

RISK ANALYSIS AT THE PLANNING STAGE IN THE BIOMETHANE PRODUCTION PLANT CONSTRUCTION PROJECT: A CASE STUDY ON PT A

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ABSTRACT

This study aims to identify potential risks during the planning phase of a biomethane plant construction project at PT A and to develop appropriate mitigation strategies. Using a qualitative case study approach, data were collected through interviews and questionnaires involving key personnel from the risk management and research divisions. A total of 27 risks were identified, and eight were prioritized based on their severity. Three primary mitigation strategies were applied: risk likelihood reduction, risk avoidance, and risk consequence reduction. The findings reveal that the highest priority risks include public objections, natural events, economic instability, unrealistic project durations, emerging stakeholders, scope creep, unclear contracts, and inappropriate technology selection. Each risk was addressed with tailored mitigation measures aligned with practical project management principles. For instance, enhancing community engagement, drafting clearer contracts, and involving expert consultants were among the real-world strategies implemented. The practical implications of this study are significant for project managers and stakeholders involved in similar construction projects. The structured risk analysis framework and corresponding mitigation actions can be used as a reference to anticipate challenges early and implement preventive measures effectively. This contributes to improved decision-making, reduced project delays, and strengthened project sustainability in high-risk industries like bioenergy development.

KEYWORDS risk, mitigation, project planning



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INTRODUCTION

The project planning stage aims to complete the project within the agreed timeframe, with specific stages and predetermined resources (Love et al., 2023; Teslia et al., 2023). In general, the stages of project planning include: (i) determining the project objectives and other requirements—this involves establishing the final project outcome, timeline, cost, and targeted performance; (ii) identifying the work required to achieve the project objectives; (iii) determining the project organization, including which departments should be involved, the necessary subcontractors, and the managers responsible for the respective tasks; (iv) developing a schedule for each work activity; (v) preparing a budget plan and identifying the necessary resources; and (vi) estimating the time, cost, and performance for project completion (Araszkiewicz & Bochenek, 2019; Mahmoud al-Mukahal, 2020; Yu et al., 2018).

PT A, in September 2023, planned to build a factory to manage palm oil waste and convert it into renewable energy *biomethane* as part of its efforts to reduce greenhouse gases (GHGs). According to Hidayat (2023), the *biomethane* that will be produced can help the company reduce the greenhouse gases generated by its factory operations, providing a solution for sustainability and serving as an alternative low-carbon energy source. This aligns with the

company's goal to reduce emissions and support the government's program to decrease GHG emissions by 29% through its own efforts, or by 41% with international assistance, by 2030. The construction project for this factory is still in the planning stage. Therefore, it is important to analyze the risks that may arise during the planning process of this factory construction project (Hidayat, 2023).

Currently, PT A has conducted a study on factory planning by carrying out feasibility studies in the areas of economics, law, environment, and business viability. However, PT A has not yet performed a risk analysis related to the planning of the *biomethane* factory construction project. The company needs to analyze risks to mitigate potential hazards that could disrupt its operational activities. Therefore, it is necessary for the company to conduct a risk analysis to mitigate significant risks that may arise and hinder the achievement of its objectives.

Risk analysis is the process of examining data from risk identification results, which involves finding and explaining risks in greater detail so that the company can determine how to mitigate or address these risks. In this study, risks that may occur during the planning stage of the factory construction project will be identified, enabling PT A to recognize potential risks in the planning process and implement mitigation strategies accordingly (ISO31000, 2018).

PT A plans to build four factories to manage palm oil waste into renewable energy *biomethane*, located in Tinjowan, Pulu Raja, Dolok Sinumbah, and Pabatu, North Sumatra. Based on initial interviews with PT A staff, the company has conducted a business feasibility risk assessment for the *biomethane* plant construction project. As of July 2024, the Tinjowan location has been approved for the first factory. However, PT A has not yet performed a risk analysis specific to the planning phase of the *biomethane* plant construction project, despite the construction being scheduled to begin in January 2025.

