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Decision Analysis of ANH Gas Field Using Value Focused Thinking and AHP

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Abstract

Purpose: The purpose of this study is to obtain the best gas field development scenario based on company values.

Research Methodology: This research used qualitative methods obtained from interviews, questionnaires, and discussions. The data obtained were analyzed by researchers with a focus on the content and the relationship between one content and another. This method is used in the value-focused thinking process to determine goals, criteria, and alternative solutions. In addition to qualitative methods, quantitative analysis was performed using the Analytic Hierarchy Process method. This method is used to determine the ranking of project selection criteria and sub-criteria and to determine the best field development scenario.

Results: The Project Profitability criterion has the largest weight score of 0.529, while the most important sub-criteria are the Profitability Index (PI) ratio and Net Present Value (NPV), with global weight scores of 0.266 and 0.263, respectively. The selected solution based on the analysis was scenario two with a weight score of 0.477 and an inconsistency value of 0.05. The scope of work for this scenario is drilling nine wells, building a pipeline, and installing a compressor, which is divided into two stages, starting with the MP-HP compressor and the LP-MP compressor.

Conclusions: This study applied VFT and AHP methods to evaluate gas field development scenarios, considering criteria such as cumulative production, cost, profitability, and risk. Profitability emerged as the most influential criterion, with the Profitability Index and Net Present Value being the highest-ranked sub-criteria. Scenario 2 was identified as the optimal development plan, involving nine wells, staged compressor installations, and pipeline construction.

Limitations: The values of reserves, production, and economic data were slightly modified due to company policies but did not change the qualitative nature of the data. An interview, Focused Group Discussion, and pairwise comparison questionnaire were distributed to Subject Matter Experts who are knowledgeable and involved in decision making in the company.

Contribution: This research provides a reference for companies who want to know how to make the right decisions according to company values, particularly in the upstream oil and gas industry.

Keywords: *Analytic Hierarchy Process, Gas Field, Value Focused Thinking.*

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1. Introduction

Natural gas is the third most commonly used primary energy source in the country, after oil and coal. Therefore, natural gas plays an important role in Indonesia's energy mix policy. The government continues to aggressively encourage the use of domestic natural gas, including the construction of natural gas infrastructure (pipes and LPG/CNG/LNG) to stimulate the domestic industry and maintain a cleaner environment. From 2015 to the present, the upstream oil and gas industry underwent a reformation era from oil to natural gas. The development of oil and gas discoveries is dominated by the discovery of natural gas fields, especially in eastern Indonesia (Aprizal, Juanda, Ratnawati, & Muin, 2022).

The Indonesian Natural Gas Balance Book divides natural gas-producing regions in Indonesia into six regions, where Sulawesi, Nusa Tenggara, Maluku, and Papua are included in Regional VI, with a total Natural Gas reserve of 40.61 TSCF. In Region VI, there are several existing gas suppliers in the Sulawesi area. Sengkang Block with estimated gas production of 55 MMSCFD, Matindok Block with an estimated Production of 100 MMSCFD, and Senoro Toili Block with an estimated Production of 330 MMSCFD (Adiputro & Martini, 2022).

The Senoro Toili Block is managed by the Joint Operating Body Pertamina Medco E & P Tomori Sulawesi (JOB PMTS). As the contractor of the largest oil and gas block in Sulawesi, the JOB PMTS plays a very important role in producing gas according to the government's expectations set out in the Indonesian Gas Balance or Gas Sales Agreement (Resosudarmo, Rezki, & Effendi, 2023). To meet this predetermined demand, efforts are needed to develop existing gas fields so that undeveloped hydrocarbon resources can be properly monetized. Currently, the existing gas supply originates in the ANH field. Similar to region VI, the existing supply in the ANH field continues to decline, causing a gap between supply and contracted demand. This gap will begin in the eighth year, potentially causing the supply target planned by the government in the gas balance above to not be achieved. Therefore, a new development project is needed to increase the ANH field gas supply so that it can meet future demand targeted by the government and companies (Borodako, Berbeka, Rudnicki, & Łapczyński, 2019).

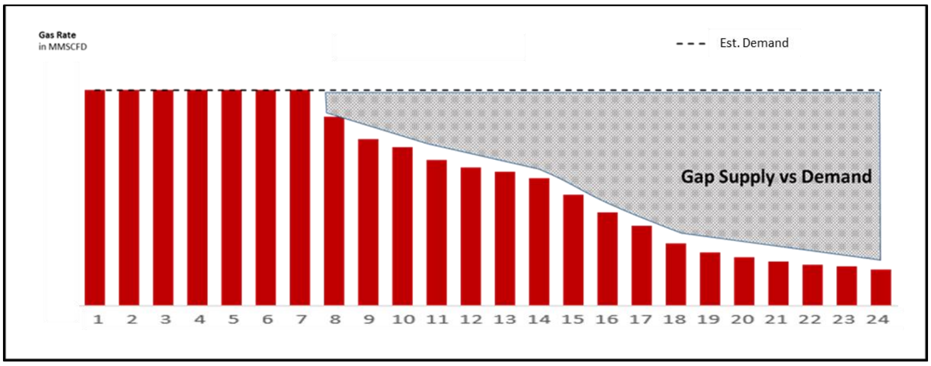


Figure 1. Gap Supply and Demand of ANH Gas Field
Source: Internal

In the figure above, the gas supply and demand from the first to the seventh year are in equilibrium. The decline in supply is predicted to begin in the eighth year. The production profile above was obtained through reservoir simulation, where the field was simulated to produce under existing conditions without any increase in field capacity (Mappadang, Wijaya, & Mappadang, 2021).

In choosing the best development project, it is necessary to determine what criteria are considered when selecting a project. After obtaining the criteria that will be considered, a comparison will be made of the available alternatives. The best alternative was selected as the field development project.

2. Literature Review

2.1 Description of Gas Reservoir

A water-driven gas reservoir is a type of gas reservoir that uses water pressure to encourage gas production from within the reservoir. The basic principle is similar to that of the water drive in oil reservoirs, but in the context of gas, gas and water have different physical properties. In reservoir gas–water drives, gas trapped in the reservoir rock is released naturally or with the help of production techniques such as water or gas injection to increase gas recovery. This process occurs when the reservoir pressure decreases, as the volume of gas extracted from the reservoir decreases. A higher water or gas pressure around the reservoir helps push the gas toward the production well (Olayinka & Mustapha, 2022).

Some characteristics of water-driven gas reservoirs include the following; Reservoir pressure is initially caused by gas or a mixture of gas and water. When gas is extracted, this pressure drops, and the pressure of the surrounding water or gas helps to keep the gas flowing to the surface. The water drive can increase the gas recovery rate from the reservoir because of the pressure relief of the injected water or gas. Production methods, such as water or gas injection, can be used to maintain the pressure and accelerate gas production from the reservoir (Malinda, Sutopo, & Fathaddin, 2023).

