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Economic Evaluation and Risk Identification of the Work Plan for Gas Turbine Compressor Engine Exchange on Offshore Platform in Field X

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Abstract

The offshore platform in Field X operates 2 (two) Gas Turbine Compressor units which function to compress gas pressure as fuel supply for the Gas Turbine Generator. The running hours of these Gas Turbine Compressor units have nearly reached 30,000 hours, prompting the manufacturer to recommend an Engine Exchange to maintain its operational reliability. Prior to the approval of the Gas Turbine Compressor engine exchange work plan, an economic evaluation and risk identification are required to assess the financial feasibility and identify potential risks that could affect the smooth implementation of the work. This study aims to provide comprehensive recommendations on economic aspects and risks to the management as a basis for investment decision-making. The research employs the Benefit/Cost Analysis method and Risk Register to evaluate the economic and risk levels of the work plan. The research findings that the work plan for the engine exchange of the gas turbine compressor on the offshore platform in Field X is feasible from an economic and risk perspective, as it has a BCR value > 1 with low to moderate risk and low risk level.

Keywords
Economic Evaluation, Risk Identification, Benefit/Cost Analysis, Risk Register

1. Introduction
The operation activities of oil and gas production in offshore areas require complex infrastructure, including continuous and reliable electrical power supply. The production facilities and utilities in these oil and gas fields necessitate reliable power sources to ensure smooth operational activities. Hence, offshore oil and gas fields are typically equipped with their own power generation facilities. The types of power generation facilities commonly used include gas engines, gas turbine generators, and diesel engines.

The offshore platform at Field X has two gas turbine compressor units, namely GTC-A and GTC-B. Both gas turbine compressor units play a vital role in the operational activities at Field X. These gas turbine compressors are responsible for compressing the gas pressure produced by the gas platforms at Field X. Subsequently, the compressed gas flows through the gas turbine compressor to supply fuel to the gas turbine generators at Field X. Therefore, the reliability and optimal performance of the gas turbine compressors are crucial to maintain operational efficiency and minimize the risk of downtime or operational disruptions that could result in significant financial and operational losses.

Given the importance of these two gas turbine compressor units, manufacturers recommend conducting engine exchanges at 30,000 operating hours. This recommendation is based on the fact that the operating hours of both gas turbine compressor units are approaching 30,000 hours, which is the recommended operating hour limit by the manufacturers. The engine exchange involves replacing the gas turbine compressor units that have reached their operating hour limit with new units or units that have been remanufactured. The purpose of the engine exchange is to

maintain or improve the reliability, efficiency, and performance of the gas turbine compressors in compressing gas pressure to meet the fuel supply needs of the gas turbine generators at Field X.

Based on the technical aspects explained above, the plan to conduct engine exchanges for both gas turbine compressor units is urgently needed to be submitted to the management as the reliability of the gas turbine compressor units directly affects operational efficiency at Field X. Therefore, before deciding to implement the engine exchange work on both gas turbine compressor units, an evaluation of the economic aspects and work risks is required. This evaluation aims to assess the financial feasibility of the plan and identify potential risks that could affect the smoothness and success of the work implementation. The results of this evaluation are expected to provide comprehensive recommendations to the management as a basis for making the right investment decisions oriented towards long-term outcomes.

2. Objectives

The main objective of this research is to determine the economic feasibility and identify potential risks of the engine exchange plan for gas turbine compressors on the offshore platform in Field X.

3. Literature Review

Mathematical models are applied to financial modeling problems. Financial models aim to analyze the undisclosed risk factors and compute the feasibility study of a project or investment for a company (Joerg Kienitz, 2012). There are parameters used in evaluating investments such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (Proctor, 2010). The profitability of an investment can be analyzed using net present value (NPV). NPV is a measure of the economic feasibility of a project; specifically, a positive NPV indicates that the project is economically feasible to pursue, while a negative NPV indicates that the project is economically infeasible to pursue (Suzan Abdelhady, 2020). Internal rate of return (IRR) is the rate at which a project breaks even. IRR calculates the actual return provided by the project's cash flow and compares that return rate with the company's hurdle rate (the desired return on investment). The feasibility indicator is: if the IRR is greater than the prevailing bank interest rate (IRR > DR), then the venture is deemed viable. Conversely, if the IRR is less than the prevailing interest rate (IRR < DR), then the venture is not feasible to pursue (Husnul, 2014). Payback Period is the time required to recover the investment outlay, or the time it takes for the total inflows to equal the investment outlay for running an investment/business (Kasmir & Jakfar, 2012). This analysis is chosen to determine how long the investment will recoup its capital (Wijayanto, 2012). Payback period criteria do not have standard indicators and are relative depending on the project's lifespan and the size of the investment.

