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Decision Analysis in Generating Robust and Systematic Gas Asset Development Strategy in Block X Subsequent to The End of PSC Using AHP and SMART

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Abstract - Development strategy along with reservoir management is a central part of a company's production strategy and crucially needed to warrant the continuous withdrawal of hydrocarbons until its estimated ultimate recovery.

Gas production has been generating high value for the XCO. However, gas production shows declining trend with >30% decline-rate. Moreover, currently there's no solid gas development plan, particularly post PSC termination to improve gas production.

In-depth assessment as part of the research indicates several root causes with key problem is the absence of gas development strategy. The solution proposed in the research is the formulation of robust and systematic gas development strategy through MCDM by utilizing AHP to identify development alternative to recover the gas remaining reserves and applying SMART to define high priority tranche as focus development target area. The outcome of the analysis generates recommendations to pursue with Convert-to-Gas to add take-point on gas field to improve gas production performance where the tranche(s) prioritization is recommended to be focused on tranche C+D (Alternative 6).

Combination of AHP and SMART is proven to be the most applicable and proper approach to tackle two facets of decision-making process to be able to establish a robust and systematic gas development strategy.

Keywords - multi criteria decision analysis, analytic hierarchy process, AHP, simple multi attribute rating technique, SMART, gas production, development strategy, oil and gas

I. INTRODUCTION

Oil is a major sector in the Indonesian energy and economy. However, there's growing recognition that the natural gas sector has considerable development potential. Indonesia has the third-largest natural gas reserves in the Asia pacific region with 95 TCF at the end of 2020 [3].

Gas opportunities have been identified in Block X since the early stage of exploration. The first non-associated gas exploitation set in history was from SBG Field in the 1940s and gas production continued to increase as XCO expanded its gas production development to exploit more gas opportunities within the block. Gas Asset are grouped based on the similarity of operation mode called Tranche. There are 5 tranches of gas production in Block X; Tranche A, B, C, D and E.

From the very beginning of gas production, the produced gas was used for power generation to support the operation facilities throughout the concession area. Although gas production continues to increase as more gas development and optimization opportunities within the Block X were being, XCO is still procuring gas from third parties until now as its own gas production is still far below the required level to support the operation. Gas production has been generating value in terms of OPEX saving impact for the company as it will reduce the amount of gas purchased from third parties as the cost of purchasing gas in the last five years is on average two-threefold higher than gas lifting cost.

The key highlight of the business issue that triggered this research is the declining gas production where within the last 5 years (2015-2020), the gas production shows a declining trend with a decline rate >30% per year. In addition to the production issue, currently there's still no robust development strategy to refer to, specifically subsequent to the end of PSC and moving forward with a gas production improvement plan under a new operator in Block X.

The main questions that aimed to be resolved through this research is how to fix the issue of gas production decline; what are the alternative solutions, and which alternative solution provides the most optimum result in regard to solving the declining production, specifically in relation with moving forward with a new operator after the end of PSC.

II. METHODOLOGY

The essential structure of the research is described in the conceptual framework to set out an explanation that is used to define, make sense and describe the flow of the approaches and/or variables as well as promotes the logical process in order to deliver high quality decision making.

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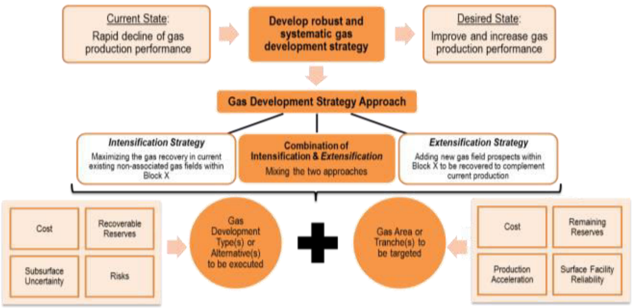

Figure 1. Conceptual Framework of the Research

The focus of the research will be targeted on developing a robust gas development strategy. The concept of the formulated solution is the combination of production intensification to maximize gas recovery through selecting the most optimum gas development alternatives and production Extensification by adding new gas prospect within Block X to complement current production.

The methodology used to rank the development scenarios during the screening and concept selection stages is based on a multi-criteria decision-making (MCDM) where economics and other technical factors such as operability and reliability are considered. Multi-criteria decision-making process account for attributes directly and indirectly associated to economics.