Water-driven gas reservoirs are a type of reservoir that is important in the energy industry because they influence the development and production strategies chosen to maximize economic gas recovery. The amount of reservoir gas recovery, or the rate of gas recovery from a gas field, can vary depending on several factors, such as the geological characteristics of the reservoir, the production technology used, and the field management strategy (Safarzadeh, Zangeneh, & Kasravi, 2024). In general, the rate of gas recovery from a reservoir usually ranges from 20% to 80% of the volume of the gas contained therein. Factors that influence this recovery rate include the type of rock that makes up the reservoir, pressure and temperature of the reservoir, production method applied (such as gas or water injection to increase recovery), and drilling and production technology used (Winowoda & Wasesa, 2024).

2.2 Development of Gas Field

Several strategies and techniques can be applied to increase the gas recovery from a reservoir, depending on the characteristics of the reservoir and its technical conditions. Some common methods for increasing reservoir gas recovery are as follows. Number of Production Wells: Increasing the number of active production wells can directly increase the production capacity of the gas field. This involves identifying high-potential new well locations and optimal design to exploit the reservoir to its maximum potential (Yu et al., 2024). Drilling Technology and Well Completion: The use of advanced drilling technology and an optimal well completion design can increase the efficiency of gas production from reservoirs. This includes choosing the right well location, using appropriate equipment, and stimulating techniques, such as hydraulic fracturing (fracking), to increase the gas flow. Reservoir Modeling and Simulation: The use of advanced reservoir modeling and simulation techniques allows reservoir engineers to better understand reservoir behavior and design optimal production strategies. This includes the adjustment of the injection pressure, well pattern design, and evaluation of the sensitivity to various production factors (Ma, He, Wei, Guo, & Jia, 2023).

Production Optimization and Reservoir Management: Implementing efficient reservoir management strategies and good maintenance techniques can help maintain stable gas production and maximize recovery from the reservoir throughout the life of the field. Lowering Pressure: Reducing the pressure in a gas field is a common strategy used in the oil and gas industry to increase production or extend the life of a field. The success of this pressure reduction can vary depending on a variety of factors, including the geological characteristics of the reservoir, production technology used, and field management strategies (Kor, Hong, & Bratvold, 2024). Gas or Water Injection: This technique involves injecting gas (e.g., CO_2, nitrogen) or water into a reservoir to increase the pressure and push the gas into the production well. Gas or water injection can increase the gas recovery by improving the reservoir pressure or by pushing the trapped gas into the well (Tian et al., 2024). Enhanced Oil Recovery (EOR): The EOR technique is applied not only to oil but also to gas reservoirs. Techniques such as gas injection (such as CO_2) or other gases are used to increase gas recovery by changing the reservoir fluid properties and increasing the pressure (Ozowe, Daramola, & Ekemezie, 2024).

Any strategy for increasing gas recovery must be adapted to the specific conditions of the reservoir in question. The appropriate combination of production technology, reservoir management, and careful monitoring can help achieve optimal results in recovering gas from reservoirs.

2.3 Value Focused Thinking (VFT)

These values are what we care about. They must be the driving force for decision making. Alternatives are simply a means of achieving better value (Keeney & Keeney, 2009). Value-Focused Thinking (VFT) is a way of thinking that focuses on the fundamental objectives of a decision maker. Compared to the (AFT), the VFT has more advantages in creating alternative solutions and identifying decision opportunities. In AFT, there is a possibility that a decision maker will not achieve the fundamental objective because he is more focused on alternative choices. In the VFT, a decision maker starts by determining the fundamental objective that is driven by the value. From this objective, a decision maker will determine several criteria that are in accordance with the objective. Based on these criteria, the determination of alternatives is more relevant to the fundamental objective. The influence of VFT on the decision-making process is illustrated in the figure below (Keeney & Keeney, 2009; Salman, 2024).

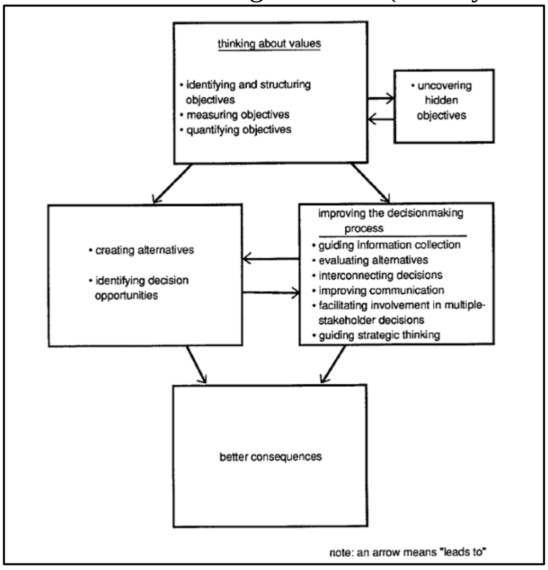


Figure 2. The Influence of VFT on Decision Making Process
Source: Author analiyze (2024)

2.4 Analytic Hierarchy Process (AHP)

After several alternatives have been generated, the next step is to choose the best alternative. One of the methods for selecting the best alternative is the Analytical Hierarchy Process (AHP). This method was developed by. AHP offers an approach for a decision maker when handling a problem with multiple objectives and uncertainty (Fauziah, 2024). This method has been widely used in decision-making in several areas such as planning, economics, material handling, energy policy, project selection, and budget allocation (Goodwin & Wright, 2014; Salman, 2024). The steps of AHP are as follows; Setting up the decision hierarchy, making a pairwise comparison among alternatives and criteria, synthesizing the result, development of Priority Ranking (Novianti, Oktaviani, Sarkawi, Aldyanto, & Syahidan, 2023).

3. Research Methodology

The purpose of this research was to choose the best scenario to solve the problem of gas supply and demand imbalance. In conducting this research, a research design is needed as a step-by-step guide to find the root cause of the problem and to find the right solution. To obtain a good understanding of the problem, data must be analyzed later. Data collection in this study focuses on primary data obtained directly from a Subject Matter Expert (Kepner & Tregoe, 1997).

This chapter is divided into three sections. The first part is the research design, which is the framework of the research methods and techniques chosen by researchers to conduct this study. In this research design, one can see the steps taken by the researcher from the beginning to the end of the study. The second part explores how the data were obtained, and the third part is the analysis method that researchers will use in conducting this study.

3.1 Research Design

A research design is required to ensure that the research framework can be implemented. The research design stages are illustrated in Figure 3.