Risk identification is a step to determine, monitor, and evaluate risks that have the potential to affect the project. Those involved in the identification process include an experienced risk management professional, stakeholders, and the risk management team (comprising managers and members). It is advisable to involve every project personnel in identifying risks (Project Management Institute, 2021). The outcome of this stage is the Risk Register, which contains a list of risks and their characteristics.The Risk Register is a tool for project management and risk assessment within an organization (Patterson & Nealey, 2002). It serves as a repository for information about risks in an organization, and the information is then filtered, standardized, and consolidated to provide relevant information to management. The format of the risk register may vary, but it generally includes the same components of information such as risk variables, causative factors, probability and impact levels, and planned mitigation efforts.

4. Methods

The research methodology is depicted through a conceptual model. The conceptual model illustrates the input, process, and output of the economic evaluation and risk identification of the engine exchange gas turbine compressor plan at the offshore platform of Field X. The development of the conceptual model aims to aid in understanding the process of conducting economic evaluation and risk identification of the engine exchange gas turbine compressor plan at the offshore platform of Field X. The conceptual model is outlined as follows (Figure 1):

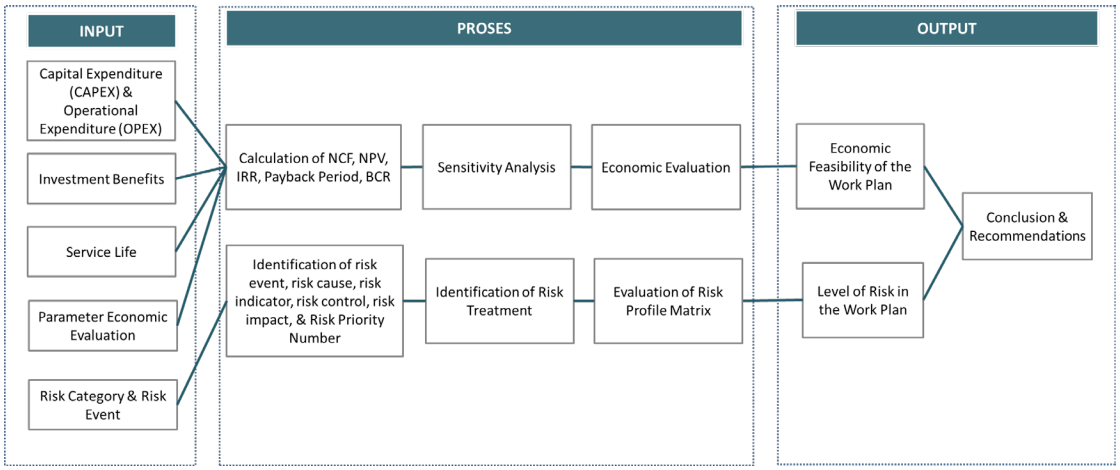

Figure 1. Conceptual model of the economic evaluation and risk identification of the engine exchange gas turbine compressor plan at the offshore platform of Field X

Data required for the economic evaluation and risk identification of the engine exchange gas turbine compressor plan at the offshore platform of Field X include investment cost data, operational cost data, investment benefits, useful life, discount rate, as well as types and occurrences of risks. This data is necessary for the calculation process of net cash flow (NCF), net present value (NPV), internal rate of return (IRR), payback period, and benefit-cost ratio (BCR). Subsequently, the results of the benefit-cost ratio (BCR) calculations will undergo sensitivity analysis to understand how BCR responds to changes in operational and maintenance costs (OPEX) and investment costs (CAPEX). The results of the economic aspects calculation are further evaluated to obtain information on the economic viability of the work plan.

In addition to economic aspects, risk aspects are also further identified using a risk register, which includes risk events, risk causes, risk indicators, risk controls, risk impacts, and risk priority numbers. The results of the risk register are further identified to obtain risk management for each risk event. Subsequently, a risk profile matrix evaluation is conducted to obtain the risk level of the work plan.

5. Data Collection

5.1 Capital Expenditure

The investment cost encompasses all expenses required to implement the engine exchange plan for gas turbine compressors on the offshore platform in Field X. This includes the package cost of the engine exchange, installation, commissioning, and start-up, as well as transportation costs from the manufacturing workshop to the dock at Field X. The investment cost for the engine exchange plan for the 2 units of gas turbine compressors on the offshore platform in Field X amounts to USD 3,180,000.

5.2 Operational Expenditure

Operating the gas turbine compressor incurs operational and maintenance costs to maintain the reliability and availability of the gas turbine compressor units in supporting the smooth operation of the power generation facilities at Field X. The operational and maintenance costs of the gas turbine compressor units consist of expenses for purchasing spare parts for preventive and corrective maintenance activities, as well as labor costs for carrying out these maintenance activities. Based on manufacturer recommendations and the operational pattern of the gas turbine compressor units, preventive maintenance is performed twice annually. Additionally, corrective maintenance activities are estimated to occur twice annually based on maintenance history data. The estimated operational and maintenance costs for the 2 units of engine exchange gas turbine compressors on the offshore platform at Field X amount to USD 368,000.

