

Risk Analysis of Gas Pipeline Relocation in Northern Sumatera

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Abstract: The development of new infrastructure aimed to stimulating economic growth, often disrupt existing facilities. The construction of toll roads in the Northern Sumatera, for example, passes through a 12 inches transmission gas pipeline that connects Kawasan Industri Medan (KIM) – Kawasan Ekonomi Khusus (KEK) Sei Mangkei. This causes crossings at six location points and results in additional loads on the gas pipelines which were not previously calculated. Therefore it is necessary to relocate the gas pipeline. However, there are many risks that might occurred in relocating gas pipeline. Hence the risk assessment must be considered to find out which risk variables have the highest influence on this gas pipeline relocation. The result of risk analysis indicates this gas pipeline relocation as a whole has moderate risk status, with safety & security risk category relating to safety in doing work, both during construction and operation, being the risk category that has the highest risk. There is a potential loss from gas sales and distribution of USD 55.223 per year if gas pipeline is not relocated, by assuming there is only one damage occurs per year at each of crossing points (six crossing points) and requires seven days repaired time of each. And also there is a potential loss of USD 320.132 if gas pipeline is relocated but the risks are not mitigated. Although risk mitigation requires an additional cost of USD 45,596 to mitigate 23 risk variables, however these costs can provide a potential cost savings of USD 274.536 compared to if the risks in this gas pipeline relocation are not mitigated.

Keywords: Gas Pipeline Relocation, KEK Sei Mangkei, Risk Analysis

I. INTRODUCTION

In order to boost economic growth in Indonesia, the constructions of new infrastructures such as dams, bridges, roads, railways, power plants, and ports are widely carried out [1]. However, these constructions often raises new problems, such as the overlapping land in Northern Sumatera between the construction of a toll road connecting Medan – Kualanamu – Tebing Tinggi (MKTT) and a gas pipeline that connecting Kawasan Industri Medan (KIM) – Kawasan Ekonomi Khusus (KEK) Sei Mangkei. This can occur due to lack of coordinator between toll road and gas pipeline manager. The land that had previously been cleared for toll road construction, at the same time it is also used for gas pipelines construction. This resulted in crossings at six location points and imposing additional loads on gas pipelines that were not previously calculated. A pipeline that transports hazardous gases raises no health hazards to person or environment near the pipeline as long as the pipeline is properly maintained its integrity and does not release gas into the environment [2]. But on the other hand, a pipeline failure that results in gas release, generates risks to people and environment in the vicinity of the release point because of the flammable, explosive, and toxic properties of the gas [3]. An action to install temporary protection for gas pipelines by using concrete boxes and temporary support have been carried out, however by considering safety factor, as well as the development of gas pipeline and toll road in the future, then the relocation of gas pipelines was carried out. The relocated gas pipeline is 12 inches in diameter and the length of relocation is about 2.5 km. Relocation was carried out in a conventional and auger boring method.