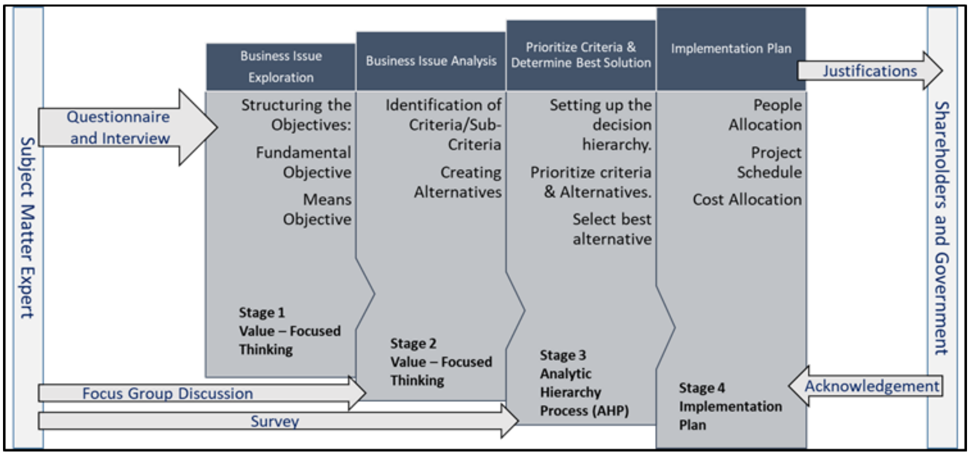


Figure 3. Research Design
Source: Author Analysis (2024)

A four-stage problem-solving model is used as a research sequence to solve this problem.

3.3.1 Business Issue Exploration

In this section, we discuss in detail the issue of the gap between supply and demand. The reason for this has been discussed in the previous chapter. This section discusses the determination of the objectives of the problem solution. Value Focused Thinking is a tool that will be used to determine fundamentals and objective means. This objective exploration was conducted using interviews and questionnaires with four Subject Matter Experts. After obtaining the objective aspirations of the SMEs, the researchers carried out an analysis to determine the relationship between one objective and another. All inputs provided by SME must be carefully considered because these are aspirations that determine the final objectives of this research.

3.3.2 Business Issue Analysis

In this section, the researcher asks for inputs from SMEs to determine the criteria that will be used in project selection. In this study, the brainstorming method in the Focus Group Discussion (FGD) forum using the VFT tool is used to define and determine decision criteria and alternative solutions by involving several technical experts who have competence and authorization in decision-making at JOB PMTS. Brainstorming with a group of people is a powerful technique for creating new ideas, solving problems, and motivating and developing teams. The criteria and sub-criteria are prepared in advance by researchers based on objectives that have mutually agreed with SME. Subsequently, the criteria and sub-criteria were discussed with SMEs to obtain a list of criteria. Then, a discussion was held on selecting alternatives that had been previously prepared by the researcher, considering the objectives, criteria, and existing resources.

3.3.3 Prioritize Criteria and Determine Best Solution

The Analytic Hierarchy Process (AHP) method was used to select the best solution from several alternative solutions obtained in the previous stage. The best solution was determined based on a survey of the SMEs. The survey was administered by asking questions related to the priority scale of the criteria and sub-criteria to obtain the most important criteria and sub-criteria. Subsequently, prioritization is performed on the existing alternatives for each sub-criterion. The criteria and alternative assessment matrix provided a score for each alternative. The alternative with the highest score is the selected solution proposed for management.

3.3.4 Implementation Plan

The final stage of this study is to develop a strategy and plan from the best selected solution so that it can be implemented appropriately in terms of time, budget, and quality. In this section, the researcher proposes the project organizational structure, its cost, and the expected work implementation schedule. This planning is carried out by considering the company's capacity and the resources owned by the company.

3.4 Data Collection Method

The method of collecting information is divided into two sections: primary and secondary data. In this process, the primary data are assembled data or information for the first time, whereas the secondary data are the data that have already been gathered or collected by others. The most important characteristic of the primary data is that it is original and first-hand, whereas the secondary data is the interpretation and analysis of the primary data.

Primary data were collected for the first time through personal experience or evidence, particularly for research. They are also described as raw data or first-hand information. Secondary data are second-hand data that have been collected and recorded by some researchers for their purpose and not for the current research problem. However, one disadvantage is that the information assembled is for other purposes and may not meet the present research purpose or may not be accurate. Therefore, this thesis focuses more on primary data derived from questionnaires, surveys, and focus group discussions by subject matter experts. Focused group discussions involve several subject matter experts who have sufficient competence and experience to produce the correct decisions. The composition of the subject matter expert consists of the subsurface, surface, and development and planning teams (Balusa & Gorai, 2019).

Researchers have used questionnaires and interviews with SMEs. The purpose of this questionnaire was to explore the value of SME to obtain the objectives of field development. Using this questionnaire and interview, researchers hope to obtain the values and concerns of each SME that represent their respective functions. The questionnaire consisted of three parts: respondent profile, business issues, and a list of questions asked. The respondent profile section provides an overview of the SME's background, which provides an explanation to the SME about the supply and demand gap problem that will occur. The third section presents the questions that will be used to address existing problems.

3.5 Data Analysis Method

This research used qualitative methods obtained from interviews, questionnaires, and discussions. The data obtained were analyzed by researchers with a focus on the content and the relationship between one content and another. This method is used in the VFT process to determine goals, criteria, and alternative solutions. In addition to qualitative methods, quantitative analysis was performed using the Analytic Hierarchy Process method. This method is used to determine the ranking of project selection criteria and sub-criteria and to determine the best field development scenario. The Expert Choice 11 software was used for data processing and analysis.

4. Results and Discussions

In this chapter, the research results are divided into three sections. The first section is an analysis of the data obtained from the results of questionnaires, interviews, and focus group discussions. The second section contains business solutions, which are the outputs of the data analysis. In this section, one solution that was selected based on the assessment that has been given quantitatively is explained. The final section presents the implementation plan and its justification. This section explains the implementation plan for the previously selected solution. This implementation plan needs to be made in detail so that the selected solution can be implemented in accordance with the aspirations of stakeholders and the company's capabilities.

4.1 Analysis

This section will discuss the analysis in a sequential manner starting from determining objectives and criteria or sub-criteria, determining priority criteria, and alternatives to selecting the best scenario. As explained in the previous chapter, this research used questionnaires and interviews as tools in the value-focused thinking method. There are seven questions to delve deeper into the value of each SME. The following is a summary of the questions answered by each SME:

Table 1. Analysis of Questionnaire Results

No	Questions	Summary of the Answers	Analysis
1	Do you think further development of this field is necessary? Why?	All experts answered Yes with the reasons to increase value creation, there is still subsurface potential that has not been produced, to increase company and state profits, and to meet potential demand in the future.	From all the answers given, it can be seen that SME considers development necessary for the main reason to increase company value.
2	What do you think is the company's goal in developing this field?	Get maximum profits, maximize gas sales, maintain gas supply stability and avoid penalties, and minimize costs.	Company profit is the main goal of the company which can be obtained through selling gas as much as possible and minimizing costs
3	What parameters need to be considered when selecting a field development project?	Technical aspects related to the amount of gas obtained and the complexity of the project. Economic aspects related to the costs required and the benefits obtained. Risk aspects relate to certainty of the volume of gas produced, regulations and safety.	In selecting a project, there are several technical, economic and risk considerations.
4	Based on your experience in managing gas fields, what is the challenges in developing this field?	Some of the challenges faced include the level of uncertainty in gas acquisition, gas prices, quite long business processes, the reliability of production facilities, increasing operating costs, and quite large investment costs.	SME provides several challenges according to current and future field conditions. The main challenges are subsurface uncertainty, facility reliability, and cost.
5	What project alternatives can be done so that gas supply can meet buyer’s demand?	Optimizing subsurface and surface strategies to drain existing reservoirs and develop potential gas reservoirs that have not yet been produced.	There are several alternatives that can be grouped into strategies for decomposing existing layers and producing new layers.
6	What benefits will the company get if it can meet buyers' demands?	Obtain optimal revenue and profit and maintain the company's good reputation for stakeholders	All SMEs have the same view that the benefits obtained are financial benefits and company reputation
7	What will be the consequences if this field is not developed?	Opportunity loss to create added value, poor economy, failure to achieve government and company targets, and bad reputation.	The negative consequences that will be faced are very significant so that development projects in this field must be hastened

The results of the questionnaire above were used as a reference in determining the fundamental objectives and means objectives. In determining the type of objective, the researcher asked the question "Why is this objective important in the gas field development?" Essentially, there are two different answers. The first type, if the answer is given, is that the objective is essential for developing this field.