This research is critical because the *biomethane* factory construction is still in the planning stage. According to Szymański (2017), risk analysis must be conducted during project planning alongside risk identification to determine potential impacts. Risk identification in construction projects hinges on defining which risk types could affect outcomes. Thus, analyzing risks at the planning stage is vital to ensure smooth execution and implement necessary mitigation measures. Failure to do so may hinder project sustainability (ALSAADI & NORHAYATIZAKUAN, 2021; Iqbal et al., 2015; Rahman & Adnan, 2020; Shibani et al., 2022; Szymański, 2017). For PT A, this underscores the urgency of conducting a risk analysis for the *biomethane* factory planning phase. The research focuses on PT A, a company in the palm oil plantation and management industry.

Existing literature on construction risk management predominantly examines conventional buildings or oil and gas sectors, with limited empirical insights into *biomethane* plant development or palm oil-based renewable energy contexts. This study addresses that gap by exploring planning-phase risks specific to *biomethane* plants, offering underrepresented academic and professional insights.

The novelty of this research lies in its tailored integration of risk identification and mitigation strategies for Indonesia's palm oil renewable energy sector. Through a qualitative case study of PT A, the study contributes theoretically and practically: it advances organizational risk preparedness during the bioenergy transition and provides a strategic

framework for companies operating under similar environmental and regulatory conditions (Szymański, 2017).

This study aims to identify risks during the planning stage of PT A's *biomethane* production plant construction project and develop tailored mitigation strategies to address them. The research provides practical value by equipping PT A with actionable insights to anticipate and respond to project risks, ensuring smoother execution. Academically, it contributes to risk management literature by offering a framework for analyzing planning-phase challenges in plantation industry construction projects, particularly in palm oil waste-to-energy initiatives, thereby supporting future research and industry best practices.

RESEARCH METHODS

This study employs a qualitative case study approach to investigate risk analysis during the planning phase of PT A's *biomethane* plant construction project. Drawing on Neill's (2018, cited in Sihab, 2019) framework for qualitative methods, the case study methodology is selected to address *how* and *why* risks emerge at this stage, enabling a comprehensive exploration of the phenomenon through contextual evidence (Yin, 2018).

Data collection involves qualitative methods such as interviews, document analysis, and observations (Neill, 2018 in Sihab, 2019). Specifically, semi-structured interviews and questionnaires are utilized to gather insights from PT A's risk management and project teams, focusing on identifying risks, their potential impacts, and mitigation strategies. This approach aligns with Yin's (2018) emphasis on multi-source evidence in case studies, ensuring a nuanced understanding of planning-phase challenges unique to *biomethane* infrastructure development.

Table 1. Case Study Series

Case Study Series (Yin, 2018)	Application of Case Studies in this Study
<i>Research problem</i>	PT A has not conducted a risk analysis related to the planning in the <i>biomethane plant construction project</i> .
<i>Unit of Analysis</i>	Company PT A

Source: Yin (2018), data processed

Table 2. Case Study Series (continued)

Case Study Series (Yin, 2018)	Application of Case Studies in this Study
<i>Linking the Data</i>	Using primary data (interviews and questionnaires)
<i>Interpretation of Findings</i>	The findings were interpreted using a qualitative descriptive method

Source: Yin (2018), data processed

The data collection for this study relies on primary sources, specifically through the distribution of online questionnaires and the conduct of in-depth interviews. Questionnaires are targeted at 17 employees from the Risk Management Division and the Research and Business Development Division at PT A, as these groups are directly involved in the planning of the *biomethane* plant construction project. The questionnaires are distributed online, with a clear explanation of their purpose provided beforehand. In-depth interviews are carried out

individually with the division managers of both divisions using Zoom, allowing for deeper exploration of risk-related issues.