The subsurface and surface attributes were assessed and selected to be appraised that could make a difference among the alternatives/concepts to be able to differentiate and rank all the alternatives. MCDM valuation is used to support the process to prioritize the field development concepts according to the scored values for the attributes selected and the weights given to them [7]. MCDM supports the process of identifying and selecting the alternative that best fits with the stakeholders' goals, objectives and requirement [1]. The robust development strategy is going to be assembled through gas development strategy formulation which consists of several facets:

- <u>Gas Development Alternative Selection</u>; choosing the best gas development alternative to ensure the optimum result of future development efforts. Analytic Hierarchy Process (AHP) will be used in the research to select the most favorable option out of three alternatives. AHP is a basic approach to decision making where it designed to cope with both the rational and the intuitive, qualitative and quantitative data to select the best from a number of alternatives evaluated with respect to several criteria [8].

  - <u>Tranche(s) Selection</u>: generating development plan through determining priority tranche(s) as focus area for Y1-2 development plan after PSC termination. Tranche(s) prioritization was performed by simple multi-attribute rating technique (SMART) to identify the most preferable tranche or focus area out of six alternatives. SMART method is utilized as its simpler, given the number of six alternatives to be evaluated; and this method has advantage where the criteria/attributes are preferentially independent as it refer to the decision maker's preference and the value of one attribute are not influenced in any way by the values of the other attribute. This characteristic is particularly useful when new alternatives or criteria are added to the existing comparison. Any further evaluations necessarily do not need to begin right from the start, but the process can continue from the previous scores obtained [4] and [9]. This characteristic is particularly useful when new alternatives or features are added to the existing comparison. Any further evaluations necessary need not begin right from the start but the process can continue from the previous scores obtain.

III. RESULTS

A. *Gas Development Alternative Selection by AHP*

The gas development alternative selection is the first step of the formulation where in general, the process of this facet is as follows:

1. <u>Establish Requirement and Goals</u>

With the decision maker's guidance and concurrence, the requirement for development alternative is defined as any type of development effort or project with proven technology, commonly applied in gas field development and is acceptable in D&C point of view (execution risk).

Furthermore, the goals that are going to be achieved is to be able to select gas development strategy alternative that able to:

- Maximize the recovery of remaining gas reserves
- Minimize the cost of development
- Minimize subsurface uncertainty
- Minimize risk, both in subsurface and non-subsurface aspects (i.e., execution)

2. <u>Identify Alternatives</u>

Focus group discussion and Brainstorming session was conducted to generate alternative solutions in alignment with achieving the requirements and goals. It is a form of qualitative research where questions are asked about their perceptions, attitudes, beliefs, opinion or ideas [2].

Refinement of alternatives was done by listing in alternatives which are viable and screened out the one that are not feasible (i.e., the process ruled out 'Sidetracking' alternative). The final refinement considered three alternatives as illustrated on the figure below.

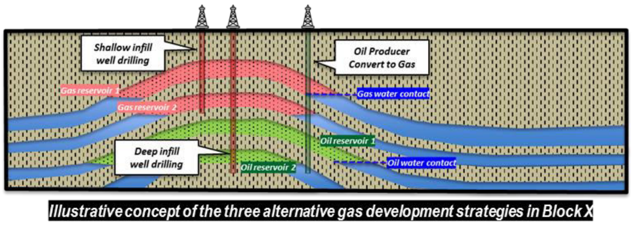

Figure 2. Illustration of Alternatives

Alternative 1: Covert to Gas (CTG)
Alternative 2: Shallow New Infill Drilling
Alternative 3: Deep New Infill Drilling

3. Define Criteria

Criteria determination was conducted through group discussion by assessing differences among alternatives. Two aspects; Economics and technical aspect, are defined as main criterion which then further broken down into sub-criteria and sub of the sub-criteria as shown on the table below.

4. Select Alternative

Analytic Hierarchy Process (AHP) is used in the research to select the most favorable option. The flow process of AHP in this research is as follows:

a) Generating hierarchy structure

The first step in an AHP analysis is to build a hierarchy for the decision. This is also called decision modeling and it simply consists of building a hierarchy to analyze the decision as AHP structures the problem as a hierarchy [5].

The hierarchy structure is developed using the criteria, sub-criteria and sub of sub-criteria that have been determined through group discussion as reference. It is also aligned with Saaty's approach/principle where a way to generate the hierarchy structure is to work down from the goal or objective and the work up from the alternatives until the levels of the two processes are connected in such a way to make comparison possible.

