RISK ANALYSIS TO MITIGATE DOMINANT RISK OF ELECTRICAL INFRASTRUCTURE CONSTRUCTION

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Abstract. Over the past 5 years, the achievement of the Risk Maturity Model (RMM) level value at PT PLN (Persero) UID Bali has not yet reached the target with a gap of 0.47 from the target of 4.19 at the end of 2024. The company's lack of optimization in using the budget period 2018-2023 may be an indicator that the enterprise risk management (ERM) culture has yet to be embedded in all business processes, especially in budget management planning. It is necessary to conduct a risk analysis study in all system development projects, one of which is the Turyapada Tower project in the PLN UP3 North Bali work area. The purpose of this study is to determine the indicators, analyze and mitigate the dominant risk of delay in the implementation of electrical infrastructure construction of the Turyapada Tower project. The research used a literature review and risk breakdown structure for risk identification, analytical network process (ANP) analysis to determine the dominant risk, and expert opinion to determine mitigation efforts for the dominant risk. The results showed that there were five risk groups consisting of technical risks (6 risk factors), management risks (5 risk factors), bureaucracy risks (3 risk factors), financial risks (5 risk factors), and safety risks (3 risk factors). The dominant risk analysis ranked five risks: bureaucracy risks (3 risk factors) and industrial accident risks (2 risk factors). The five dominant risks were mitigated.

Keywords: risk management, risk indicator, risk mitigation, analytical network process, dominant risk.

1 INTRODUCTION

PT PLN (Persero) has three main business processes, namely, generation, transmission, and distribution of electricity. The Bali Main Distribution Unit (UID) is a PLN main unit that concentrates on the business processes of electricity distribution and customer service. The North Bali Customer Service Implementation Unit (UP3) is a PLN unit under UID Bali that focuses on electricity distribution services to customers from

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2 districts, namely, Buleleng Regency and Jembrana Regency. PT PLN (Persero) UP3 North Bali, a business unit that runs its business in the form of fulfilling the availability of electricity, will require an investment budget every year to realize electricity projects by a predetermined plan. However, the investment budget that has been planned is often ineffective and inefficient and cannot be completed as planned. This can be seen from the percentage of the subsidiary budget in the following year, due to constraints in planning and the field.

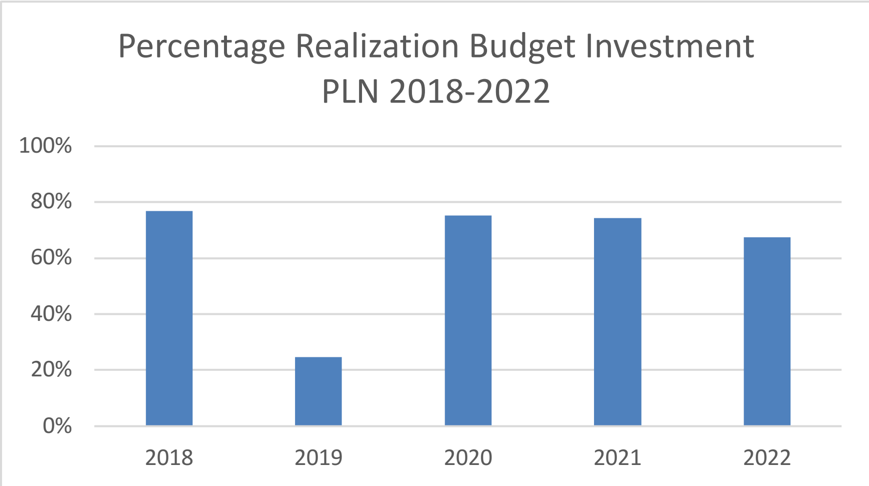

Fig. 1. Percentage Realization Budget Investment PLN Period Of 2018-2022
Source: PT. PLN (Persero) UP3 Bali Utara (2023)

Figure 1 illustrates the amount of the realization investment budget that has decreased from year to year. In 2018 the number of releases reached 77% of the total investment budget provided, but there was a data anomaly in 2019, namely, reaching 25% of the realization budget of the total budget received. This occurred because in 2019 there was a COVID-19 pandemic outbreak so almost all projects were hampered due to the PPKM (Community Activities Restrictions Enforcement, CARE) policy and the economic slowdown both worldwide and in Indonesia. In 2020, the number of releases decreased compared to 2018, which is 75% of the total budget received. The decrease will occur again in 2021 and 2022, by 74% in 2021 and the lowest in 2022, by 67% of the realization budget of the total budget received by PLN UP3 North Bali. The company's lack of optimization in using the budget period 2018-2023 may be an indicator that the enterprise risk management (ERM) culture has not been embedded in all business processes, especially in budget management planning.

One of the efforts to reduce the risk of discrepancies in infrastructure development project plans can be carried out with risk management of the findings of constraints and obstacles caused by conditions in the field that are not by the plan. The results of the literature review conducted by [1] explain that implementing effective risk management can improve the quality of various project management.