If so, these objectives are grouped into fundamental objectives. The second type of answer is that objectives are important because they have implications for other objectives. In this case, these are the mean objectives.

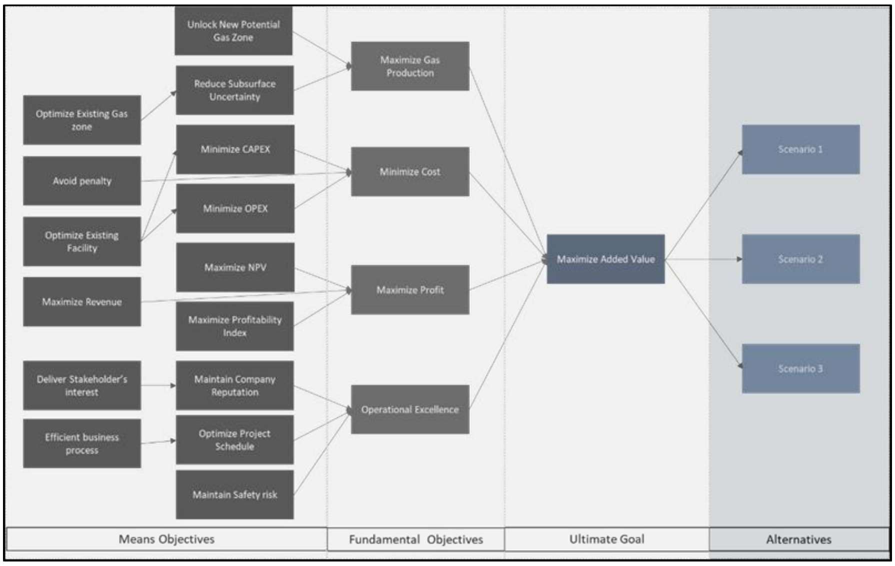


Figure 4. Objectives Structure for ANH Gas Development
Source: Author analysis (2024)

Based on the structure above, criteria and sub-criteria are selected, which are considered factors in selecting development projects. The mean objectives are references that are used as the main reference in creating a list of criteria and sub-criteria.

Table 2. Criteria and Subcriteria for ANH Gas Development

No	Criteria	Sub-criteria	Description
1	Cumulative Production obtained	Unlock new potential gas zone	Produce layer Y and Z
		Optimize existing gas zone	Produce layer X
2	The amount of cost required	Capital Expenditure (CAPEX)	Investment costs include drilling costs, surface facilities costs such as flowlines and compressors, as well as other supporting costs.
		Operating Expenditure (OPEX)	Operating costs include operating and maintenance costs for wells and surface facilities, as well as other operational costs.
3	Project's Profitability	Net Present Value (NPV)	NPV calculates the present value of the expected net cash flows from the project, after deducting the initial capital costs incurred to start the project.
		Profitability Index (PI)	PI measures the ratio between the present value of the expected net cash flows from a project and the cost of capital initially invested to start the project.
4	Project's Risk	Safety Risk	The possibility of work accidents resulting from drilling and surface facilities work.

	Project Completion Time	This parameter is to see how timely the job starts and ends.

Source: Data research (2024)

To determine alternative development projects, a focus group discussion involving Subject Matter Experts was conducted. Apart from discussions carried out in meetings with management, discussions are also carried out on a daily basis because the process of determining alternatives is iterative and depends on company dynamics.

Discussions involving various parties with various functions will enrich the resulting alternatives. This discussion involves planning and development functions, including risk, subsurface, drilling, and technical management. Based on the discussions that have been conducted, there are three alternative development projects. The selection of this scenario also considers stakeholders and company interests. The following is a detailed explanation of each scenario. Scenario 1 is to infill drilling 9 wells existing X zone, pipeline construction, and modification of production facilities (Medium Pressure and Low Pressures Compressor estimated on stream on eighth year). Scenario 2 is to infill drilling 9 wells existing X zone, pipeline construction and modification of production facilities (Medium Pressure stage estimated on stream on eighth year and Low Pressures stage estimated on stream on twelfth year). Scenario 3 is to infill drilling 9 wells existing X zone, new 2 wells Y zone, new 3 wells Z zone, pipeline construction, and modification of production facilities (Medium Pressure stage estimated on stream on eighth year and Low Pressure stage estimated on stream on twelfth year).

The three scenarios shown above are those that produce the highest gas recovery based on reservoir simulation. After determining the amount of gas obtained, an economic analysis is carried out to determine which project provides the highest economic value. The following are the results of technical and economic studies for each scenario:

Table 3. Technical and Economic Output of Alternatives

No.	Parameter	Scenario 1	Scenario 2	Scenario 3
1	Cumulative Production (Bscf)	167.3	166.8	199
2	CAPEX (Mio USD)	114	119	148
3	OPEX (Mio USD)	115	114	138
4	NPV (Mio USD)	79	84	91
5	PI (ratio)	1.69	1.70	1.61
6	Safety Risk (probability of incident occured)	High	Medium to high	Very high
7	Punctuality (probability of on-time schedule)	Likely	Most likely	Least likely

Source; Data research (2024)

Decision Hierarchy of AHP

The first step that must be performed when starting the AHP is to determine the hierarchical structure of the existing problem. The main objective of developing this field is to maximize added value, as explained in the previous chapter. This goal is at Level 1 in the hierarchy structure. Level 2 is the project selection criterion, consisting of four criteria. Level 3 contains the project selection sub-criteria, which include eight sub-criteria. Meanwhile, at Level 4, there is an alternative scenario where, in the end, the best scenario will be chosen.