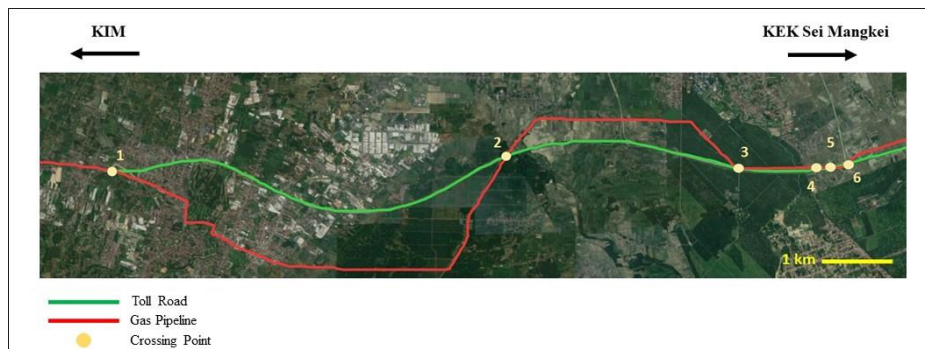


Fig. 1 Crossing points location



Oil and gas projects are very complex, risky and have challenges that continue to increase every day because of the various problems that faces. For instance in gas pipeline relocation. There are many risks can occur in relocating gas pipeline that can result in failure of the gas pipeline. Miao and Zhao [4] divided the main causes of pipe failure into four groups : third-party damage, corrosion, design and construction errors, and improper operating condition. In general, risks associated with gas pipeline projects may be classified into risk during construction and risk during operation [5]. Risks during construction are time-prone. These generally relates to the implementation of work processes, availability of materials, labor, budget, timeframes, accidents, law and environmental. For example, gas pipeline relocation in East Java, the addition of material with a long delivery time during the construction of the gas pipeline is the highest risk in that project. This condition causes additional time which can delay project completion and have an impact on project finances [6]. Another example of risk during gas pipeline construction is resistance from local residents or land owners. Bogucki and Polonski [7] in their paper explain that community rejection risk of high pressure gas pipeline construction has a high risk. It can affect the project completion time. To overcome this condition, it is necessary to carry out information campaign before construction started. In operation, the risks are slightly different, where more emphasizing on safe and smooth operation/functioning of pipeline. Several previous studies, explain the risk of terrorism & sabotage is the highest risk in gas pipeline operations [8, 9]. In Indonesia terrorism risk on gas pipeline has occurred in Gading Serpong in 2011, where there were plans for suicide bombing in the vicinity of a gas pipeline. Fortunately, the plan was thwarted. In addition, the risk of damage to gas pipelines is also a risk that often occurs and needs attention in gas pipeline operations [10]. For example in Nigeria, pipeline ruptures is the most common incident causing oil spill, fires and explosion. These occur due to corrosion, lack of routine inspections, operational failures and natural disaster [11]. The emergence of risk cannot be avoided. Risk can be defined as an opportunity for an occurrence or a failure that can lead to a negative consequence in the form of loss, damage, injury, and even death to the personnel, facilities and the environment [12]. Therefore, in order to maintain a safe and secure construction and operation circumstances, monitoring and evaluation must be carried out continuously [13].

Risk can be overcome by carrying out risk management. For effective risk management, risk classification is paramount. There are many kinds of risk classification have been made so far [14]. Risk can also be managed by referring to the concept of risk assessment. Risk assessment is a quantification process to determine what kind of risks that may occur in a system. To get the concept of quality and good management from a process, it is necessary to quantify the involved factors. The size or value obtained will determine the size and risk of loss that may arise from a process [15]. A common method used for assessing risk is risk matrices. These are typically 5x5 matrices, and each block of the matrix represents some level of risk [16]. Risk matrix is defined as a mechanism to characterizing and ranking risk, which has several categories of probability and impact for its rows and columns [17, 18]. Risk matrices can help in determining the risk status by multiplying the probability and impact values, to find out whether the risk has low, medium or high status [19].

Probability	Threats					Opportunities				
	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05	0.10	0.20	0.40	0.80	0.80	0.40	0.20	0.10	0.05

Fig. 2 Probability-impact matrices

Another method that can be used is sensitivity analysis, which is a quantitative risk analysis that is used to assist in determining which risks have the highest influence on the project. Sensitivity analysis makes it possible to forecasts using real historical data by studying all possible variables and outcomes. The results of this sensitivity analysis allow decision makers to identify where they can make improvements in the future. So that the decisions taken become more precise and reliable [20]. However, the results of this analysis are not completely accurate.

II. METHODOLOGY

The research procedure scheme can be seen in Figure 3.