The research instruments consist of semi-structured interviews and closed-ended questionnaires. The semi-structured interviews, detailed in the study's appendix, are designed to guide the discussion while still allowing interviewees to introduce new topics or insights. The questionnaires are based on established project planning risk indicators drawn from previous research, including studies by Appiah (2020), Dziadosz & Rejment (2015), and Nadir (2020), ensuring that the data collected is both relevant and grounded in existing literature.

RESULTS AND DISCUSSION

Interviews

Interviews in this study were conducted with 2 (two) respondents using Zoom and WhatsApp media. Interviews were conducted with a duration of about 45 minutes to 60 minutes by asking questions that were semi-structured, so that the information received was more detailed and answered the research questions. Here are the profiles of respondents:

Table 3. Profile of Resource Persons

Resource Person Code	Sources
Resource Person 1 (N1)	Head of Risk Management Division
Resource Person 2 (N2)	Head of Research and Development Division

Source: Data processed

In conducting risk planning, N1 said that PT A has KPIs and aspirations set by shareholders, including related ministries. The company considers various factors, such as changes in the weather, productivity, selling prices, plant investment, asset monetization, and so on. The first step is to set clear goals. Once the goals are determined, the Company identifies risks that may affect the achievement. The company analyzes potential risks by examining their causes and impacts, and assessing the probability of such risks occurring.

N1's experience in identifying risks at PT A focuses on potential sources of risks that have occurred and that can threaten the company's targets. N1 analyzes various factors that can affect the company's achievements, such as productivity, crop yields, the risk of theft in the field, and so on. In addition, the company also takes into account extreme weather factors which can have a significant impact on operational activities and production results. With this approach, companies can be more proactive in identifying and mitigating risks that may arise, so that companies can maintain sustainability and achieve corporate goals.

For risk assessment, N1 explained that there are criteria for categorizing the likelihood and impact of the risk. Companies use a scale of 1-5 to assess the probability and impact of each risk, where each scale has specific criteria. Risk assessment is done by multiplying the impact by the probability. And in terms of carrying out the risk control process, N1 identifies the cause, so that PT A can take appropriate mitigation steps. After knowing the cause, the company focuses on minimizing the risks that may occur. This includes implementing measures that can reduce the likelihood of such risks occurring.

Regarding the control carried out by PT A so that unwanted risks do not occur, N1 said that currently PT A is building risk *awareness* by holding training to increase awareness of the

importance of risk management. This training aims to provide a better understanding of the risks that companies face and how to manage them. The company also holds monthly webinars featuring speakers from the Ministry and from various experts to provide additional insights and strengthen its commitment to risk management.

"... With increased risk awareness among employees, we believe risk management will become more effective, which can help minimize unwanted risks." (N1, 2024)

Furthermore, based on the results of the interview with N2, in dealing with risks that may occur, the risk management division conducts a study from risk identification to mitigation. For control of unwanted risks, PT A takes actions such as providing sanctions if employees violate regulations. However, if the risk occurs due to a natural disaster, then this risk will be accepted by PT A.

N2 said that the risks that PT A often experiences when carrying out its operational activities at the factory are related to work accidents by employees. Usually this happens because employees are negligent in not complying with regulations by not using personal protective equipment in factory and plantation areas. For this negligence, employees will be sanctioned by the Head of the Factory by giving a direct reprimand. However, when it has been reprimanded but ignored, the incentive will be reduced and have an impact on employee performance assessment. In addition, the weather is also crucial in affecting the harvest.

In the planning of the factory construction project *Biomethane* N2 conducted a study on *feasibility study* or feasibility study, to assess whether the project is feasible to run, then the results of the study will be poured into the company's budget to be met with shareholders. Furthermore, if approved, the announcement of the factory construction project will be carried out by a process *tender* open through the website, so that the bidder or vendor will submit *tender* through the website. PT A will select the vendor with the highest qualifications. For the reduction of possible risks, the company selects the vendor with the highest qualifications in the hope of complying with the existing clauses, thereby reducing the risk of delays in the construction of the plant. However, if the vendor does not comply with the clause, sanctions will be given as stated in the contract.

