*Proceeding Book of **The 6th ICMEM 2021**, 11-13 August 2021, Bandung, Indonesia*
***ISBN**: 978-623-92201-2-9*

Integrated Decision Analysis Process for Selecting Oil Production Optimization and Completion Strategy Alternatives; Study Case of Primary Field (Tiger Field) using VFT and SMART Analysis

Riska Milza Khalida* and Utomo Sarjono Putro

School of Business and Management, Institut Teknologi Bandung, Indonesia

E-mail address: riska-milzakhalidan@sbm-itb.ac.id

Abstract - **Improving reserve recovery in a complex multilayer reservoir of the mature oil field is one challenging task. Some common problems encountered are low rate from tight reservoirs and high water cut from high-quality reservoirs impacts low oil production. Drain more remaining oil from complex reservoir character requires rigorous evaluation and optimization. However, there is no robust decision-making process to choose the best optimization and completion design.**

Therefore, the solution proposed in the research is the construction of systematic optimization and completion strategy through SMART. However, SMART is unable to be implemented directly since there are problems where the available alternatives are limited and not holistic. ValueFocused Thinking then is required to describe and illustrate concepts for creating better alternatives. VFT compliments SMART and it resulted in a more comprehensive set of alternatives.

The outcome of the combination VFT and SMART analysis resulted in a recommendation to implement Full Perforation and commingle several tight reservoirs on the upcoming Tiger Field Workover Campaign. It successfully improved the production recovery of Tiger Field and maximize revenue to the company.

Keywords - **decision-making, SMART, Value-Focused Thinking, oil production, complex reservoir**

I. INTRODUCTION

The reason why people bother to make decisions is to purposefully influence the quality of life or anything that people care about to get things for the better. Decisionmaking is a critical skill for effective management and leadership. Several problems related to production decline can be arrested and anticipated with good decisionmaking from all teams and stakeholders.

PT. Abadi Bakti Cahaya is one of the oil and gas companies in Indonesia. It operates under a production sharing contract coordinated with the government represented by SKKMigas. The company started its venture in Sumatra in 1941 with two super-giant fields: Ridu and Nasmi Field. Several fields are in secondary recovery but a lot of small fields are still in primary recovery.

This study will focus on Tiger Field as one of the small fields in PT. Abadi Bakti Cahaya. Tiger Field was first drilled in 1975, currently in the primary recovery stage where reservoir drive comes from several natural mechanisms. After more than forty years of production, the field is entering the mature phase. It followed with declining production. Tiger Field has various types of reservoir quality. Optimization was focused on highquality reservoirs that currently have high water cut. Meanwhile tight reservoirs (lower quality) of this field showed very low recovery due to less priority. It has complexity and difficulty to deliver fluid from the reservoir to the surface of these sands. Tiger Field Optimization failed to get expected production results in terms of production target and workover gain. Before, there was no systematic decision-making process to choose the best optimization and completion strategy to optimize tight reservoirs. Looking at this trend, without optimum strategy and improvement, production at Tiger Field will remain low and even continue decreasing. Production target will not be achieved, and Tiger Field possibly reaches abandonment phase (economic limit) more quickly.

The objective of this research is to have the understanding on the cause of unoptimized Tiger Field production and to have a holistic alternative and comprehensive method to improve decision quality and determine the effective optimization and best completion strategy for tight reservoirs at Tiger Field. The selected alternative of this optimization is expected to improve oil production, maximize oil recovery and value to the company. The extension of the study would be applied to other primary fields that have similar characteristics. This effort also could improve the movement of Resource to Reserve to Production (R2R2P) and help GOI meet national production targets.

To identify the root cause of the problem, problem analysis was being conducted by using the 5 Why Analysis. Based on the root cause analysis, one of the main root causes is there is no formal decision analysis

ISBN*: 978-623-92201-2-9*

process to choose the best optimization and completion strategy to optimize production especially from tight reservoirs at Tiger Field.

The problem needs to be solved by having a comprehensive evaluation and defining the best approach for production optimization from the reservoir level into the completion strategy to improve Tiger Field Recovery. The decision-making process is required to be performed to select the best alternative for oil production improvement that meets the criteria given a unique reservoir condition to be developed.

