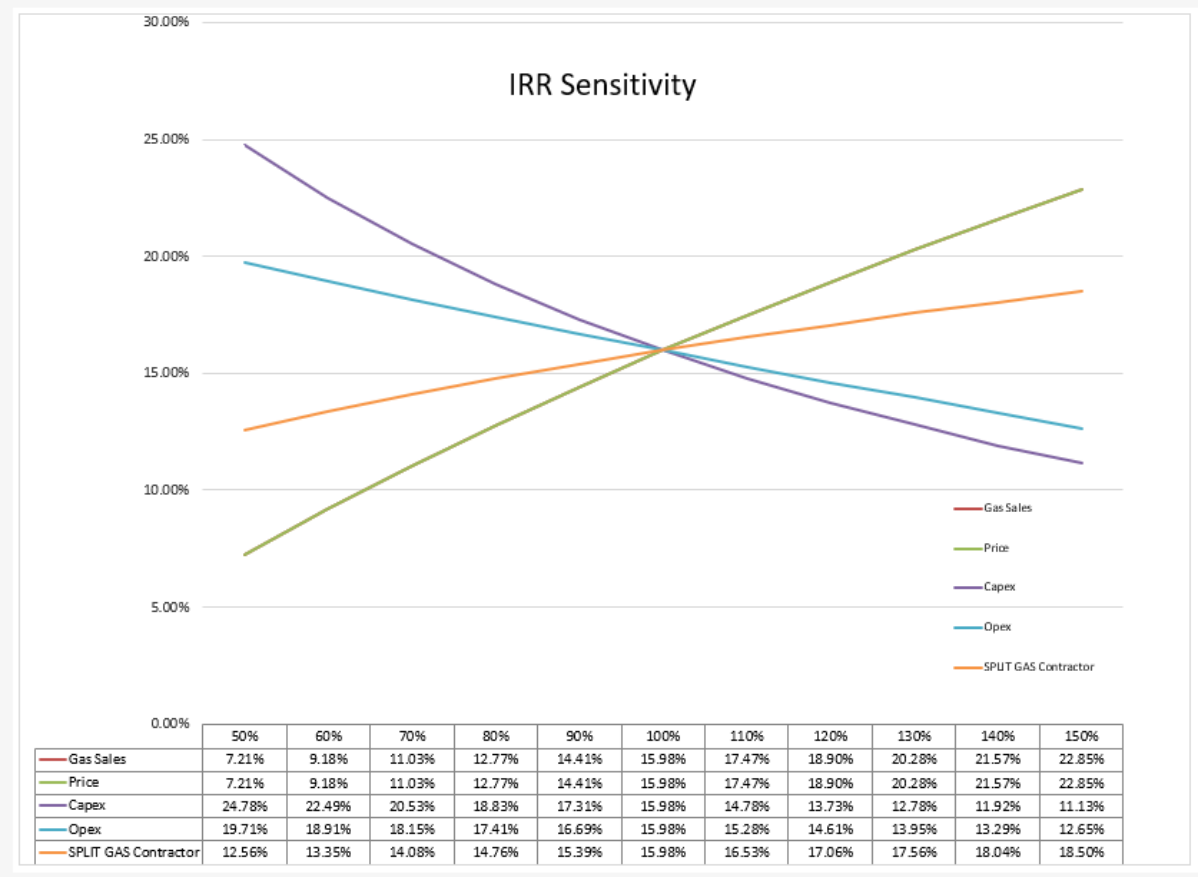
This calculation shows that Project in Play A delivers a positive EMV.

Economic Scenario – IRR based yardstick approach

The economic calculation based on 2,000 BCF or 2 TCF is as follows:

Economic Parameter	Basis PSC	Policy INSTRUMENT				DELAY EFFECT 2 yrs		DELAY EFFECTS 5 YRS	
	0	1	2	3	4	IRR	Gas Price	IRR	Gas Price
Contr. Cash Flow	3,199,680	3,811,428	3,992,908	4,265,156	4,073,557	4,101,084	5,504,291	4,188,824	7,237,620
Contr.NPV @10% DF	349,379	562,289	577,084.71	591,996	499,702	274,626	650,741	86,907	784,332
MARR or IRR 15%	13.78%	16.01%	15.98%	15.78%	14.82%	12.30%	15.11%	10.65%	15.08%
POT	6.34	5.64	5.76	6.09	6.52	5.77	4.78	5.22	3.51
PV Ratio @10%	0.32	0.51	0.53	0.54	0.46	0.25	0.59	0.08	0.72
Gov. Take	5,337,435	6,473,539	4,544,206	3,398,033	2,715,705	4,640,020	6,355,052	4,701,339	8,427,645
Gov.NPV @10%DF	1,392,937	1,690,309	1,165,231	895,179	732,332	991,989	1,370,123	877,228	1,606,999
Disc Factor	10%								
Policy Instrument									
Harga Gas/ MMBTU	6	7	6	5.5	5	6	7.75	6	9.75
Effective tax rate	44%	44%	40%	40%	40%	40%	40%	40%	40%
FTP	20%	20%	10%	10%	10%	10%	10%	10%	10%
After tax split									
Contractor	35%	35%	45%	55%	60%	45%	45%	45%	45%
Government	65%	65%	55%	45%	40%	55%	55%	55%	55%

The IRR sensitivity graph



	50%	60%	70%	80%	90%	100%	110%	120%	130%	140%	150%
Gas Sales	7.21%	9.18%	11.03%	12.77%	14.41%	15.98%	17.47%	18.90%	20.28%	21.57%	22.85%
Price	7.21%	9.18%	11.03%	12.77%	14.41%	15.98%	17.47%	18.90%	20.28%	21.57%	22.85%
Capex	24.78%	22.49%	20.53%	18.83%	17.31%	15.98%	14.78%	13.73%	12.78%	11.92%	11.13%
Opex	19.71%	18.91%	18.15%	17.41%	16.69%	15.98%	15.28%	14.61%	13.95%	13.29%	12.65%
SPLIT GAS Contractor	12.56%	13.35%	14.08%	14.76%	15.39%	15.98%	16.53%	17.06%	17.56%	18.04%	18.50%

The following are further elaboration of the various scenario and sensitivity analysis

i. Policy Instrument :

0. Base PSC – base model

For exercise purpose, the standard PSC fiscal terms contained in the PSC is used. At a gas price of $6.00 per mmbtu, the IRR is 13.78%. Thus, from a micro Contractor/Investor perspective, this Project will not be executed.

1. Policy Alternative one : to increase gas prices

In policy alternative one, the model is still using the standard PSC terms. It turns out that in order to pass the hurdle rate, it is necessary to increase gas price. With a gas price of $7.00 per mmbtu, the IRR is 16.01%. From the micro side (Investor's Perspective), of course this is something encouraging. However, from a macro perspective (Government's perspective), raising prices is not always a favorable option.

2. Alternative policy two – increase the share of the Contractor/Investor's profit sharing

High gas prices will make it difficult for the downstream side of the industry. In the industrial value chain, the price of gas from upstream plus the cost of transmission, and distribution costs, will be a burden that is ultimately pass through to the end user or consumer, whether the consumer uses it as feedstock or fuel. In alternative two, the gas price is maintained at $6.00 per mmbtu. The price of $6.00 per MMBTU is one of the Government's basic policies for certain group of gas users, such as referred to in Government Regulation number 121 of 2020 .

To compensate, kept whole and maintain the IRR of Investor according to the hurdle rate test, the Government's share is reduced. In this exercise, when the split of the government's share is reduced by 10% to 55%, and to be added to the Contractor's share, to become 45%, it will end up with an IRR of 15.98%. The applicable tax rates is applied in line with the evolution of PSC regime fiscal terms. In addition, FTP was reduced from 20% to 10%. In several generations of upstream oil and gas contracts, the decline in FTP is one of the instruments option available to the Government in determining fiscal terms (Rusamseno, 2017)

3. Policy alternative three – Further reduction Split the Government's share to a minimum and push lower gas prices further.

In this third alternative, the Government's share is reduced to almost a minimum level, at 45% before tax. With an effective tax rate of 40%, basically the remaining portion of the Government as Non-Tax State Revenue is only left at 5%. For the Aceh region, this method is not very favorable. This is mainly because in Law No. 11 of 2006 concerning the Government of Aceh, Article 181 paragraph 3 specifically stipulates that there is an additional 55% oil revenue sharing fund and 40% from gas which is the Aceh Government's revenue. By reducing the Government's share to 5%, it can provoke negative sentiment among local elites and actors. It can be interpreted directly, such reduction will significantly disrupt the fiscal regional capability of the Aceh Government to finance its development, and indirectly enforcing the region to rely on National Central Government.