N2 also said, in terms of risk avoidance, PT A ensures that the people who work on the project are experts in their fields. For risk acceptance, natural disasters are risks that will inevitably be accepted, in contrast to the risk of delay caused by vendors, which will be sanctioned in accordance with the clauses in the contract. In terms of risk transfer, PT A transfers risks using social security, so that when there is a work accident, it will use the fees that have been paid to social security. For factories, when the factory has been completed, PT A will usually insure it, because the useful life of the factory ranges from 20 to 25 years.

Questionnaire

The questionnaire was distributed to employees from the Risk Management Division and the Research and Business Development Division. These two divisions are divisions related to the planning of the *biomethane plant construction project* at PT A. The Research Division consists of the head of the division (1 person), the head of the sub-division (4 people), and the staff (8 people). The Risk Management Division consists of the head of division (1

person), the head of the sub-division (1 person), and the risk management assistant (2 people). So that the total distribution of questionnaires amounted to 17 people.

From the answers of 17 respondents to 27 risk statements, each probability and impact were summed up, then divided by the number of respondents, so that the mean of probability and impact was obtained, and also the calculation of the risk value by multiplying the *probability mean* by the *impact mean*, as presented in table 4.

Table 4. Calculation of Risk Level

Risk Statement No.	Mean Probability	Mean Impact	Risk Assessment
1	1.47	1.59	2.34
2	1.35	1.59	2.15
3	1.88	2.06	3.88
4	2.06	2.24	4.60
5	3.18	3.00	9.53
6	3.41	3.24	11.04
7	2.76	2.76	7.64
8	2.35	2.47	5.81
9	2.41	2.65	6.38
10	2.88	3.12	8.99
11	2.59	2.94	7.61
12	2.59	2.76	7.16
13	2.59	2.76	7.16
14	2.29	2.53	5.80
15	2.35	2.35	5.54
16	2.41	2.35	5.67
17	2.35	2.53	5.95
18	2.53	2.53	6.40
19	3.35	3.59	12.03
20	2.06	2.41	4.97
21	2.71	3.24	8.75
22	2.88	3.24	9.33
23	4.12	3.88	15.99
24	3.18	3.06	9.72
25	2.59	2.59	6.70
26	3.29	4.00	13.18
27	2.82	2.94	8.30

Source: Data processed

From the table, the risk value will be ranked next, so that the highest value will be obtained and which is of concern for further mitigation for the planning of the factory construction project *biomethane*.

Discussion

Risk Analysis at the Planning Stage in the Biomethane Plant Construction Project

The risk analysis in this study was carried out by identifying risks. According to Szymanski (2017), before implementation, each project must carry out a risk analysis that is carried out at the same time as the identification of possible risks. Risk management in project construction is designed to plan, monitor and control the actions necessary to prevent risk

exposure. So, (Appiah, 2020) There is a planning stage for the factory construction project *Biomethane* by PT A, a risk analysis must be carried out. Therefore, identifying risks that may arise during the planning process is an important first step to achieving project success.

Based on the results of the questionnaire distributed to employees from the Risk Management Division and the Research and Business Development Division with a total of 17 questionnaire distributions, the level of risk from the calculation is known by multiplying the *probability mean* and *the impact mean*, as presented in the following table.