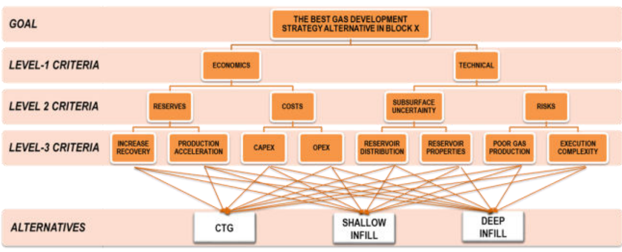

Figure 3. AHP Structure

b) Perform pairwise comparison

This process is used to determine the relative importance of criteria in each level and compare how well each alternative competes on different criteria. The Saaty fundamental scale of value is used to represent the intensities of judgements. The pairwise comparison process is incorporating Subject Matter Experts' (SME) feedback to be able to get a sense of relative strength of preference between criteria and alternatives. The pairwise comparison consists of two questionnaires to be filled in by the SMEs. SME involved in this proses consist of eight (8) experts who have experience in the industry of more than 10 years.

c) Transform comparisons into weights

The pairwise comparison from all respondents (SMEs) were aggregated and processed further. The overall AHP computation for the research is conducted using AHP online system (AHP-OS) developed by Klaus G. Goepel. The tool performs an aggregation of individual judgments for all 8 respondents or participants and creates a consolidated decision matrix for each criteria and sub-criteria, referred to as node.

The priority computation result of the AHP provides an imperative insight on the decision-making process for selecting the most favorable gas development strategy in Block X. Referring to the main criteria, the respective stakeholders represented by SME have strong interest in the "Economics" of the development strategy where that aspect appeared as the highest priority in selecting the alternatives to solve the business issue. And referring to the sub-criteria, Level 2 and 3 which are "Reserves" and "Increase Recovery" have the highest priority.

d) Alternative selection

The second part of the pairwise comparison questionnaire is aimed at to get data on the level of importance among three gas development strategy alternatives (CTG, Shallow infill drilling and Deep infill drilling).

The same process was conducted to acquire the pairwise comparison scoring from a total of eight SMEs. However, in this part, quantitative data derived from assessment during the alternative deliberation incorporated to the process:

- Reverse which can be recovered from the project represents the Recovery Increase criteria
- Capital expenditure and operational expenditure of the project represent the CAPEX and OPEX criteria

The alternative selection computation is also run in the AHP-OS tool and the result of the process is the consolidated alternative calculation for all respondents.

The result indicates, CTG (Alternative-1) is selected as the best option with the highest final priority of 0.377 (37.7%). CTG as selected alternative received highest priorities mainly in 3 criteria as following order:

- Execution complexity (0.731/73.1%)
- CAPEX (0.625/62.5%)
- Production acceleration (0.497/49.7%)

B. Tranche(s) Selection by SMART

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Relative similar to the Gas Development Alternative Selection process, several stages of the process were conducted through focus group discussion activity. The alternative and criteria identification were also conducted mainly in a 'bottom-up' manner to allows more exploration, experimentation and a better judgement and insight of the issue.

Decision-making techniques using the SMART method based on the theory that each alternative consists of some criteria that have values and each of the criteria has a weight that illustrates how important compared with other criteria [xx]. The overall process of SMART is consisting of eight (8) stages as follows:

Stage-1 Identify decision maker

Decision maker of the project is the owner of Gas Asset Team which is Team Manager of Asset Optimization Gas and Deepwater. Throughout the process of project development, the decision maker is supported by advisors and senior/lead engineers and scientists during the decision-making process

Stage-2 Identify alternative

Brainstorming within the team was conducted to define alternatives. Main consideration on generating the alternatives were based on subsurface aspect (remaining recoverable reserves). Referring to subsurface data, the alternatives consist of six option as follows:

- Alternative 1: Tranche B
- Alternative 2: Tranche C
- Alternative 3: Tranche D
- Alternative 4: Tranche B+C
- Alternative 5: Tranche B+D
- Alternative 6: Tranche C+D

In depth review and discussion was conducted to assess the prominent aspects in regard to the alternatives. There are mainly two aspects that deem to have big impact on each of the tranche development plans:

- Subsurface aspects: Reserves by tranche, Reservoir quality by tranche
- Non subsurface aspects: Project costs, Surface facility reliability, Project execution

Stage 3 Identify criteria

Criteria determination was conducted through review and group discussion by assessing impactful aspects on tranche development project and element of differences among alternatives (reverse direction method).

Two aspects are defined as main criterion: Cost & Benefit which then further broken down into sub-criteria described through the SMART value tree below.

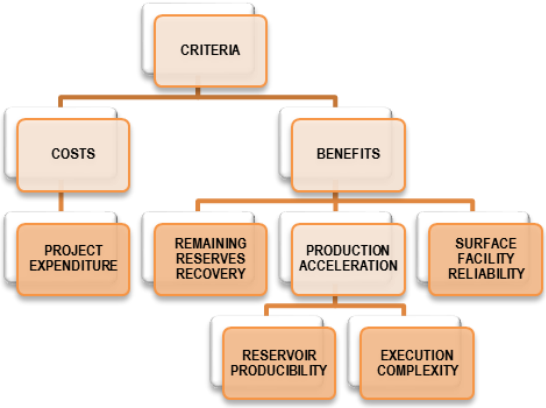

Figure 4. SMART Value Tree

Stage 4 Assign value for each alternative based on chosen criteria

Value assignment was conducted for each alternative to measure how well the options perform on each criterion.