On the other hand, a decrease in gas prices to $5.5 is indeed good to the downstream side. However because the current industrial consumers who use gas is not exclusively in Aceh Province, but mainly are channeled to the neighbor province of North Sumatra Province through the transmission line, meaning that the direct the benefits and outcome is not on the Aceh Province. On the other hand the disincentive from the reduction in profit sharing has a direct impact to local government finances.

Furthermore, from the investor/contractor perspective, the decrease in gas prices compensated by increasing the contractor's share split also did not make it better off. As can be noticed in the exercise spreadsheet, the scenario of increasing the Contractor's share will result in a decrease of the Contractor's IRR from 15.98% to 15.78%.

The IRR sensitivity graph shows that price is the most sensitive parameter compared to the others. For example, if the gas price is increased by 10%, the IRR will increase to 17.47%, while the increase in Contractor split by 10% will only increase the IRR to 16.53%. The slope (slope) of the price line (which is also commingle with sales line), which is steeper moving from the lower left to the upper right, indicates higher sensitivity, and the change (delta) of price moves in the direction of the change in IRR. Likewise, the reduction of operational expenditure (opex) by 10% will

increase IRR to 16.69%. But the reduction of gas price by 10% will decrease IRR to 14.41%

4. Policy alternative four – lower gas prices, with compensation for a reduction in the Government's split (profit sharing), to ZERO, and receive only part of the tax

In this scenario, to get a lower gas prices to $5.00 per mmbtu, the split or government entitlement is reduced by 40%, thus equaling to the effective tax rate. That means, the government's share is only from taxes.

The exercise in excel above shows that such alternative policies are not in line with the expectations of the parties. The Contractor's IRR fell below the hurdle rate to 14.82%. On the other hand, the Central Government and Regional Governments do not get a share of the profit sharing (entitlement). Bear in mind that the entitlement is one of the specific effective fiscal instruments utilized by the Government for fiscal transfers to the regions. The addition of profit sharing beyond what is generally applicable, is one of the privilege features of the Aceh Province from a financial aspect, as stipulated in Article 181 of the Law on Governing Aceh.

Of the five exercise scenarios, the most viable policy alternative for all parties is the second policy alternative. From the micro aspect, the solicitude of the Contractor are maintained with the IRR yardstick. On the other hand, from the macro aspect, the interests of the Central Government and the concerns of the Regional Governments are also well balanced and maintained. The interests of the public or gas user industries are also considered to have been considered in terms of willingness to pay, as implied in the gas price policies undertaken by the Government. In public policy theory, this optimal choice is known as pareto efficiency (Luc, 2000), (Boadway, 1997)

ii. Delay effect

In the exercise above, the two rightmost columns based on the scenario of the fiscal terms as referred to in alternative two. However, the result shows if the project is executed late, the negative effect is very significant. Assuming a production delay of 2 years, although it can still monetize the total reserve of 2 TCF, it turns out that by maintaining the price of $6, the Contractor's IRR resulted in very bad results, down to 12.3%. To maintain the hurdle rate at the 15% IRR, it is necessary to increase the gas price to $7.75 per mmbtu, or more than 25%. The longer the delay, the worse the impact. Of course this will not make the Project more economical and competitive on the downstream side.

A proper decision making process is of important in project (Payne, Bettman, & Luce, 1996). In practice, the causes of project delays are mainly categorized in three factors. One is internal to the corporation (technical, operational and commercial factors). The second factor are fingered out due to the government yard (for instance slow and complex licensing process, bureaucracy and approvals, or changes in rules). The third one, are external factors, such as disturbance and security factors, disasters and internationally related matters.

Conclusion

There are three important things that are the conclusions of this study, namely:

First: To make a simulation of economic calculations, rational conservatism is needed, to discount the total estimated ultimate recoverable resources to a reasonable level. The conclusiveness of the drilling data and subsequent production performance will be able to be improved as necessary

Second: Corporations and the Government must have a flexibility compromise points to find a balance consideration between the micro aspects of the internal rate of return and the macro aspects of abstract benefit cost analysis. The use of sensitivity analysis tools will help the parties to more easily justify decisions