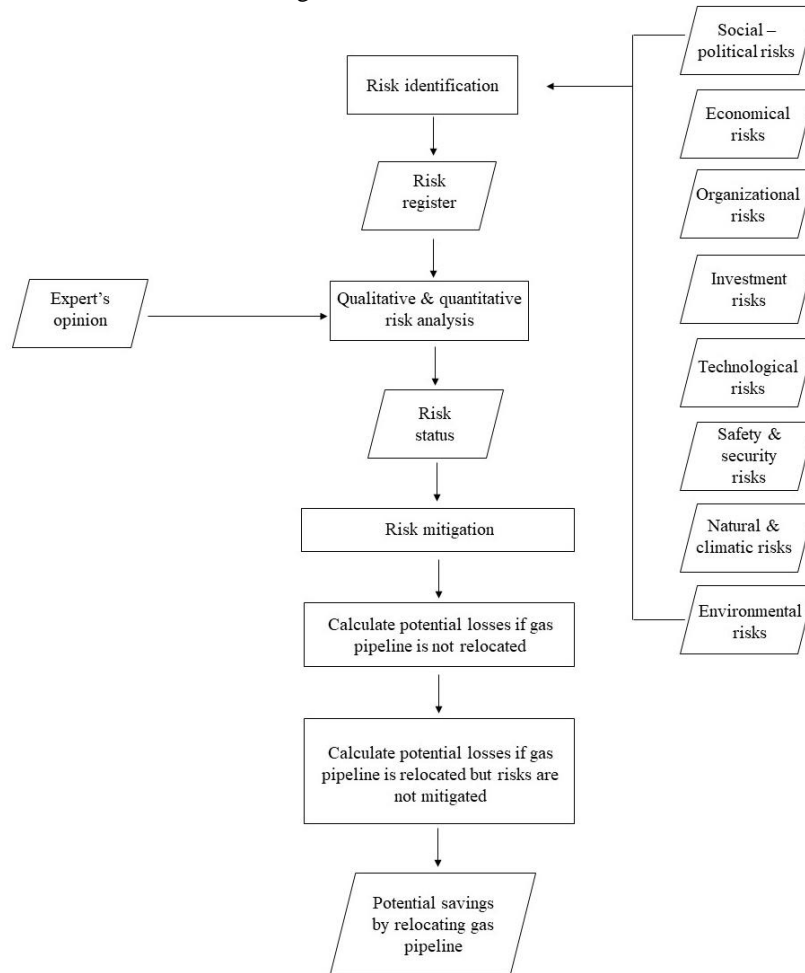


Fig. 3 Research procedure scheme

III. RESULT

A. Risk Analysis and Mitigation

Risk identification is carried out and obtained 44 risk variables from eight risk categories. By referring to probability – impact matrices, there are 6 risk variables with low status, 29 risk variables with moderate status, and 9 risk variables with high status.

TABLE I RISK VARIABLES AND RISK STATUS

No	Risk Category	Risk Event		Risk Status	Author
		No	Variable		
1	Social - Political	1	Delays in licensing process	Moderate	[5]
		2	Demonstrations and objections from residents	Moderate	[5]
		3	Riot and area closure at the project site	Moderate	[5]
		4	Non-Governmental Organization opposing and provoking residents	Moderate	[21]
2	Economical	5	Inflation and rising prices of the material	Moderate	[5]
		6	Changes in economic policy	Moderate	[5]
3	Organizational	7	Breach in contractual relationship	Moderate	[5]
		8	Incompetent of the labour	Moderate	[5]
		9	Contractor cannot meet the material delivery time	Moderate	[5]
		10	Delay in completing EPC stages	Moderate	[5]



		11	Lack or unavailability of labour	Low	[5]
		12	Bad communication (Example : lack of coordination meetings, language differences, etc.)	Moderate	[5]
		13	Strike of the labor	Moderate	[21]
		14	Decreasing work productivity and labor motivation	Low	[21]
		15	Dishonest workers and corruption	Moderate	[21]
		16	Internal conflict	Moderate	[22]
		17	Contractor bankruptcy	Moderate	[23]
4	Investment	18	Increasing loan interest rates	Moderate	[5]
		19	Decreasing gas demand by consumers	Moderate	[24]
5	Technological	20	Incompatibility of the technology used	Moderate	[5]
		21	Errors in work that results in doing a re-work	Moderate	[5]
		22	Poor welding quality	High	[10]
		23	Damage to equipment in the field	Moderate	[21]
		24	Difficult access to project site	Moderate	[21]
		25	The existence of additional materials or equipment that takes a long time in delivering	Moderate	[6]
		26	Design changes	Moderate	[23]
		27	Incomplete project documentation	Moderate	[25]
6	Safety & Security	28	Pipeline getting stuck when drilling using auger boring method	Moderate	[25]
		29	Pipeline get off the track of drilling path when drilling using auger boring method	Moderate	[25]
		30	Accident during construction	High	[5]
		31	Accident during operational and maintenance	High	[5]
		32	Terrorism	Moderate	[5]
		33	Criminal acts (Vandalism, theft, extortion, etc)	High	[5]
		34	Leakage in pipeline due to corrosion	High	[5]
35	Accidents on public roads during mobilization	High	[6]		
7	Natural & Climate	36	Damage to pipeline facilities during operation caused by external parties (For example: pipe leaks due to excavation activities)	High	[10]
		37	Earthquake	Moderate	[5]
		38	Flood	Moderate	[5]
		39	Landslide	Moderate	[5]
8	Environmental	40	Bad weather condition	Low	[5]
		41	Environmental pollution	Moderate	[5]
		42	Ecological and wildlife damage	Low	[5]
		43	Damage to existing infrastructure underground (Fiber optic cable, PDAM, power cable)	Moderate	[6]
		44	Failure to return the land to its original condition	Low	[25]