The value assignment derived from transferring the quantitative data relative to decision maker's preference (value function). The value function is used to transfer or translate the 'actual value', in this case such as Remaining reserves recovery, reservoir quality/producibility and other two criteria used in the assessment.

Stage 5 Determine weight for each criteria

Determining the weight for each criteria was conducted to be able to see the level of importance of aspect. The weighting was derived from the average of decision makers' relative ratings to each of the dimensions of the objective mentioned previously in criteria identification section.

TABLE 1. WEIGH FACTOR AND NORMALIZED WEIGHT FACTOR

Goals	Criteria with respect to Goal	Weight Factor	Normalized Weight Factor
Maximize Gas Recovery	***Reserves Recovery***	100	**0.32**
Maximize Surface Facility Reliability	***Surface Facility Reliability***	79	**0.25**
Maximize Production Acceleration	***Reservoir Producibility***	71	**0.23**
	Execution Complexity	63	**0.20**
Normalized Weight = $\frac{\text{Weight Factor by Criteria}}{\text{Total Weight Factor}} * 100\%$		313	1

Stage 6 Calculate aggregate of weighted value for each alternative

The aggregate of weighted value is derived from the summation of the score that each alternative obtained for every criterion which already calibrated with the normalized weight factor.

Stage 7 Make provisional decision

Provision decision performed to eliminate the inferior alternatives by evaluating the tradeoff between benefit and cost for each alternative.

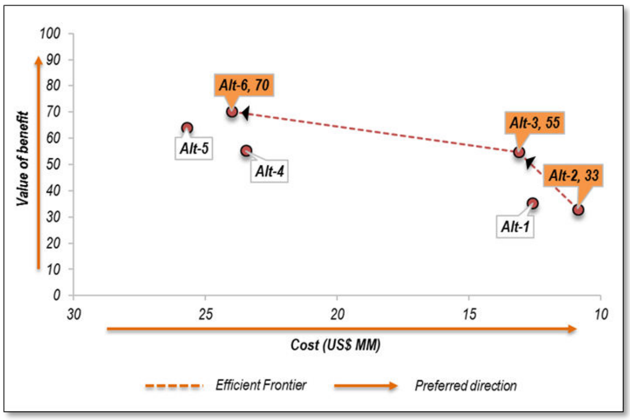

Figure 5. SMART Value vs. Benefit Chart

Aggregated benefit (aggregated weighted value) versus cost for each alternative displayed on the chart below indicates Alternative 2, 3 and 6 are among the efficient frontier, meaning that those alternatives are preferable as the tradeoff between cost indicates more viable compared to the other remaining three alternatives. The result of the assessment will be brought back to the decision maker to be evaluated and decided which alternative will be chosen in respect to the approval of the cost of investment.

IV. CONCLUSION

The research reveals the combination of AHP and SMART is proven to be the most applicable and proper approach to tackle and analysis two facets of decision-making process to be able to formulate a robust and systematic gas development strategy. The alternative selection for the gas development alternative through Analytic Hierarchy Process (AHP) suggests the best alternative for gas development strategy is Convert to gas (CTG) The second facet of the strategy is the Tranche(s) prioritization where Simple Multi-Attribute Rating Technique suggests the best alternative for gas development focus area is Alternative-6 (Tranche C+D) which has the highest aggregated weighted value. However, with close to half of an investment cost, Alternative-3 (Tranche D) is also attractive by compromising the value down from 70 (Alternative 6) to 55 (Alternative 3).

The research was conducted in order to be able to find the best solution in overcoming the production performance issue by generating a robust and systematic gas development strategy to increase gas recovery and improve the production. The AHP result indicates, CTG (Alternative-1) is selected as the best option with the highest final priority of 37.7%. The result suggests that even though the overall priority based on the criteria/sub-criteria falls on the increase of recovery and ideally objective can be achieved by Deep Infill, However the tradeoff in terms of the complexity of the project, the cost and timeframe, CTG is deem significantly preferable.

Simple Multi-Attribute Rating Technique suggested that the best alternative for gas development focus area is Alternative-6 (Tranche C+D) which has the highest aggregated weighted value. However, with close to the half of an investment cost, Alternative-3 (Tranche D) is also attractive by compromising the value down from 70 to 55. In this case, it is suggested to put Alternative-3 (Tranche-D) as scenario-2 to be further reviewed on the next phase of the Project Development and Execution Process and identify comparison between two scenarios, specifically in terms of project economics (using more robust cost estimate).

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