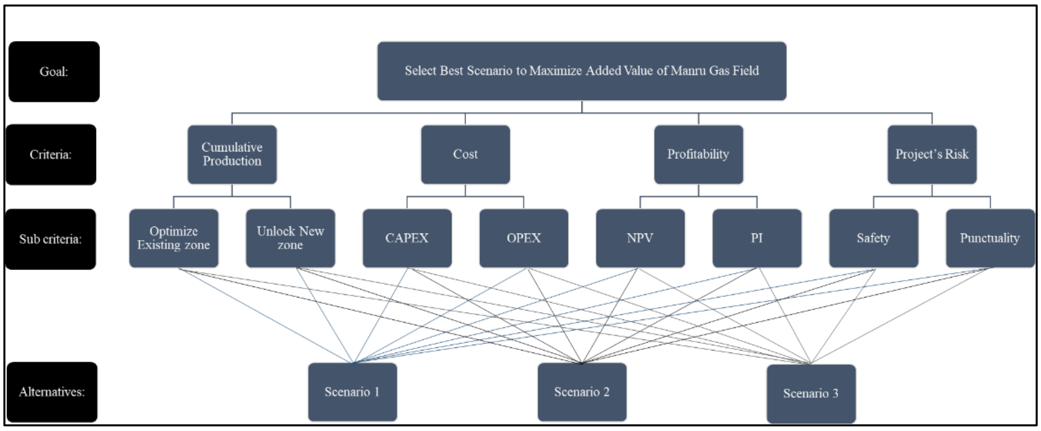


Figure 5. Hierarchy Structure of AHP for ANH Gas Field
Source: Author analysis (2024)

Pairwise Comparison Results

Below is a recapitulation of the survey results completed by SMEs. The results of this survey will be used as input data for AHP calculations using the Expert Choice 11 software.

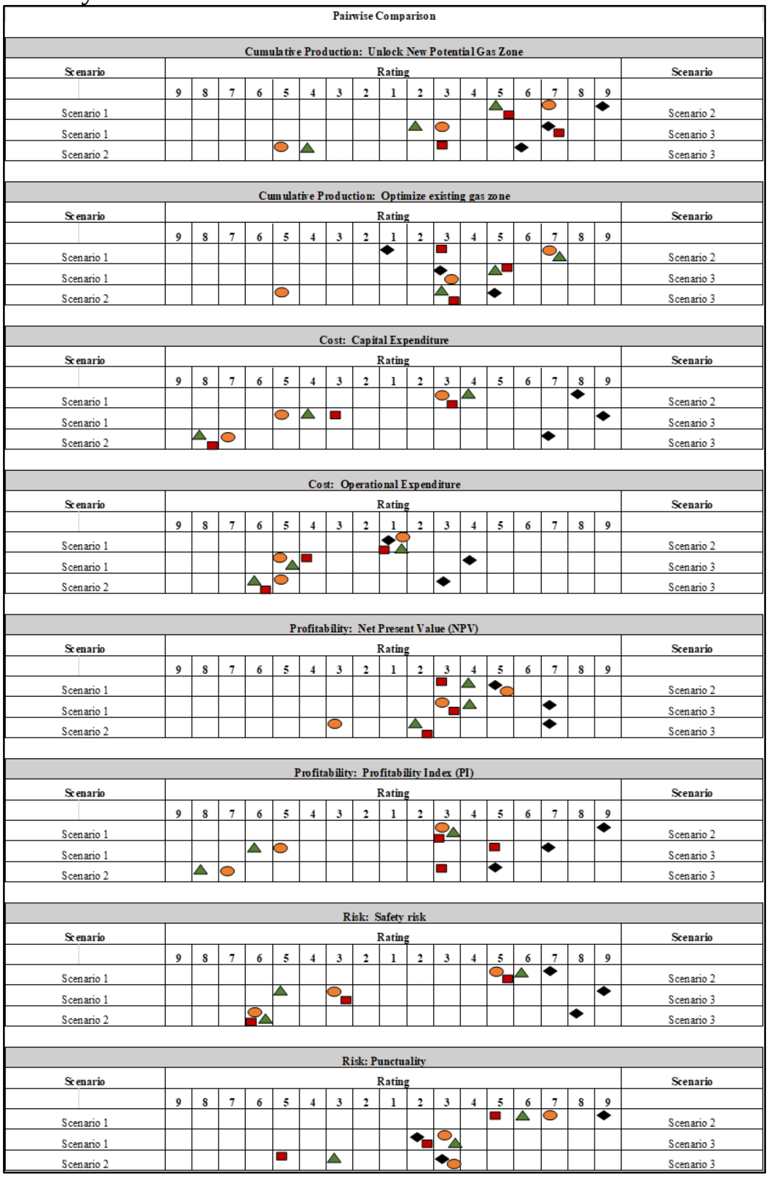
Expert 1	◆
Expert 2	●
Expert 3	▲
Expert 4	■

Table 4. Results of Survey Criteria and Sub criteria

Pairwise Comparison																		
Criteria																		
Parameter	**Rating**																	**Parameter**
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Cumulative Production				◆			● ▲	■										Cost
Cumulative Production											● ▲	■					◆	Profitability
Cumulative Production						■	● ▲								◆			Risk
Cost											■	▲	●	◆				Profitability
Cost					■	▲	●							◆				Risk
Profitability			●	▲ ■							◆							Risk
Sub-Criteria																		
Parameter	**Rating**																	**Parameter**
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Cumulative Production																		
Unlock new potential gas zone													●	▲ ■			◆	Optimize existing gas zone
Cost Proyek																		
Capital Expenditure			● ■	▲	◆													Operational Expenditure
Profitability proyek																		
Net Present Value (NPV)					●		▲				■				◆			Profitability Index (PI)
Tingkat risiko proyek																		
Safety risk					■		◆ ●	▲										Punctuality

Source: Data analiyze (2024)

Table 5. Results of Survey Alternatives



Source: Data analiyze (2024)

AHP Calculations

The AHP calculation results are presented in table below. It can be concluded that based on the assessment given, the profitability criterion is a priority criterion compared to other criteria with a weight score of 0.529. The least priority criterion was cost, with a weight score of 0.120. For sub-criteria, it can be seen that the Profitability Index and NPV sub-criteria are priority sub-criteria compared to other sub-criteria with global weight scores of 0.266 and 0.263. Meanwhile, the sub-criteria with the lowest priority are operational expenditures with a global weight score of 0.017. Based on the global weight score, the Profitability Index and NPV sub-criteria are key parameters for selecting alternatives.

Table 6. Weighted Score of Criteria and Sub-criteria

Criteria	Weight	Sub-criteria	Local Weight	Global Weight	Global Rank
Cumulative Production	0.228	Unlock new potential gas zone	0.136	0.031	7
		Optimize existing gas zone	0.864	0.197	3
Cost	0.120	Capital Expenditure	0.861	0.103	4
		Operational Expenditure	0.139	0.017	8
Profitability	0.529	Net Present Value (NPV)	0.497	0.263	2
		Profitability Index (PI)	0.503	0.266	1
Risk	0.122	Safety	0.610	0.074	5
		Punctuality	0.390	0.048	6

Source: Data analiyze (2024)

Based on the assessment given, Scenario 2 is the best scenario compared to the other scenarios with a score of 0.477. Scenario 3 had a score of 0.364 and third place is Scenario 1 had a score of 0.158. In the selected scenario, the highest order of the three sub-criteria is the Profitability Index with a score of 0.134, followed by the NPV sub-criteria with a score of 0.110. The third position is the optimized existing gas zone sub-criteria, with a score of 0.096. The overall inconsistency of each sub-criterion for alternatives is always below 0.1, so that the results obtained are valid.