This gas pipeline relocation, overall, has a risk distribution value between 0.097 to 0.107, with a value at 85% certainty level is 0.104. If referring to the probability-impact matrices at Figure 2, then this gas pipeline relocation has moderate risk status. It is necessary to mitigate the risks so the status can be lowered to low. By using sensitivity analysis, there are 23 risk variables that need to be mitigated. Risk mitigation certainly requires additional cost. By discussing with experts, the estimated cost required to mitigate 23 risk variables in Table 2 is USD 45.596.

TABLE III MITIGATION ACTION

Risk Category	Risk Variable	Mitigation Action
Social - Political	Demonstrations and objections from residents	<ul style="list-style-type: none"> Conducting an intensive approach, socializing, and educating to the local community

		<ul style="list-style-type: none"> Carrying out project work in accordance with applicable standards and does not cause any damage to the environment and surrounding facilities
	Non-Governmental Organization opposing and provoking residents	<ul style="list-style-type: none"> Involving local companies and human resources from the region as a partners in accordance with their qualifications Empowering the communities around the project site through community development program or partnership and community development programs
	Delays in licensing process	<ul style="list-style-type: none"> Enhancing cooperation with local governments or related parties
Economical	Changes in economic policy	<ul style="list-style-type: none"> Conducting negotiation with policy-makers regarding policy changes. For example, if the gas price is reduced to USD 6 / MMBTU for a particular industry, the company can propose an incentive option through the application of special price for gas that bought from the supplier to distribute to those particular industries
Organizational	Incompetent of the labour	<ul style="list-style-type: none"> Recruiting certified workers and placing the workers according to their expertise.
	Bad communication (Example : lack of coordination meetings, language differences, etc.)	<ul style="list-style-type: none"> Improving communication by conducting weekly meetings, and regular reporting on project progress Ensuring to use a language that can be understood by all workers
Investment	Decreasing gas demand by consumers	<ul style="list-style-type: none"> Managing cost-efficiency in terms of operations and maintenance while still concern to safety aspects
	Increasing loan interest rates	<ul style="list-style-type: none"> Making an agreement from the beginning related to making the interest rate flat
Technological	Poor welding quality	<ul style="list-style-type: none"> Recruiting certified and competent experts in welding work Conducting direct supervision in the field
	Errors in work that results in doing a re-work	<ul style="list-style-type: none"> Improving coordination, regular reporting and direct supervision in the field
	The existence of additional materials or equipment that takes a long time in delivering	<ul style="list-style-type: none"> Doing the reengineering process earlier Improving communication with suppliers
	Difficult access to project site	<ul style="list-style-type: none"> Conducting a survey in advance of site project area, so the access can be planned and built
	Design changes	<ul style="list-style-type: none"> Conducting surveys, ensuring that matters related to implementation standards such as technical drawings, specifications, equipments and materials used are clear, without any changes Involving contractors in the planning process
Safety & Security	Criminal acts (Vandalism, theft, extortion, etc)	<ul style="list-style-type: none"> Increasing security level by placing special security officers Tightening access and prohibiting other parties from entering the project area Sterilizing the project area from unauthorized parties.
	Accident during construction	<ul style="list-style-type: none"> Providing socialization of work procedures to workers related to the construction process Performing safety induction before work Conducting daily safety evaluations after finishing work Equipping workers with personal protective equipment Assigning an HSE supervisor
	Leakage in pipelines due to corrosion	<ul style="list-style-type: none"> Covering pipelines to protect from direct contact with the environment Performing periodic checks inside the pipeline using the intelligent pigging method Using gas pipelines in accordance with the standard