Table 5. Risk Rating

Risk Rating	Risk Number	Risk Assessment	Risk Rating	Risk Number	Risk Assessment
1	23	15.99	15	25	6.70
2	26	13.18	16	18	6.40
3	19	12.03	17	9	6.38
4	6	11.04	18	17	5.95
5	24	9.72	19	8	5.81
6	5	9.53	20	14	5.80
7	22	9.33	21	16	5.67
8	10	8.99	22	15	5.54
9	21	8.75	23	20	4.97
10	27	8.30	24	4	4.60
11	7	7.64	25	3	3.88
12	11	7.61	26	1	2.34
13	12	7.16	27	2	2.15
14	13	7.16	-	-	-

Source: Data processed (2024)

From the table, the risk ratings for each risk statement are obtained. It is known that the highest risk is worth 15.99 and the lowest risk is worth 2.15. Thus, the 8 highest risks based on the ranking will be taken for further mitigation.

Risk Mitigation at the Planning Stage in the Biomethane Plant Construction Project

Based on the results of the risk identification that has been carried out above, PT A is expected to have a basis for risk mitigation. Risks that have a high level of risk matrix will then be the focus of PT A in mitigating risks. According to Coppola (2015), mitigation includes any ongoing action or effort undertaken to reduce the risk of harm through the reduction of the likelihood of occurrence and/or the consequential component of the risk of such harm.

Given the limited resources owned by the company, the risks to be mitigated are assessed based on the level of risk, which is 8. The following are the highest risks that are of concern in the planning of the *biomethane production plant* construction project at PT A:

Table 6. Risk Statement Ratings

Rank	Statement	Risk Assessment
1	There is a risk of objections from the public.	15.99
2	There is a risk from natural events.	13.18
3	There is a risk of economic instability (Inflation and Exchange Rate).	12.03
4	There is a risk that the project duration is too short for the required activities.	11.04
5	There is a risk of the emergence of new stakeholders and changes in demand.	9.72
6	There is a risk of expanding the scope of employment.	9.53
7	There is a risk of contract accuracy (change of purpose during the project, unclear scope).	9.33
8	There is a risk of inappropriate technology selection (type of construction, material).	8.99

Source: Data processed (2024)

The following are the mitigations for each risk in the planning stage of the *biomethane* plant construction project at PT A:

1. Mitigating for Risk Causes "objections from the public"

The strategy to deal with the possibility of objections from the public is to reduce the likelihood of it (*risk likelihood reduction*). Companies can take steps that embrace society, such as providing jobs.

According to N1, objections from the community to the construction of the factory are unavoidable. Generally, objections from the community are related to the air pollution produced by the factory. Therefore, PT A can embrace the community by providing job opportunities at PT A. In addition, the company also ensures that the location of the factory construction is on land that has met the applicable regulations. With this involvement and the fulfillment of land requirements, it is hoped that complaints from the community will be reduced because part of the community's livelihood is sourced from companies.

2. Mitigating for Risk Causes of "natural events"

The strategy to deal with the possibility of such risks is to avoid risks (*Risk avoidance*). Thus, the contract must define in detail the work, scope, and requirements in the event of a natural event (Coppola, 2015).

N1 said that natural events, such as floods, earthquakes, landslides, are unavoidable. So what the Company can do is to conduct an environmental study where the factory will be built, which includes the aspect of completeness to ensure that the selected location is not in an area prone to natural disasters such as floods or earthquakes.

3. Mitigating for Risk Causes "economic instability (Inflation and Exchange Rates)"

The strategy to deal with the possibility of economic instability such as inflation and exchange rates is to reduce risk *consequences*. N1 said that the step that can be taken is to take into account inflation every year. For example, by using historical data or available inflation projections, project managers can estimate price increases by a certain percentage per year and adjust the budget accordingly. These projections can be applied to raw material costs, labor costs, and other operational costs, so that the prepared budget can include the possibility of

unexpected price increases. and can help maintain the smooth running of the *biomethane plant construction project*.

4. Mitigation for Risk Causes "project duration that is too short for the required activities"

The strategy to deal with the possibility of a project duration that is too short for the required activities is to reduce the likelihood of it happening (*risk likelihood reduction*). Companies can reduce the possibility of a project duration that is too short by planning more accurately and in accordance with the capacity of the plant to be built.