Table 7. Weighted Score of Alternatives

Sub-criteria	Scenario 1	Scenario 2	Scenario 3	Overall Inconsistency
Unlock new potential gas zone	0.003	0.016	0.015	0.00
Optimize existing gas zone	0.027	0.096	0.099	0.00
Capital Expenditure	0.019	0.052	0.014	0.03
Operational Expenditure	0.008	0.008	0.003	0.01
Net Present Value (NPV)	0.031	0.11	0.132	0.00
Profitability Index (PI)	0.057	0.134	0.075	0.06
Safety	0.008	0.037	0.013	0.02
Punctuality	0.005	0.024	0.013	0.00
Total	**0.158**	**0.477**	**0.365**	

Source: Data analiyze (2024)

The following are the score level criteria, sub-criteria, and alternatives in the AHP hierarchy structure based on the results of data processing conducted by researchers. Scenario 2 is the best scenario where the development of this gas field is carried out in this way: infill drilling nine wells in the X zone, pipeline construction, and modification of production facilities.

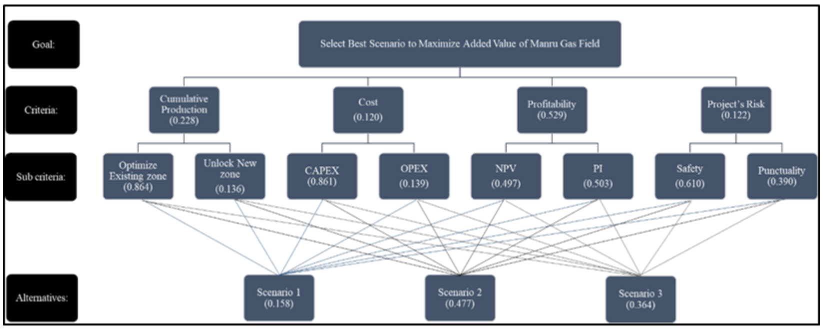


Figure 6. Hierarchy Structure Results for ANH Gas Field
Source: Author analysis (2024)

Sensitivity Analysis
A sensitivity analysis was performed to determine the effect of changes in priority criteria on the sequence of scenarios. From the results of the calculations above, it was found that the most important

criterion is profitability and produces the second scenario as the best scenario. There are four sensitivities used in this research, namely performance, dynamic, gradient, and head to head sensitivity.

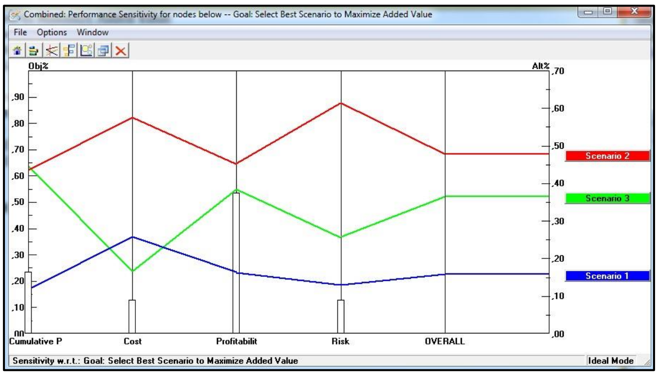


Figure 7. Performance Sensitivity of ANH Gas Field
Source: Data analiyze (2024)

Performance sensitivity shows that, overall, there is no change in the order of the best scenarios for each criterion. There is a change in the order of priority in the cost criteria, where scenario 1 becomes the second-place beating scenario 3. The scenario weight score in the cost criteria was 0.576 for scenario 2, whereas those for scenarios 1 and 3 were 0.257 and 0.166, respectively.

In this sensitivity analysis, dynamic sensitivity was also performed on the criteria of cumulative production, cost, and risk. In the profitability sensitivity criteria, changes in the scenario towards the weighted score of NPV and PI can be seen. These two sub-criteria have similar global weight scores of 0.497 and 0.503. By changing the weighted score PI to 0.25 and NPV to 0.75, the priority order of the selected scenarios was changed. Scenario 3 was the best scenario, with a score of 0.436, scenario 2 had a score of 0.427, and scenario 1 had a score of 0.137.

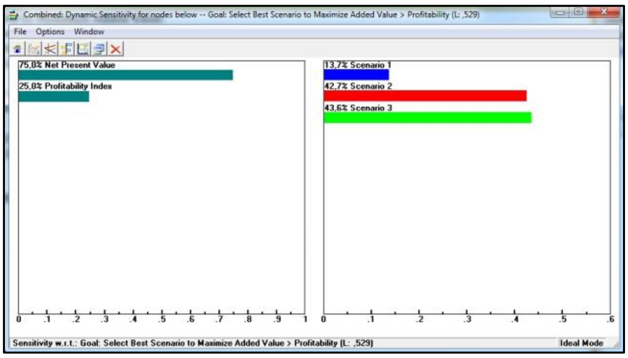


Figure 8. Dynamic Sensitivity for Profitability to Alternatives
Source: Data analiyze (2024)

In addition, gradient sensitivity was carried out for each criterion to determine the magnitude of the change in the weight score of the alternatives. From the sensitivity results for cumulative production, it can be concluded that the greater the cumulative production weight score, the greater the weight score for scenario 2, and the greater the weight score for scenario 3. However, the second scenario remains the best scenario if the cumulative production has a weight score below 0.95.

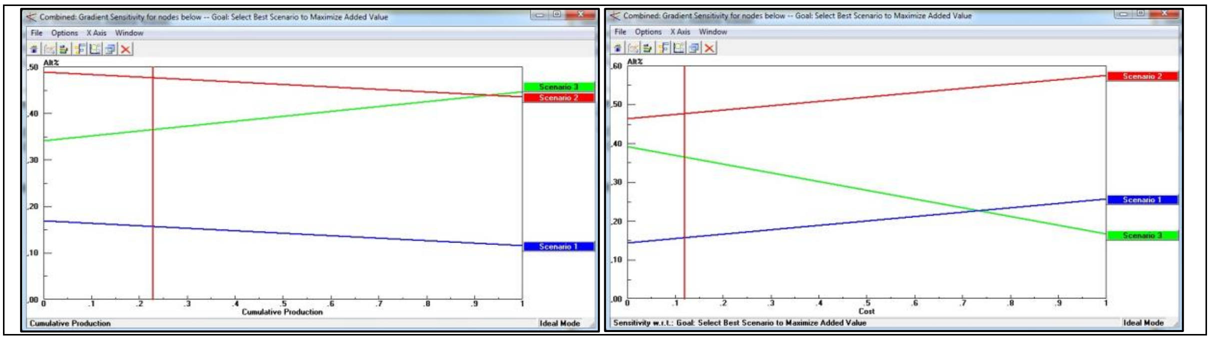


Figure 9. Gradient Sensitivity for Cumulative Production and Profitability to Alternatives
Source: Data analiyze (2024)

Sensitivity analysis was also carried out on the cost criteria, with the results showing that scenarios 1 and 2 will obtain a higher weight score as the cost criteria score increases. This is inversely proportional to Scenario 3, which decreases with increasing priority cost. Scenario 1 will rise to the second-rank beating scenario 3 if the weight score cost is above 0.75. Overall, Scenario 2 remains the best scenario for cost sensitivity. The sensitivity carried out next is the sensitivity of profitability to a sequence of scenarios. From the sensitivity results, we conclude that changes in profitability have no effect on the sequence of scenarios. Scenario 2 is the best scenario, although the weight score of scenario 2 decreases as the profitability score increases.