II. METHODOLOGY

Conceptual Framework

As an analytical tool, a conceptual framework is necessary to get a comprehensive understanding of a phenomenon. It is used to visually explain the key concepts or variables and the relationships between the current condition or problem, why the problem happened, and the existing gap to achieve the goal through the available process.

The conceptual framework represents the research's concept including Tiger Field's current conditions and problems, how to solve the problem, tools, and actions that are required to achieve the expected target.

Decision-Making Process that is applied in this research is adopted and summarized from generic problem solving and decision-making models [1].

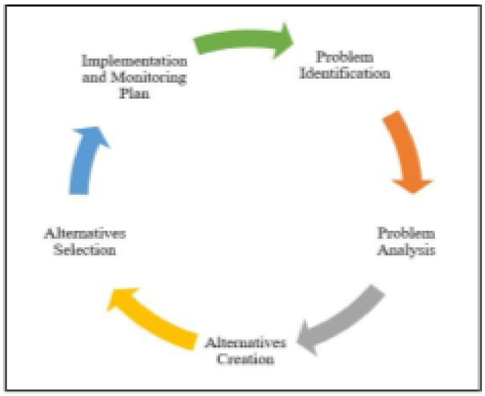

Fig 1. Decision-Making Model

Literature Review

Root Cause Analysis

According to Mahto D & Kumor A (2008), Dugget (2004) explained that several root cause analysis tools have emerged from the literature as generic standards for identifying root causes including Why Why Analysis, Cause-and-Effect Diagram (CED), the Interrelationship Diagram (ID) and the Current Reality Tree (CRT). Dugget added that why why analysis is one of the most simplistic root cause analysis tools [3].

Value-Focused Thinking (VFT)

Value-Focused Thinking mainly consists of two activities which are deciding what the desired result is then figuring out how to get it [2]. By creating and changing alternatives, it led to more appealing decision problems and choice among better alternatives compared to those generated by conventional approaches. Through group discussion and interviews, the SME delivered ideas for criteria and alternatives that related to the decision problem to achieve the objectives.

Simple Multi-Attribute Rating Technique (SMART)

SMART is a method of decision support system, benefited from the work and applications of engineers, management scientists, and mathematicians. The main equipment of SMART is a functional hierarchy [5]. The analysis split the problem into small parts and focused on each part separately. It has a weighting method with parameters or attributes that determines the decision. These attributes have a range of values. The value will be a determinant of the decision taken.

Sometimes problems happen because the decision maker has limited information. A decision-making is required to simplify due to too much information to be handled simultaneously. The simplicity of SMART influences directly the understanding of the decision-maker about the process used in the solution of the problem [4]. The main role of project team analysis is to provide decision-makers better information and help them increase understanding of decision problems.

Decision-making using combination VFT and AHP has been applied to research related to optimization and improve recovery. According the research, elaboration of Value-Focused Thinking with AHP has been formulated as one of the best prioritization tools for development projects [6].

The solution proposed in this research was the construction of systematic optimization and completion strategy through SMART. However, SMART was unable to be implemented directly since there are problems where the available alternatives are limited and not holistic to solve the problem that Tiger Field experienced. It requires an approach to solve problems by putting more articulation and emphasis on fundamental values to guide and integrate all decision-making activities to make a systemically and more holistic decision.

In this research, the combination was required by elaborating Value-Focused Thinking prior to SMART.

***ISBN**: 978-623-92201-2-9*

III. RESULTS

Value-Focused Thinking is being conducted through group discussion and interviews with Subject Matter Experts (SME) in February 2021. The selection of the SME was based on their expertise of the discipline, working experience, job function, and their experience related to optimization of a typical field that has lowquality reservoir. Before VFT, there were limited available alternatives (three). VFT helps to structure thinking to address decision opportunities and problems in creatively. The value model guides the search for creative alternatives.

The result of effective optimization and best completion strategy alternatives for tight reservoirs at Tiger Field is divided into six alternatives based on Value-Focused Thinking. The best strategy is selected based on SMART Analysis.
According to Goodwin, there are eight (8) main stages of SMART analysis as shown below:

1). Stage 1: Identify the decision-maker(s)

The decision- maker or decision executive in this case is the person who has the biggest interest and the budget owner (OPEX) of the Optimization Primary Team. The Decision Executive is supported by the Decision Review Board (DRB) during the decision-making process.