5.3 Investment Benefits

The implementation of the engine exchange plan for gas turbine compressors on the offshore platform at Field X aims to maintain and enhance the reliability, efficiency, and performance of the gas turbine compressors in compressing

gas pressure to meet the fuel supply needs of the gas turbine generators at Field X. Damage to the gas turbine compressors can cause the gas turbine generators to stop operating, resulting in a loss of oil production at Field X.
Based on the explanation above, the investment activity of engine exchange for gas turbine compressors has the benefit of eliminating potential financial and operational losses due to disruptions in the operation of the gas turbine compressor units. These potential losses can be estimated based on historical data on oil production losses due to operational disruptions of the gas turbine compressor units at Field X, which amount to 57,000 barrels per year.
The research data used in this study is a case study from one of the Offshore Installations in Indonesia. The crew boat performs ship movement activities with 1 (one) depot. The distances between facilities are obtained by referring to the coordinate data. Subsequently, the coordinate data of these facilities is illustrated in the graph below.

5.4 Risk Identification

Risk identification is conducted with the aim of recognizing and understanding potential risks that may hinder or affect the smooth implementation of the engine exchange plan for gas turbine compressors on the offshore platform at Field X. By identifying potential risks, planners can design effective mitigation strategies before commencing the implementation of the plan. This is expected to reduce or eliminate the negative impacts of these risks, ensuring the smooth and successful implementation of the plan in line with the set objectives.

Risk identification for the engine exchange plan for gas turbine compressors on the offshore platform at Field X is conducted using a qualitative risk measurement method, namely the risk register. The risk identification process is carried out through interviews with stakeholders involved in the engine exchange work for gas turbine compressors on the offshore platform at Field X. Interviews are conducted by completing questionnaires (Appendix 1) containing questions regarding the plan based on relevant risk classifications according to the Global Association Risk Professionals, including business risk, financial risk, health and safety risk, production risk, project management risk, and construction risk.

a. Business Risk
   Business risks arise due to the unavailability of the engine exchange contract for gas turbine compressors, requiring procurement processes for goods and services before commencing the work. Additionally, planners must comply with procurement guidelines regarding direct appointment procedures to manufacturers or authorized distributors because engine exchange work for gas turbine compressors can only be carried out by manufacturers that match the brand of the gas turbine compressor unit. The potential business risks can lead to delays in the procurement process, affecting the timeline of subsequent work phases. Business risks may also involve bribery of Planning Function or User Function personnel by contractors providing goods and services. Planning Function or User Function personnel may potentially receive bribes, fraud, abuse of authority, or violations of company code of ethics during the investment plan submission process and procurement of goods and services.
b. Financial Risk
   Financial risks occur due to potential changes in market prices for work components that may affect the increase in investment costs and operational/maintenance costs of gas turbine compressors. Such cost increases can be caused by macroeconomic conditions, inflation rates, and currency value stability. According to Taleb (2018), financial risks should be managed by focusing on reducing significant losses and considering uncertainty, as well as the potential impact of unexpected events.
c. Health and Safety Risk
   Occupational health and safety risks may arise during engine exchange work for gas turbine compressors due to the restricted working area on the offshore platform. These risks include workplace accidents due to unsafe conditions and behaviors, adverse weather conditions, and disease outbreaks.
d. Production Risk
   According to Irimia, D.C., & Stoian (2017), production risks are potential failures or issues in the production process that can lead to financial losses, decreased product quality, or even threats to worker safety and health. In the engine exchange work for gas turbine compressors, there is a potential risk of damage to the gas turbine compressor unit during shipment to Field X due to production failure or remanufacture unit failures in the manufacturing workshop, as well as procedural errors during unit transportation and mobilization until reaching the installation point.
e. Project Management Risk
   Project management risks can result in risk events such as failure to achieve work progress targets for engine exchange. This can be caused by poor contractor/subcontractor performance, leading to poor project

implementation quality and potential work completion delays. Additionally, project management risks may also occur due to changes in the scope of work during project implementation.

f. Construction Risk

Construction risks can be defined as potential events that can disrupt or hinder work processes, including schedule delays, exceeding cost estimates, quality and safety issues, and other factors that can lead to financial losses, property damage, or threats to worker safety and health. In the engine exchange work for gas turbine compressors, potential construction risks include procedural errors during installation, commissioning, and start-up of gas turbine compressor units.