The final sensitivity is the influence of risk on the sequence of scenarios. From the sensitivity results, it is concluded that scenario 2 retains the scenario with the highest weight score compared to the other scenarios. Increasing the weight score on the risk criteria also increased the score for Scenario 2. This is inversely proportional to Scenarios 1 and 3, which decrease as the weight score for the risk criteria increases.

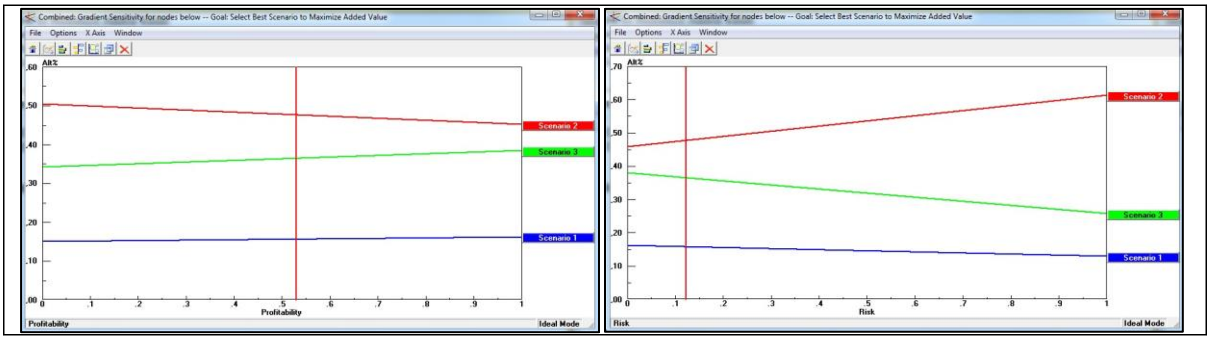


Figure 10. Gradient Sensitivity for Profitability and Risk to Alternatives
Source: Data analiyze (2024)

The head-to-head sensitivity between the scenarios was also presented in this study. The head-to-head scenario 1 versus scenario 2 gives an overall weighted score of 30.32% for scenario 2. The head-to-head scenario 1 vs. scenario 3 gives an overall weighted score of 8 – 15% for scenario 3. Meanwhile, the head-to-head scenario 2 vs. scenario 3 was 15 – 20% for scenario 2.

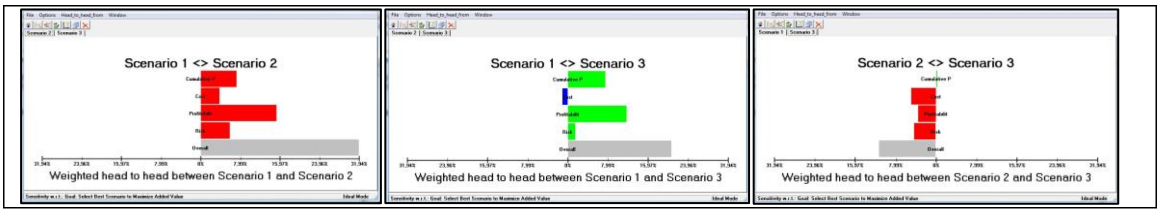


Figure 11 Head to Head Alternatives
Source: Data analiyze (2024)

4.2 Business Solution

From all the analyses previously explained using VFT and AHP, the selected solution was obtained to solve problems in the ANH Gas Field. The gap between supply and demand that has occurred since the eighth year can be overcome by carrying out the second of the three development scenarios. The order of the criteria and sub-criteria, which are considered factors in selecting a development project, were also obtained through this research.

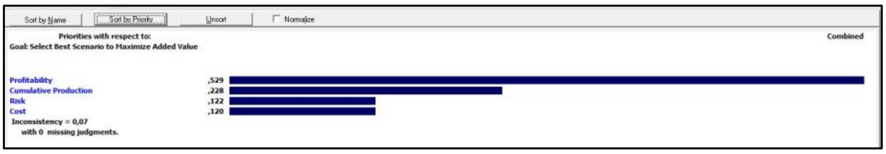


Figure 12. Weight Score of Criteria with Respect to Goal
Source: Data analiyze (2024)

Scenario 2 was selected for developing this gas field with a weight score of 0.477 and an overall inconsistency of < 0.1. This scenario is a valid scenario represents the values held by Subject Matter Experts. We hope that this scenario can be executed because it is the best scenario to increase the added value for the company.

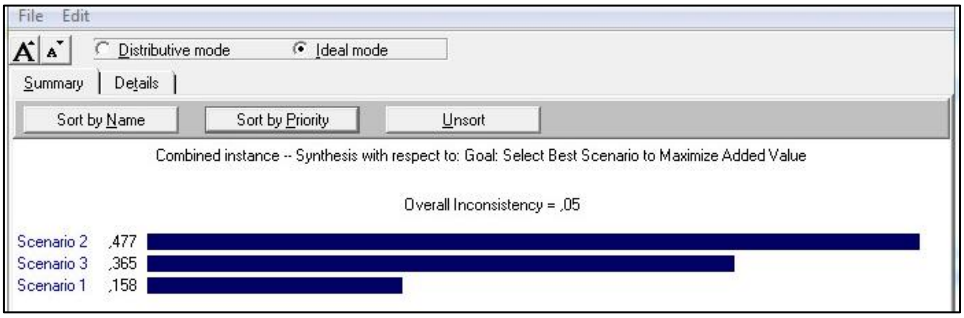


Figure 13. Weight Score of Alternatives with Respect to Goal
Source: Data analiyze (2024)

The development project was carried out by infilling nine wells in the X zone, pipeline construction, and modification of production facilities (Medium Pressure stage estimated on stream in the eighth year and Low Pressure stage estimated on stream in the twelfth year). The following is the production profile of the existing conditions (baseline) and after implementing this scenario.