2). Stage 2: Identify the alternative courses of action

Through Value-Focused Thinking, it is identified 6 alternatives that comprehensive to achieve the objective with listed below:
Alt 1: Fracturing - Single tight reservoir Alt 2: Fracturing only one tight reservoir - Comingle with non-fractured tight reservoir
Alt 3: Fracturing more than one tight reservoir - Comingle
Alt 4: Full Perforation – Comingle several tight reservoirs from B and BP
Alt 5: Radial Jetting – Single tight reservoir
Alt 6: Full Perforation – Single tight reservoir

3). Stage 3: Identify the relevant attributes

The decision criteria were developed based on the group discussion and lessons learned from previously proven methods. The relevant attributes in this research are oil recovery, the certainty of good oil result, execution complexity. and pump reliability.
4). Stage 4: Assess the performance of the alternatives on each attribute

At this stage, each alternative is being assessed with the value or scoring matrix range zero to five to measure the performance based on chosen attribute.

The first step is to understand and measure how well the options perform on each attribute. For incremental recovery and production sustainability attributes, the score was based on value function meanwhile for implementation and execution complexity attributes, the score was based on direct rating. If the value of all attributes is converted to the range [0,5] then below is the value of all alternatives on each attribute:

TABLE I
VALUE OF ALL ALTERNATIVES ON EACH ATTRIBUTE

Alternative	Oil Recovery	Execution Complexity	Pump Reliability	Certainty of Good Oil Result
Alternative 1	5	3	4	4
Alternative 2	5	3	5	3
Alternative 3	5	3	4	3
Alternative 4	3	4	5	5
Alternative 5	5	3	3	1
Alternative 6	1	4	2	2

5). Stage 5: Assess the performance of the alternatives on each attribute

At this stage, each of the attributes is weighted and determined based on the level of importance ranging from 0 to 100.

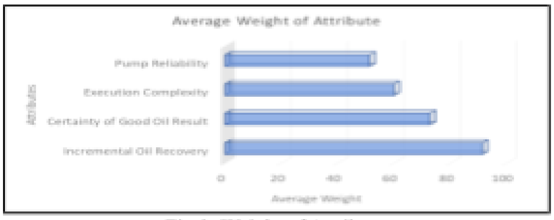

Fig 2. Weight of Attribute

The weight value predetermined attribute of the highest to the lowest value then being normalized by dividing the weight of attribute with a total weight value. The normalized weight of each attribute may be described in the following table.

TABLE II
NORMALIZED WEIGHT FACTOR FOR EACH ATTRIBUTE

Benefit	Original Weight	Normalized Weight
Pump Reliability	51	50/276 = 0.19
Execution Complexity	60	60/276 = 0.22
Certainty of Good Oil Result	73	73/276 = 0.26
Incremental Oil Recovery	91	91/276 = 0.33

6). Stage 6: For each alternative, take a weighted average of the values assigned to that alternative
At this stage, the value of the attribute from stage 4 is multiplied with the normalized weight from stage 5 for each alternative. Table 3 showed the weighted averages of the values assigned to each alternative.

7). Stage 7: Make a provisional decision

Fig.3 showed the final value (weighted averages of the values assigned to each alternative). Cost vs Benefits plot is generated to compare the swings from the least preferred to the most preferred level of benefits and swings from the minimum to the maximum cost. It can

ISBN: 978-623-92201-2-9

identify the benefits of action as well as associated costs and subtracting costs from benefits.

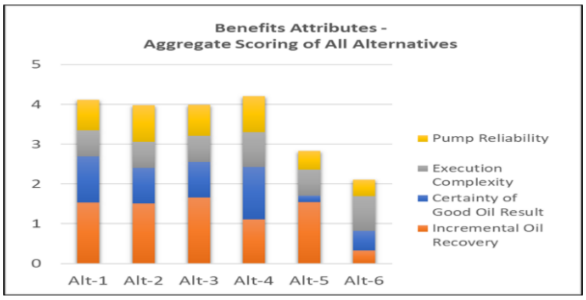

Fig 3. The Aggregate of Weighted Value

It is expected to give more comprehensive information for the decision-maker before taking the final decision. Figure 4 showed the plot of aggregate benefits value against cost.