5.5 Risk Register

After identifying the risks associated with the plan for engine exchange of gas turbine compressors, the risk register further identifies each risk event, including the causes, indicators, positive factors, and risk impacts. This allows for the analysis and evaluation of the Risk Priority Number (RPN) for each risk event. The risk register for the plan for engine exchange of gas turbine compressors is as follows (Table 1):

Table 1. Risk register

No	Risk Register					Risk Analysis & Evaluation		
	Risk Category	Risk Event	Risk Cause	Risk Control	Impact Description	I	P	RPN
1	Business Risk	Delay in procurement process of goods and services	1. Tender failure; 2. Delay in the preparation of procurement administrative documents	1. Clear GTC specification data for price inquiry needs 3. Availability of procurement guidelines for goods/services	1. Failure to Achieve On-Time Project Targets Delayed Execution of Subsequent Phases Delayed Absorption of Investment Budget for the Current Year	3	3	9
2	Business Risk	Bribery of End Users by Contractors	1. Potential risks of gratification, violation of the Code of Ethics, fraud, abuse of authority, and others, in the process of submitting and implementing investment projects; 2. Collusion with contractors to win tenders;	1. There is an Investment Guideline involving a cross-functional team (comprised of representatives from relevant functions) and delegation of authority with hierarchical approval; 2. Monitoring processes by management in accordance with applicable Standard Operating Procedures	1. Delay in project completion due to auditing of the submission and procurement processes	3	3	9
3	Financial Risk	Increase in investment costs and operational/maintenance expenses for the gas turbine compressor.	1. Changes in market prices for work components due to macroeconomic conditions, inflation rates, and currency value stability.	1. The investment budget planner utilizes the current conditions; 2. Availability of long-term operational/maintenance contracts	1. Potential delays or postponements in project implementation. 2. Cost overruns. 3. Decrease in the economic value of the project.	3	3	9
4	Healthy And Safety Risk	Occurrence of workplace accidents during project execution.	1. Lack of safety awareness, understanding, and worker competence; 2. Insufficient socialization of safety aspects; 3. Observations of unsafe behavior; 4. Near-miss incidents.	1. Implementation of Control of Work, HSE Training, Safety Behaviour and Technical Competency (SBTC), Medical Check-Up, and HSE Passport, Safety Observation, and Communication. 2. Worker and facility inspections (including equipment/machinery) are conducted routinely both before and after work begins.	1. Failure to achieve HSSE targets due to incidents. 2. Potential for fatalities to occur.	4	4	16
5	Healthy And Safety Risk	Delay in mobilizing equipment and personnel.	1. Inclement weather during the mobilization phase of equipment and personnel to the offshore field.	1. Availability of weather forecast reports 2. Arrangement of vessel units to support transportation facilities.	1. Delayed completion of work due to the unavailability of materials and workers at the offshore platform.	2	5	10
6	Healthy And Safety Risk	Worker health issues	1. Disease outbreaks or viruses, such as a COVID-19 outbreak; 2. Food poisoning; 3. Workers in unfit conditions to work.	1. Implementation of Contractor HSSE Management System (CSMS), Project HSSE Assurance (PRR), HSSE Plan; 2. Preparation of Emergency Response Plan Procedure (including Medivac and Incident Management Team) and regular drills conducted routinely.	1. Failure to achieve HSSE targets due to the occurrence of medical treatment cases. 2. Outbreak conditions leading to production operation shutdown.	3	3	9
7	Production Risk	Damage of the gas turbine compressor.	1. Failure in production or remanufacture of units at the manufacturing workshop. 2. Errors in procedures during the transportation and mobilization process.	1. Routine reporting for monitoring the production/remanufacture implementation. 2. Implementation of Factory Acceptance Test (FAT) before unit shipment.	1. Delay in completing the work. 2. Unit performance does not meet its target, requiring additional time for rectification.	4	4	16

No	Risk Register					Risk Analysis & Evaluation		
	Risk Category	Risk Event	Risk Cause	Risk Control	Impact Description	I	P	RPN
8	Project Management Risk	Failure to achieve the work progress target for the engine exchange.	1. Poor performance of Contractor/Subcontractor. 2. Changes in the scope of work during project implementation.	1. Conducting prequalification and contractor evaluation processes during procurement. 2. Holding regular monitoring and evaluation meetings to assess the progress of the work.	1. Implementation of work not according to the scheduled timeline. 2. Potential additional investment costs due to changes in the scope of work.	3	4	12
9	Construction Risk	The performance of the gas turbine compressor unit does not meet its performance target.	1. Errors in the installation, commissioning, and start-up procedures of the gas turbine compressor unit.	1. Implementation of strict installation, commissioning, and start-up procedures in accordance with manufacturing standards. 2. Fulfillment of competency requirements for the installation, commissioning, and start-up team in the contractor selection process.	1. Decrease in unit performance leading to an increase in operational costs. 2. Disruption or delay in operation and production schedules resulting in financial losses.	4	3	12