N2 said that the larger the factory capacity, the longer the time frame to build the factory. Thus, a detailed plan is needed to ensure that all stages in the construction of the factory can be carried out in accordance with the targeted factory capacity. And it is also necessary to supervise the Head of the Factory Office and the Factory Assistant, to ensure that the construction of the factory will get progress according to the plan.

5. Mitigating for Risk Causes "the emergence of new stakeholders and changes in demand"

The strategy to deal with the possibility of new stakeholders and changes in demand is to reduce the likelihood of them (*risk likelihood reduction*). N1 said that the step that can be taken by PT A is to design a structured plan for the short, medium, and long term. This way, the company has clear guidance regarding the steps to be taken at each stage, so that even if new stakeholders emerge or market demand changes, the plan that has been drawn up does not need to be significantly changed. Management that has a clear priority scale will find it easier to adjust to those changes without disrupting the project's main objectives. For example, new stakeholders can be engaged in talks or meetings to understand the impact of their changing demands, while ensuring that key project priorities are maintained and do not hinder the project's progress. With this strategy, companies can mitigate the risks associated with uncertainty, maintain project sustainability, and ensure that the plans that have been drafted remain relevant despite new dynamics in the project.

6. Mitigations for Risk Causes "expansion of work coverage"

The strategy to deal with the possibility of expanding the scope of work is *risk avoidance*. The need to avoid expanding the scope of work, as the costs that have been included in the project budget can increase significantly if the scope is expanded. Therefore, it is important to draft specifications and contracts clearly and in detail from the outset, as well as ensure that all stakeholders understand and agree on the agreed scope. Thus, potential conflicts and cost overruns can be minimized, keeping projects within predetermined plans and budgets.

N1 and N2 said that coordination with vendors is needed, in order to find out why the scope of work is needed. And if there is an expansion of the scope of work, then there needs to be a modification or addendum to the contract, because the value of the contract will change and the possibility of the term will also change.

7. Mitigations for Risk Causes "contract appropriateness (change of purpose during the project, unclear scope)"

A strategy to deal with changes in objectives during the project, objectives that are unclear in scope and require the accuracy of the contract is to carry out *risk avoidance*. According to N1 and N2, the content of the contract must be explained in detail and complete related to the

clauses for the construction of the factory. This includes a clear explanation of the scope of work, project objectives, and existing limitations. In addition, it is necessary to conduct periodic evaluations during the project to ensure that all parties carry out their respective responsibilities. If any changes are required, the change management process must be carried out formally, including obtaining approval from all relevant parties.

8. Mitigation for Risk Causes "improper selection of technology (construction type, material)"

The strategy to deal with the improper selection of technology is to reduce risk likelihood (*risk likelihood reduction*). N2 said that it is necessary to involve consultants to get recommendations that suit the needs of the project. Consultants can provide recommendations that are more appropriate and in accordance with the needs of the project, both in terms of efficiency, cost, and technological suitability with the goals and characteristics of the factory. And ensure that the technology used to build the factory, is in accordance with the choice, so as not to cause delays in the construction of the factory, and in accordance with the set timeframe.

CONCLUSION

The risk analysis conducted during the planning stage of PT A's *biomethane* production plant construction project highlights the critical role of early risk identification in ensuring project success. Through questionnaires with employees from relevant divisions, 27 potential risks were identified, with eight key risks—such as public objections, natural events, economic instability, unrealistic project timelines, new stakeholders, scope expansion, contract inaccuracies, and improper technology selection—prioritized for focused mitigation. The mitigation strategies applied include reducing the likelihood of risks, avoiding risks altogether, and minimizing the consequences should risks occur. For future research, it is recommended to expand the analysis to the implementation and operational stages of the project, as well as to compare risk management practices across different renewable energy projects to develop more comprehensive mitigation frameworks.

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