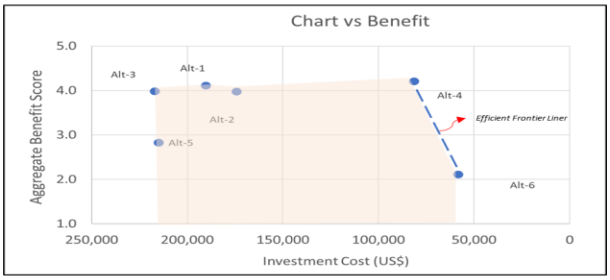

Fig 4. Cost vs Benefit of the Alternatives

It was identified there are two alternatives that are connected by *Efficient Frontier Liner* meaning that those alternatives are preferable as the tradeoff between cost indicates more viable compared to the other remaining four alternatives. Table 4 showed the analysis between both alternatives.

TABLE III
COST AND BENEFIT ANALYSIS BETWEEN ALT 4 VS ALT 6

Cost and Benefit Analysis		Alt -6	
		US$ 58,300	2.13
Alt-4	US$ 81,480	US$ 11,060/point	
	4.14		

To identify the preferred efficient frontier point, the further assessment was being conducted by the team to calculating the cost of extra value. Referring to Table 4, the cost of extra value point to switch from Alternative 6 to Alternative 4 is approximately US$ 11,060. This result is being discussed and in respect to the approval of decision-maker which mainly focuses on the value of the alternatives (value of alternative 4 is doubled than alternative 6) meanwhile the cost of investment is slightly different with the extra budget available, then it is decided to choose Alternative 4 (Full Perforation – Commingle several TR from B and BP strategy). It is agreed to spend an extra budget of US$ 11,060 to achieve better value. This strategy also will optimize the OPEX budget compared to the strategy from Alternative 2 and 3 which give higher cost but lower value.

8). Stage 8: Sensitivity Analysis

Sensitivity analysis was being conducted to observe the stability of solutions when the level of importance for the attribute is changed. Sensitivity analysis is being done by changing the weight of the attributes to zero.

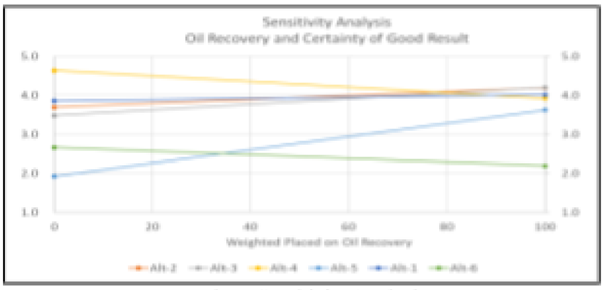

Fig 5. Sensitivity Analysis

In this case, to evaluate the robustness of Alternative 4, sensitivity analysis is performed with an attribute between "Incremental Oil Recovery" and "Certainty of Good Oil Result". Based on the sensitivity analysis as shown in Figure 5, alternative 4 is still the best solution if normalized weight is placed on oil recovery less than 80%. Meanwhile, if the value is higher than 80%, then alternative 3 is the best solution.

Implementation

The result of this research is being discussed and agree upon. Program approval for the upcoming workovers and campaign that will implement this strategy was being conducted through meeting with all the approvers in one room and directly give the decision therefore team be able to generate a program based on the decision and minimize the amount of re-work per program.

The first batch of this research has been conducted on the first batch and to successfully improved Tiger Field Production ~480 BOPD. The strategy had proven successfully deliver good result with efficient cost. Further, there would be nine opportunities for the next batch that are expected to enhance production recovery of Tiger Field by implementing this strategy.

IV. DISCUSSION

In this research, the combination has been applied by elaborating Value-Focused Thinking and SMART. VFT to describe concepts for creating better alternatives truly compliments SMART and it resulted in a more comprehensive set of alternatives. By implementing Value-Focused Thinking prior to SMART, the team does

ISBN*: 978-623-92201-2-9*

not simply accept predetermined problems or prespecified lists of alternatives.

In this research, VFT is being conducted through group discussion and interviews with Subject Matter Experts (SME). The selection of the SME was based on their expertise of the discipline, working experience, job function, and their experience related to optimization of a typical field that has low-quality reservoir. The SME involved the Value-Focused Thinking has various backgrounds including Senior Petroleum Engineers, Senior Geologists, and Senior Completion Engineers. Through Value Focus Thinking, several attributes and alternatives were identified.