5.6 Risk Profile Matrix

The risk profile matrix depicts the level of risk based on impact and likelihood, thus providing a clearer understanding of the risks faced. The initial risk profile matrix for the engine exchange plan for gas turbine compressors on the offshore platform at Field X is as follows (Figure 2):

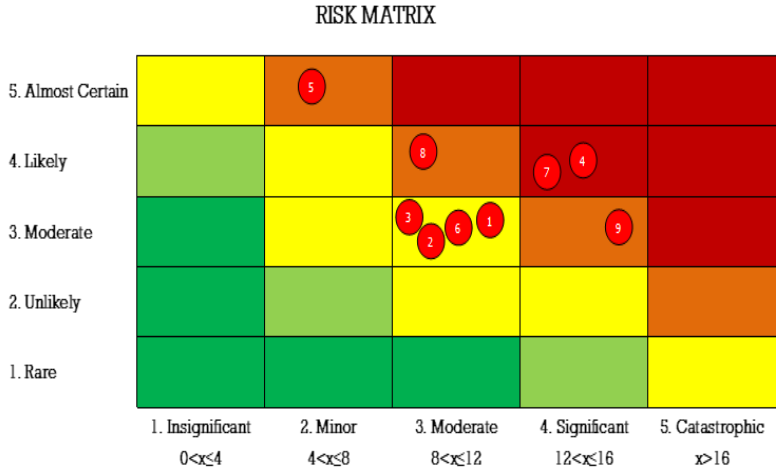

Figure 2 The initial risk profile matrix

Based on the above risk profile matrix, it can be observed that the engine exchange plan for gas turbine compressors on the offshore platform at Field X carries a high level of risk due to 2 risk events with a risk level of 16, namely workplace accidents during the implementation of work and damage to replacement gas turbine compressor units. Additionally, the plan also entails 3 risk events with a Moderate to High risk level, namely:

- Delay in equipment and personnel mobilization;
- Failure to achieve progress targets for the engine exchange work;
- Performance of gas turbine compressor units not meeting their performance targets.

6. Results and Discussion

6.1 Financial Model Sensitivity Analysis

Financial model sensitivity analysis for the investment plan for the engine exchange of gas turbine compressors in the offshore platform at field X involves variations in operational and maintenance costs (OPEX), as well as investment costs (CAPEX), on the Benefit/Cost Ratio (BCR). By conducting this sensitivity test, it is expected to evaluate how sensitive the BCR value is to changes in these parameters, thus understanding the potential risks and uncertainties associated with the investment project. The following are the results of this sensitivity testing (Figure 3 and Figure 4):