	Damage to pipeline facilities during operation caused by external parties (For example: pipe leaks due to excavation)	<ul style="list-style-type: none"> • Providing information and knowledge to the communities around the gas pipeline • Providing a sign that indicating the existence of pipeline around the gas pipeline area
	Accident during operational and maintenance	<ul style="list-style-type: none"> • Providing training equipped with a competency test at the end of the training session to each gas pipeline operational operator. • Carrying out tasks in accordance with the applicable Standard Operational Procedures (SOP) during the operational and maintenance period
	Accidents on public roads during mobilization	<ul style="list-style-type: none"> • Overseeing personnel performance and enacting personnel exchange if others experience a decrease in performance (tired, lack of concentration, etc) • Checking vehicles condition that will be used to transport equipment or personnel to the project site • Running the applicable Standard Operating Procedure (SOP)
Natural & Disaster	Earthquake	<ul style="list-style-type: none"> • Using an earthquake-based design
	Landslide	<ul style="list-style-type: none"> • Identifying prone area to landslides, and selecting relocation area with the least risk of landslides • Improving and maintaining good drainage around the pipeline location
Environmental	Damage to existing infrastructure underground (Fiber optic cable, power cable)	<ul style="list-style-type: none"> • Searching for information about the presence of existing infrastructures around the project site
	Environmental pollution	<ul style="list-style-type: none"> • Creating waste management plan and provide a place for residual waste disposal

B. Potential Cost Savings by Relocating Gas Pipeline

Total investment cost incurred to relocate a 12-inch diameter gas pipe with a relocation length of about 2.5 km is USD 1,600,660. However, this total investment cost is more economical than the potential losses that could occur if gas pipeline is not relocated. In this case if gas pipeline is not relocated, and assumed that there is only one damage occurs per year at each of crossing points (six crossing points), and requires seven days repaired time of each, so the gas pipeline cannot be operated temporarily, then the potential loss can reach up to USD 55.223 per year. This potential loss can continue to increase considering that the amount of gas being distributed currently is only around 4% of the total available capacity. Thus by relocating the gas pipeline, this potential loss can be eliminated. In addition, if the gas pipeline is relocated but the risks are not mitigated, then with a moderate risk status, will cause a potential loss of 20% of the investment cost, which is around USD 320.132. Although risk mitigation requires an additional cost of USD 45.596, however, these costs can eliminate this potential loss thus providing a potential cost savings of USD 274.536.

TABLE IIIII POTENTIAL LOSSES IF GAS PIPELINES ARE NOT RELOCATED

No	Information	Amount	Unit
1	Assumed number of days for pipeline restoration in case of damage		
	Number of crossing points	6	
	Assumed number of days required for recovery	7	Days
	Assumption the number of events in 1 year at each crossing point	1	Times / Year
	Total days of recovery	42	Day / Year
2	Losses from gas delivery		
	Gas volumes	1533	MSCF / D
	Toll Fee	0,66	USD / MSCF
	The amount of losses per day	1012	USD / Day
	The amount of losses per year	42.495	USD / Year
	Commercial losses from gas sales		

Gas volumes	1595	MMBTU / D
Gas sales margin	0,19	USD / MMBTU
The amount of losses per day	303	USD / Day
The amount of losses per year	12.728	USD / Year
Total Losses		55.223 USD / Year

IV. CONCLUSION

The results of risk analysis indicate that the risk on this gas pipeline relocation as a whole has a moderate risk status, with safety & security being the risk category with the highest risk status. Relocating this gas pipeline, even though requires an investment cost of USD 1.600.660, however, this cost can eliminate potential losses up to USD 55.223 per year, which can continue to increase because the amount of gas currently flowed through the gas pipeline is only around 4% of the total pipeline capacity. In addition, the mitigation cost of USD 45.596 required to mitigate 23 risk variables can eliminate potential losses of USD 320.132 if gas pipeline is relocated but the risks are not mitigated. Thus this can provide a potential savings of USD 274.536.

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