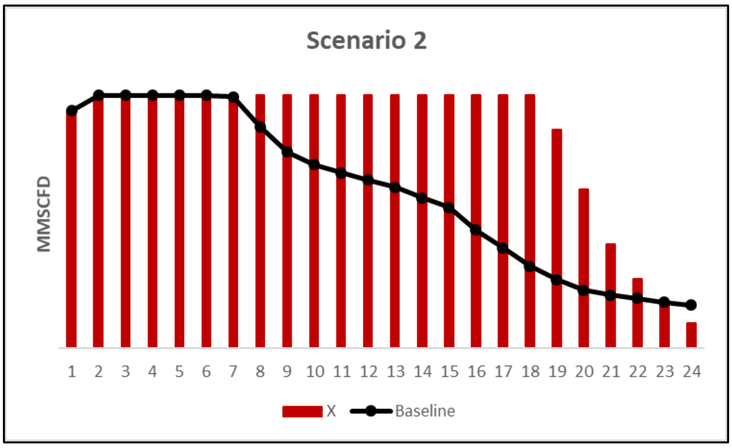
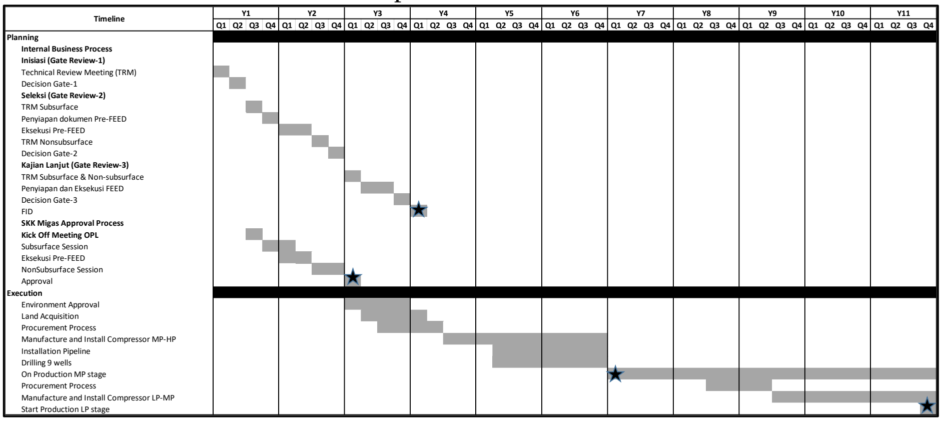


Figure 14. Production Profile of Selected Scenario
Source: Data analiyze (2024)

4.3 Implementation Plan

The selected scenario certainly needs to be executed well so that project implementation can run according to the specified time frame and the planned budget, and obtain the profit as determined. The following is the implementation plan for the field development project, which was prepared from the project proposal submission process to stream production.

Table 8. Timeline of ANH Gas Field Development



Source: Data analiyze (2024)

There are two parts to the timeline above, consisting of the planning and execution sections. In the planning section, two approval processes must be carried out by the company: internal approval and SKK Migas approval. In this timeline, the internal approval corresponds to one of the parents who has the longest business process. Internal approval begins with initiation (Gate Review-1), which consists of a technical meeting and approval with an estimated time of six months. Gate Review-2 was then continued for 18 months, which consisted of subsurface and non-subsurface meetings as well as the execution of the Pre-FEED Study. The next stage is Gate Review-3, which consists of a technical review meeting and FEED Study execution. This stage took 15 months until the FID approval process was obtained in the first quarter of Y4.

Apart from this internal process, SKK Migas approval was also obtained after obtaining TRM Subsurface approval in GR-2. This process began with the OPLL Kick Off Meeting, followed by a discussion of subsurface and non-subsurface materials, as well as Pre-FEED. The entire approval process at SKK Migas was estimated to take 21 months to obtain the approval letter in the first quarter of Y3.

After approval was obtained from the internal and SKK Migas, the execution process continued. Execution begins with the approval process from the Ministry of Environment, land acquisition, and procurement processes, which began in parallel with the approval process. It is hoped that the procurement will be completed in the second quarter of Y4. Subsequently, the MP compressor manufacturing and installation processes are carried out until Y6. The drilling of nine wells and pipeline installation will also be carried out at the same time as the compressor installation, so it is hoped that the well will be able to be produced in Y7. The next procurement process is performed for the compressor. The second stage occurred until the second quarter of Y9. Subsequently, it continues with the manufacturing and installation of the LP stage compressor, which is expected to be completed by the end of Y11. The gas field was estimated to be produced at low pressure from the end of Y11.

Organization Chart

The need for labor in executing this development project comes from internal companies and personnel from related contractors. For the company internally, the General Manager will be the sponsor of this project as the highest leader of the company. In addition, there is a Project Steering Committee serving as a project supervisor. The project owner will coordinate two project managers: surface facilities and the drilling project manager. Apart from the two project managers, there are also several enabler functions that support this activity, which come from various functions within the company.

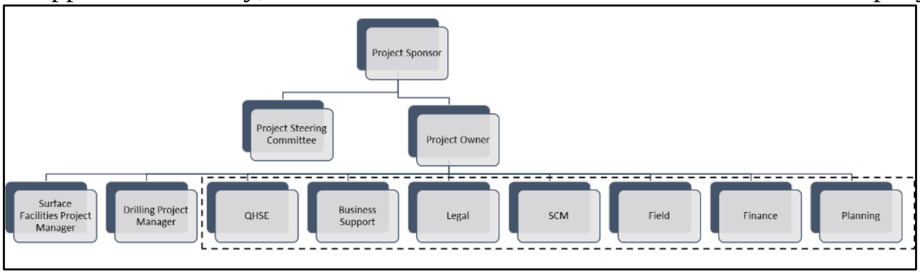


Figure 15. Organization Structure of ANH Gas Field Project
Source: Data analiyze (2024)

The organizational structure above is also supported by the contractor's organizational structure and manpower. The contractor's organizational structure is determined after the approval of the winner of the work tender.

5. Conclusion

The following are several conclusions obtained from this research based on the VFT and AHP methods that have been carried out; in developing this gas field, several criteria and sub-criteria are considered when selecting a development project. The first criterion is cumulative production, which consists of two sub-criteria: unlocking new potential gas zones and optimizing existing gas zones. The second criterion is cost, which consists of capital and operating expenditures. The third criterion is profitability, which consists of two sub-criteria: Net Present Value and Profitability Index. The final criterion is risk, which comprises the safety risk and punctuality of the project.

The weighting scale for each criterion begins by extracting the Subject Matter Expert value via the VFT and AHP pairwise comparison survey. The most important criterion was profitability, with a weight score of 0.529, followed by cumulative production, risk, and cost. The sub-criteria with the highest global weight score are the Profitability Index of 0.266 and the Net Present Value with a score of 0.263, while the lowest score is Operational Expenditure with a score of 0.017.

The best field development scenario was Scenario 2, with a weight score of 0.477. The scope of work for this scenario is drilling nine wells, building a pipeline in the seventh year, and installing compressors in stages starting with the MP-HP compressor, which is on stream in the eighth year, and the LP-MP compressor in the twelfth year. This scenario produces an NPV of USD 83.5 mio, PI ratio 1.7, CAPEX USD 118.5 mio, and OPEX USD 114.5 mio.

Limitations and Future Study

The study is limited by its reliance on expert judgment for weighting and scenario evaluation, which may introduce subjectivity. Additionally, the economic and operational assumptions may not fully capture uncertainties such as market fluctuations or unforeseen technical issues. Future research should incorporate sensitivity analyses, real-time data integration, and advanced simulation models to improve robustness and adaptability of the decision-making framework.

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