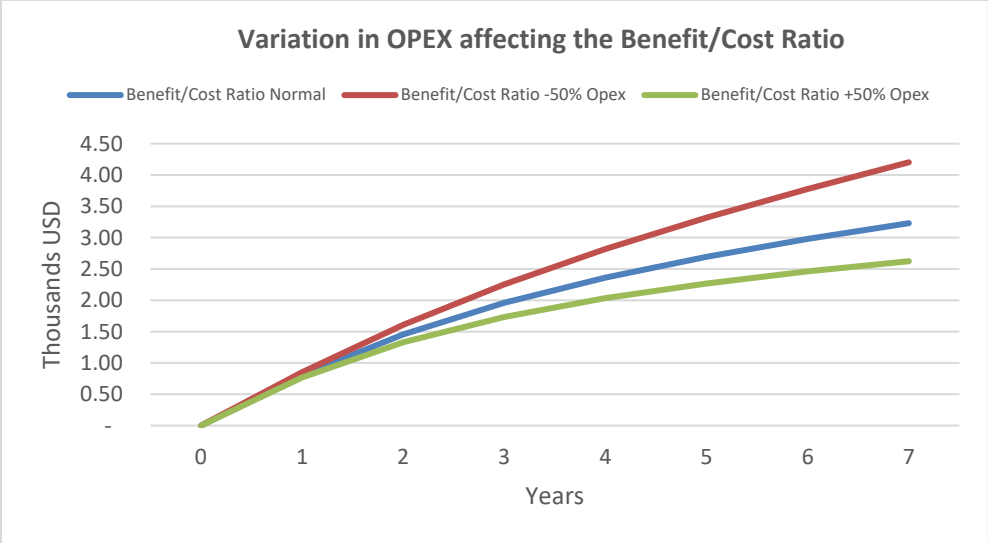

Figure 3 Sensitivity test in OPEX variation

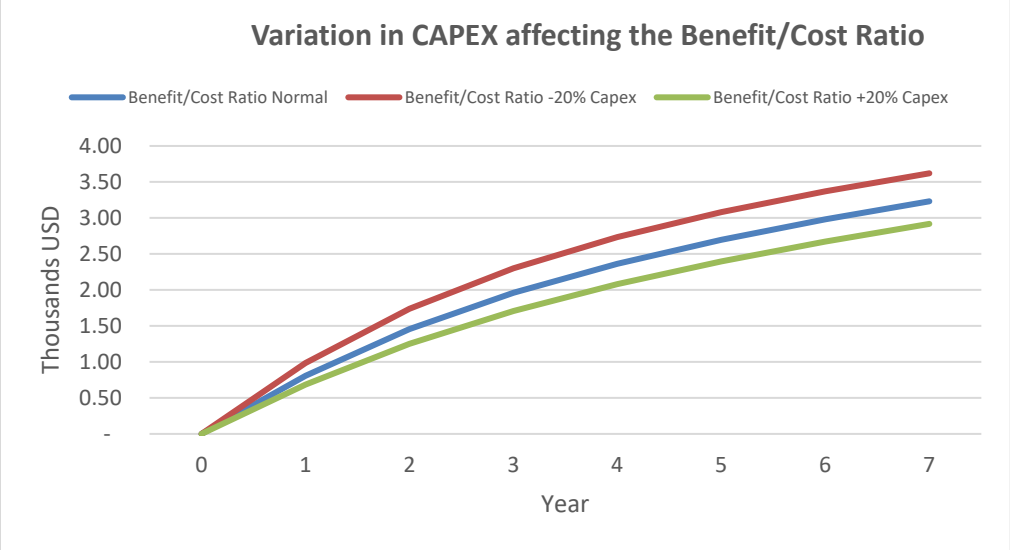

Figure 4 Sensitivity test in CAPEX variation

The results of the financial model sensitivity analysis for the investment plan for the engine exchange of gas turbine compressors in the offshore platform at field X show how changes in operational and maintenance costs (OPEX), as well as investment costs (CAPEX), affect the Benefit/Cost Ratio (BCR). In this analysis, scenarios that may occur have been considered by changing the OPEX ±50% and CAPEX ±20% values to see how these changes affect the financial feasibility of the investment plan.

From the results of this sensitivity analysis, it can be seen how increases and decreases in operational and maintenance costs, or investment costs, affect the BCR. The graph shows that a decrease in operational and maintenance costs, or investment costs, can directly impact an increase in the BCR value. Conversely, if there is an increase in operational and maintenance costs, or investment costs, it can lead to a decrease in the BCR value. The results of this sensitivity analysis provide information that planners and implementers should estimate the accuracy of operational and maintenance cost values, as well as investment costs, to obtain a representative BCR value as one of the parameters for economic evaluation.

6.2 NPV, IRR, and Payback Period Analysis

Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period are important indicators that need to be evaluated in assessing the feasibility of an investment. In the context of the investment plan for the engine exchange of gas turbine compressors in the offshore platform at Field X, these three indicators provide a comprehensive overview related to the economic aspect evaluation.

The investment plan yields an NPV of USD 8,130,462. A positive NPV value indicates that this investment can generate greater profits than its initial capital cost. This indicates that the project has the potential to provide profitable financial results. Furthermore, the IRR value of this investment plan reaches 74.88%. A high IRR indicates a very favorable internal rate of return from the investment. IRR exceeding the discount rate used in the evaluation confirms that the project has excellent return potential. The payback period of this investment plan is 2.28 years, indicating a lower level of risk. Thus, the initial capital invested can be recovered relatively quickly.
With a positive NPV, a high IRR, and a relatively short payback period, it can be concluded that the investment plan for the engine exchange of gas turbine compressors in the offshore platform at Field X is economically viable.

6.3 Benefit/Cost Ratio Analysis

In evaluating the economic feasibility of an investment, one of the important indicators used is the Benefit/Cost Ratio (BCR). BCR is the ratio between the benefits obtained from the investment and the costs incurred to make the investment. In the investment plan for the engine exchange of gas turbine compressors in the offshore platform at Field X, the obtained BCR value is 3.23.

A BCR value greater than 1 indicates that the benefits obtained from the investment are greater than the costs incurred. With a BCR value of 3.23, it can be concluded that this investment plan is highly economically efficient, indicating that the investment in the engine exchange of gas turbine compressors has the potential to provide significant profits compared to the costs incurred to implement the plan. Therefore, the analysis results indicate that the investment plan for the engine exchange of gas turbine compressors in the offshore platform at Field X is economically feasible.

6.4 Risk Treatment

An analysis of risk treatment is conducted for each risk cause. Risk treatment aims to reduce the Risk Priority Number (RPN) for each risk event. After the risk treatment activities, a reassessment of the Risk Priority Number (RPN) is carried out to determine the residual risk following the implementation of risk treatment steps or actions in the risk register (Table 2).