To determine the best alternative, a multi–Criteria Decision Analysis such as SMART is a very good and recommended decision tool to be applied to accommodate quality and quantitative attributes since the oil industry deals a lot with uncertainty and risk. Its applicability and simplicity influence directly the understanding of the decision-maker related to the process used in the solution of the problem.

As a combination VFT and AHP, the combination of VFT and SMART also has been formulated as excellent prioritization and decision-making tools. VFT provides comprehensive criteria and alternatives prior to input into SMART. The advantage of this combination compares to combination VFT and AHP is that SMART considers qualitative and quantitative parameters that are independent. If there is a revision alternative based on Value-Focused Thinking, additional alternatives can be readily added to an analysis in the middle of the SMART process. It is applicable and simple which can be used by the project team and decision-makers from different backgrounds.

The combination of this method is suggested to be applied in Phase 1/2 of a project at PT. Abadi Bakti Cahaya where the project team identifies problem, looks for some alternatives, analyzes, and selects the available alternatives that relate to the decision problem. Incorporation of this tool in Phase 1/2 could leverage the confidence level in selecting the best alternative for a decision problem or project. This research does not include aspirations from the new operator (PT. PAR).

Implementation of the selected strategy is expected to improve the oil production and success ratio through best practice implementation in Tiger Field and other fields that have a similar type of reservoirs and adopt the costefficiency. Prior to field implementation, a pilot test is required to be conducted to prove the strategy and oil productivity. Field expansion then can be done on proven sand and area based on pilot results. Collaboration with other teams is important to lead a faster and safer execution. The impact of this strategy should be monitored to ensure the actual production meets the production target (as per expected). Full Perforation – Commingle several TR from B and BP strategy has great advantages to deliver R2R2P with cost-effective.

V. CONCLUSION

The main business issue encountered in this research is Tiger Field Optimization failed to get expected production results. Discussion and the 5 why analysis are conducted which is considered as an effective method to identify the root cause of the business issue. The objective of this research is to have the understanding of the cause of unoptimized Tiger Field production and to have a holistic alternative and comprehensive method to improve decision quality and determine the effective optimization and best completion strategy for tight reservoirs at Tiger Field. Root cause analysis has been conducted and it resulted that one of the main root causes is there is no formal decision analysis process to choose the best optimization and completion strategy to optimize production especially from tight reservoirs.

Based on VFT and SMART decision-making analysis, the recommendation of effective optimization, and best completion strategy to improve oil production especially from the tight reservoirs at Tiger Field is by implemented alternative 4 (Full Perforation – Comingle several tight reservoirs from B and BP strategy) on Tiger Field Workover and Reactivation Campaign.

Comingle several layers of LQ proven successfully deliver good workover result. The 1st batch workover successfully improved Tiger Field production with a total oil gain ~480 BOPD and water shut off ~4,800 BFPD. By applying this optimization and completion strategy on the next reactivation and underperformed wells, it is expected to increase Tiger Field production with efficient cost. The production target and the objective of this research can be met and exceeded.

ACKNOWLEDGMENT

I would like to pass the gratitude and presents this milestone of a learning journey to all experienced lecturers of SBM ITB for the priceless insight and knowledge especially for this research, all leaders, and peers in the Asset Optimization Team for sharing knowledge and great discussion.

REFERENCES

[1] Adair John., (2010). Decision Making and Problem-Solving Strategies (2nd ed), United Kingdom, Kogan Page.

***ISBN**: 978-623-92201-2-9*

[2] Keeney R., 1996, *Value-Focused Thinking – A Path to Creative Decision Making*, Harvard University Press.

[3] Mahto D., Kumor A., 2008, Application of Root Cause Analysis in Improvement of Product Quality and Productivity. *Journal of Industrial Engineering and Management*

[4] Patel M., Vashi M., Bhatt B., 2017, SMART-Multi-Criteria Decision-Making Technique for Use in Planning Activities. *New Horizons in Civil Engineering Conference*, 2-4

[5] Risawandi, Rahim R., 2016, Study of the Simple MultiAttribute Rating Technique for Decision Support. *International Journal of Scientific Research in Science and Technology*, 2 (491 – 494)

[6] Setiyawan, H., Decision Analysis of Field Development Strategy in Low Quality Reservoir Within Block Contract Expiration Perspective using Integrated Analytical Hierarchy Process (AHP) and Monte Carlo Simulation, School of Business and Management Institut Teknologi Bandung 2017