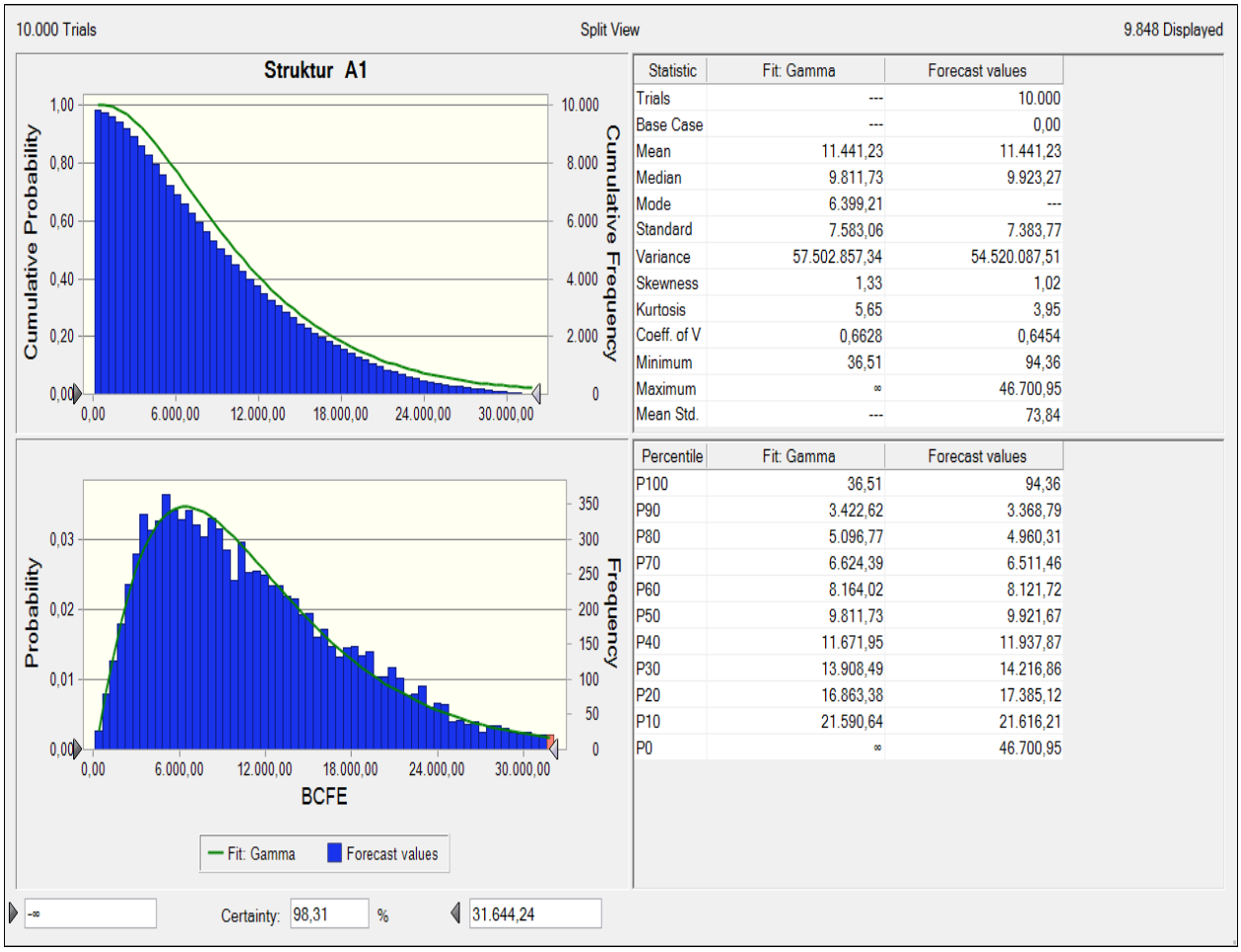
Third: Delays in making decisions and execution have a detrimental impact on investors, the government and the community. Optimizing the use of natural resources such as gas is very important as part of the welfare

approach to increase national resilience in border areas, especially in Aceh region who has a geostrategic position the tip of the Malacca strait choke point to the Andaman Sea.

Acknowledgment

We would like to thank the Directorate General of Oil and Gas Indonesia, SKKMIGAS and BPMA for the discussion, input and modeling.