Table 2. Identification of Risk Treatment Activity

No.	Risk Event	Risk Cause	Aktivitas Risk Treatment (Risk Treatment Activity)	Residual Risk		
				I	P	RPN
1	Delay in procurement process of goods and services	1. Tender failure;	1. Conducting a thorough evaluation of potential bidders to ensure their qualifications and experience align with the requirements, thus aiding in selecting the most suitable and competitive vendor. 2. Preparing clear and comprehensive tender documents to reduce misunderstandings/misinterpretations that could lead to tender failures. 3. Ensuring that the tender committee involved in the procurement process holds certification of tender committee competency.	3	1	3
		2. Delay in the preparation of procurement administrative documents	1. Ensuring that the planning team submits a realistic timeline for the preparation of administrative documents such as RFQ (Request for Quotation), Work Plan and Terms, and Estimated Price. 2. Conducting regular monitoring and evaluation to identify potential delays and taking swift corrective action to minimize their impact.			
2	Bribery of End Users by Contractors	1. Potential risks of gratification, violation of the Code of Ethics, fraud, abuse of authority, and others, in the process of submitting and implementing investment projects;	1. Implementing clear and stringent anti-corruption policies and procedures, as well as training for all parties involved in the project investment submission and implementation processes to enhance awareness and understanding of the Code of Ethics and associated risks. 2. Conducting regular internal and external audits to identify and evaluate potential risks of gratification, abuse of authority, and fraud in the project investment submission and implementation processes.	2	1	2
		2. Collusion with contractors to win tenders;	1. Signing an Integrity Pact as one of the tender document requirements. 2. Conducting verification and validation of tender document evaluation results in a hierarchical manner involving relevant cross-functional personnel.			
3	Increase in investment costs and operational/maintenance expenses for the gas turbine compressor.	1. Changes in market prices for work components due to macroeconomic conditions, inflation rates, and currency value stability.	1. Budgeting investment costs considering sufficient contingency margins to address potential cost increases due to changes in market prices and unforeseen macroeconomic conditions. 2. Conducting market assessment with potential bidders to obtain investment cost estimates in line with current conditions.	2	2	4

No.	Risk Event	Risk Cause	Aktivitas Risk Treatment (Risk Treatment Activity)	Residual Risk		
				I	P	RPN
4	Occurrence of workplace accidents during project execution.	1. Lack of safety awareness, understanding, and worker competence;	1. Implementing a comprehensive and regular occupational safety training program to enhance workers' awareness, understanding, and competency in safety principles and safe work procedures. 2. Launching intensive communication and awareness campaigns regarding the importance of occupational safety and the negative impacts of unsafe behaviors, while promoting a safety-focused work culture.	4	1	4
		2. Insufficient socialization of safety aspects;	1. Developing and implementing a systematic and sustainable safety awareness program to enhance workers' awareness, understanding, and commitment to occupational safety principles. 2. Utilizing various communication media and information platforms such as seminars, workshops, bulletin boards, and digital media to disseminate information and education on safety aspects.			
		3. Observations of unsafe behavior;	1. Implementing a comprehensive and regular occupational safety training program to enhance workers' awareness, understanding, and competency regarding safety principles and safe work procedures. 2. Implementing a feedback and coaching system for workers identified to engage in unsafe behaviors, focusing on understanding and promoting safer behaviors.			
		4. Near-miss incidents.	1. Conducting Tool Box Meetings before commencing work. 2. Implementing a systematic reporting and analysis system for Near Miss incidents to identify causes, triggering factors, and conditions that may potentially lead to serious accidents. 3. Implementing a comprehensive and regular occupational safety training program to enhance workers' awareness, understanding, and competency regarding safety principles and safe work procedures.			
5	Delay in mobilizing equipment and personnel.	1. Inclement weather during the mobilization phase of equipment and personnel to the offshore field.	1. Planning the timeline for mobilization to the offshore field by evaluating the latest weather forecast reports.	2	2	4
6	Worker health issues	1. Disease outbreaks or viruses, such as a COVID-19 outbreak;	1. Implementing a comprehensive health and safety program, including regular health check-ups, vaccinations, fit-to-task assessments, and daily check-ups for workers. 2. Providing specialized training and education to workers regarding symptoms, prevention, and emergency actions to take when facing illness at the workplace.	3	1	3
		2. Food poisoning;	1. Enforcing strict cleanliness and sanitation standards in food storage, preparation, and serving areas. 2. Requiring catering staff to meet competency requirements for hygienic practices and food safety protocols. 3. Conducting regular audits and inspections of kitchen facilities, storage warehouses, and food suppliers to ensure compliance with health and food safety regulations.			
		3. Workers in unfit conditions to work.	1. Implementing a comprehensive health and safety program, including regular health check-ups, vaccinations, fit-to-task assessments, and daily check-ups for workers. 2. Enforcing strict access regulations to operational areas by requiring proof of medical check-ups and fit-to-task assessments.			
7	Damage of the gas turbine compressor.	1. Failure in production or remanufacture of units at the manufacturing workshop.	1. Establishing a reporting mechanism and routinely monitoring the performance of production/remanufacturing processes to identify potential risks or issues that may arise during production/remanufacturing. 2. Conducting factory acceptance tests (FAT) witnessed by company representatives prior to the shipment of the gas turbine compressor replacement unit.	4	1	4
		2. Errors in procedures	1. Ensuring the availability of clear, comprehensive, and standardized transportation and mobilization procedures, and monitoring compliance with their implementation.			
8	Failure to achieve the work progress target for the engine exchange.	1. Poor performance of Contractor/Subcontractor	1. Implementing a rigorous contractor selection and evaluation process, including verification of qualifications, references, and past performance to ensure their compliance and ability to meet specified standards of quality, safety, and performance. 2. Establishing mechanisms for routine monitoring, inspection, and audits of contractor performance, as well as conducting periodic reviews and performance evaluations to identify and address potential issues or errors that may affect the outcome and quality of work.	2	2	4
		2. Changes in the scope of work during project implementation.	1. Creating clear, detailed, and transparent technical contract documents outlining the scope, requirements, and project expectations to reduce misunderstandings that may trigger scope changes. 2. Conducting thorough risk analysis and project planning, including identifying potential scope changes.			
9	The performance of the gas turbine compressor unit does not meet its performance target.	1. Errors in the installation, commissioning, and start-up procedures of the gas turbine compressor unit.	1. Requiring the availability of detailed and standardized installation, commissioning, and start-up procedures, and monitoring compliance with their implementation. 2. Supervising, reviewing, and validating by company representatives or professional experts to ensure the quality, safety, and effectiveness of the installation, commissioning, and start-up procedures applied and executed in accordance with applicable standards, regulations, and technical specifications.	4	1	4

6.5 Risk Profile Matrix

Following the identification and evaluation of risk treatment, this risk analysis section redefines the risk profile matrix before and after risk treatment, facilitating a better understanding of the types of risks faced. The risk profile matrix for the engine exchange gas turbine compressor project offshore at Field X is as follows (Figure 5):

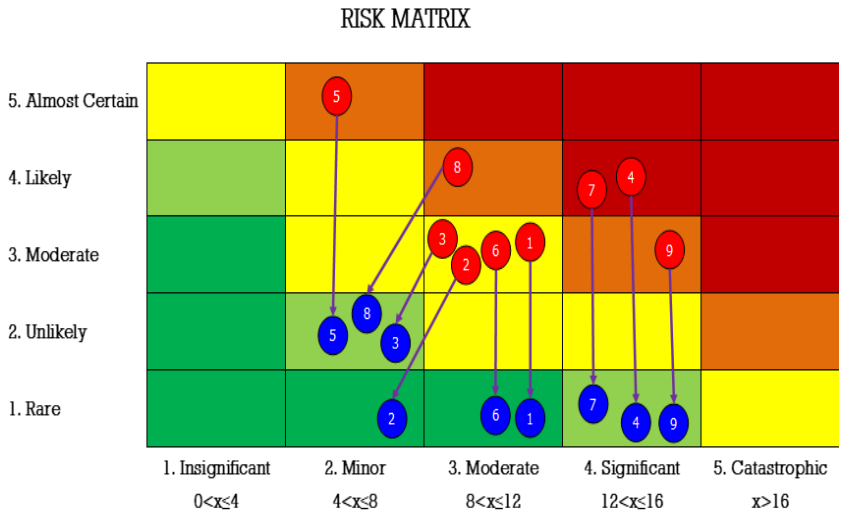

Figure 5 risk profile matrix after risk treatment

In the risk profile matrix above, it can be observed that risk treatment can reduce the level of risk for each risk event. Risk treatment activities can mitigate the causes of risk for each risk event, thereby reducing their probability and impact levels. Initially, the engine exchange gas turbine compressor project offshore at Field X had 2 (two) risk events with a Moderate to High risk level and 3 (three) risk events with a Moderate to High risk level. After risk treatment, these risk levels can be reduced in terms of probability and impact, resulting in the risk level for the engine exchange gas turbine compressor project offshore at Field X consisting of 6 (six) risk events with a low to moderate risk level and 3 (three) risk events with a low risk level.

7. Conclusion

Based on the evaluation of economic aspects, the plan for the engine exchange gas turbine compressor at the offshore platform in Field X is deemed feasible due to its positive net present value (NPV) of USD 8,130,462, a high rate of return with an internal rate of return (IRR) of 74.88%, a relatively short payback period of 2.28 years, and a benefit/cost ratio (BCR) of 3.23, indicating that the investment benefits outweigh the costs. The risk identification results show that risk events associated with the plan for the engine exchange gas turbine compressor at the offshore platform in Field X can be mitigated through risk treatment activities, thereby reducing the risk level to 6 (six) risk events with a low to moderate risk level and 3 (three) risk events with a low risk level.

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