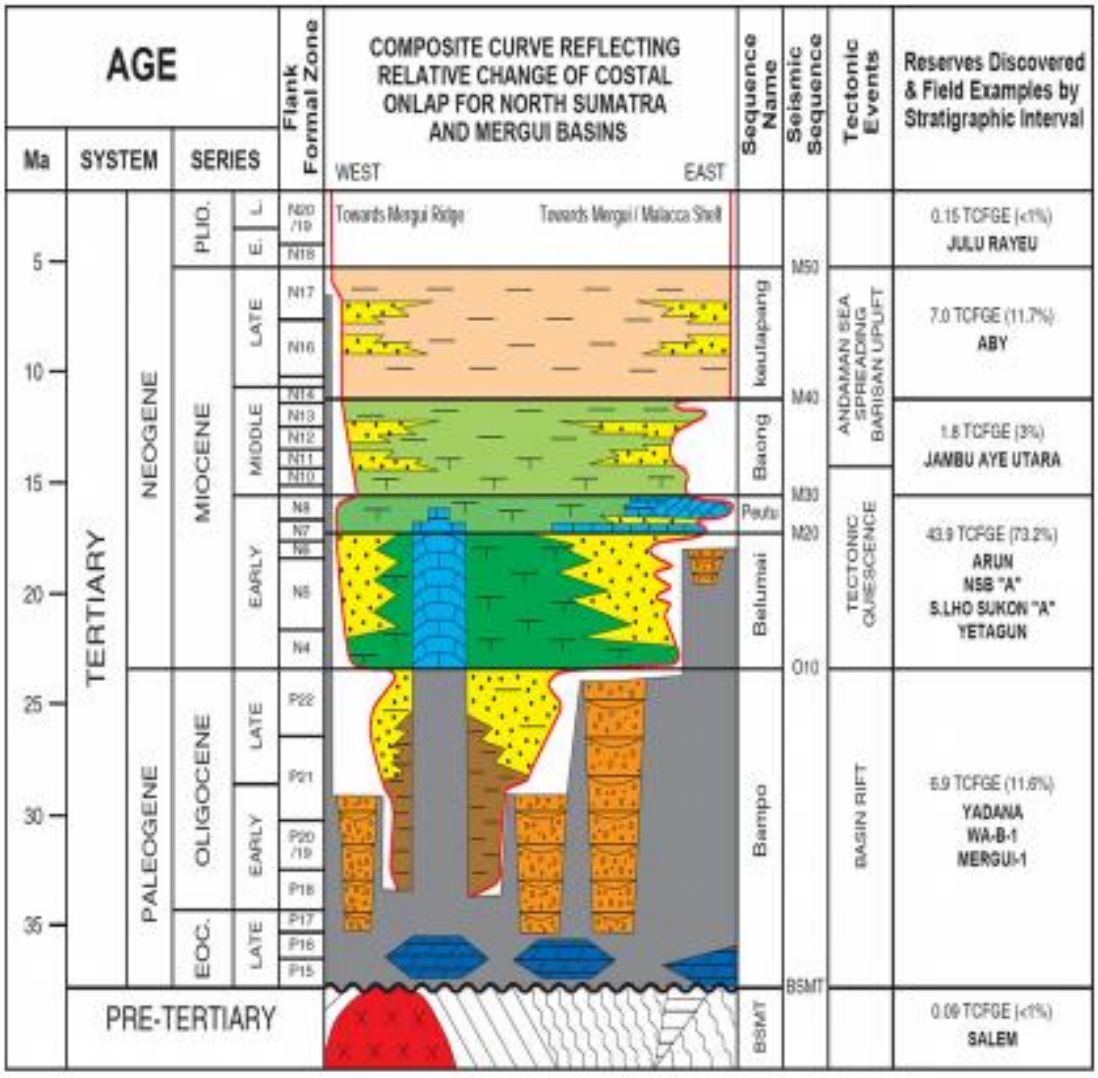
Attachment 1 : Montecarlo simulation excerpts



Statistic	Fit: Gamma	Forecast values
Trials	---	10.000
Base Case	---	0,00
Mean	11.441,23	11.441,23
Median	9.811,73	9.923,27
Mode	6.399,21	---
Standard	7.583,06	7.383,77
Variance	57.502.857,34	54.520.087,51
Skewness	1,33	1,02
Kurtosis	5,65	3,95
Coeff. of V	0,6628	0,6454
Minimum	36,51	94,36
Maximum	∞	46.700,95
Mean Std.	---	73,84

Percentile	Fit: Gamma	Forecast values
P100	36,51	94,36
P90	3.422,62	3.368,79
P80	5.096,77	4.960,31
P70	6.624,39	6.511,46
P60	8.164,02	8.121,72
P50	9.811,73	9.921,67
P40	11.671,95	11.937,87
P30	13.908,49	14.216,86
P20	16.863,38	17.385,12
P10	21.590,64	21.616,21
P0	∞	46.700,95

Attachment 2
North Sumatran basin stratigraphic map (Offshore North Sumatra basin)



Source: Ministry of Energy and Mineral Resources, 2009; Elders, 2019

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