However, power plant infrastructure projects are infrastructure projects whose implementation is complex due to the involvement of many stakeholders, a complex organizational structure, the use of various tiered contract systems, and the many interrelated activities in various phases of the project life cycle [2]. These factors result in significant risk exposure, uncertainty, ambiguity, and vulnerability throughout the project life cycle [3], so management needs to adopt a broader standpoint [4].

Decision-making on risks that emerge from the existence of a power plant infrastructure project needs to be done by prioritizing risks as an effort to obtain a list of risks that are priority or dominant to reduce their impact. In line with the character of the risks that emerge from the existence of a power plant project, such as the risk of excess costs that are dynamic [5], interdependent, complicated, uncertain, subjective, and unclear due to their large size, higher complexity, and unique environment [6], the appropriate analytical method used in determining risk priority is Multi-Criteria Decision Making (MCDM) using the Analytic Network Process (ANP) method.

The ANP method was chosen because this method could consider the relationship between criteria, and draw complex networks that can help reduce subjectivity and uncertainty [7],[8];[9],[10]. The ability to manage development project plan discrepancies in risk management is one of the approaches in risk control so that risks can be avoided, able to reduce the occurrence of risks to failure for the losses they cause. Based on this explanation, the purpose of this study is first to determine risk indicators of delays in the implementation of the Turyapada Tower electrical infrastructure construction project. Second, the ANP method is used to analyze the risk of delays in the construction of electricity infrastructure, and third, the dominant risk of delays in the implementation of electricity infrastructure construction is mitigated.

2 LITERATURE REVIEW

2.1 Project management

Projects are complex businesses with planned performance specifications, and limited time, budget, and resources to meet predetermined needs [11]. The project has three main limitations: scope, time, and cost. The success of a project is determined by the project manager in consideration of these limitations [12]. Three constraints must be met in a project or what is known as the triple constraint, which consists of quality accuracy, timeliness, and cost accuracy. Several construction projects often experience problems with delays due to their complexity. Time is an important aspect of project management in addition to cost and quality. Project implementation certainly has a deadline that needs to be completed on time as planned [13].

Project management is a series of activities consisting of planning, scheduling, and project control activities that consist of several activities/activities. The main focus of project management is the achievement of the ultimate goal of the project with all available constraints, time, and available funds. The existence of a project management process will assist management in compiling a project schedule, determining the total time used in completing a project, determining activities/activities that need to be prioritized, and determining the costs required to complete a project [14].

2.2 Risk Management

A risk is an event that can harm a project due to uncertainty. The concept of risk in a project is a measure of the probability and consequences of not achieving certain project objectives. This risk has two major components to an event. That is, the probability that an event will occur and the impact if the event does occur. may cause harm, damage, or loss [15]. Risk management is the set of activities undertaken within an organization to deliver the most favorable outcome and reduce the volatility or variability of that outcome [16]. Fourth risk management processes are structured and systematic, namely: risk identification, risk analysis, risk management, developing alternative risk management, as well as monitoring and controlling risk treatment [17].

2.3 Literature Studies

Infrastructure construction projects are dynamic and complex, with the combined effect of human and other factors interacting in a dynamic environment [5]. The power plant project can be a good example of a complex project because there are many stakeholders involved, a complex organizational structure, the use of various tiered contract systems, and many activities within which are interrelated in various phases of the project life cycle [2].

Risk management is an important scientific and practical study in power plant infrastructure projects at all stages of the project cycle. The power plant infrastructure project cycle stages include the main stages consisting of sitting, designing, construction, commissioning, and decommissioning. The risk management system for power plant infrastructure projects will include several stages consisting of risk identification; risk classification; risk analysis, estimation, and rating; and development of countermeasures [18]

[5] argues that in research related to the implementation of risk management in power plant infrastructure projects, the ANP method is a suitable method due to the uncertain, causal, interdependent, and subjective nature of cost overruns characteristic of power plant infrastructure projects, where various previous studies did not always address these unique inherent risks. ANP calculates the complex (causal and interdependent) relationships between decision elements by changing from a hierarchical structure to a network structure. In addition, ANP has all the positive features of AHP, such as simplicity, flexibility, simultaneous use of quantitative and qualitative criteria, and the ability to review consistency in assessments [9]. In addition, [19] states that the ANP model will be able to increase the efficiency of the decision-making process and assist decision-makers in choosing more efficient solutions based on their interests and their impact on business.

3 METHODS

3.1 Research Design

The stages of this research include identification, problem formulation, goal setting, literature review on secondary data in the form of theories related to project risk analysis, and continued with the data analysis stage in the form of determining the dominant risk of the Turyapada Tower project using ANP. The next stage ends with implementation and evaluation in the form of mitigation efforts for the dominant risks. The following is a research flowchart:

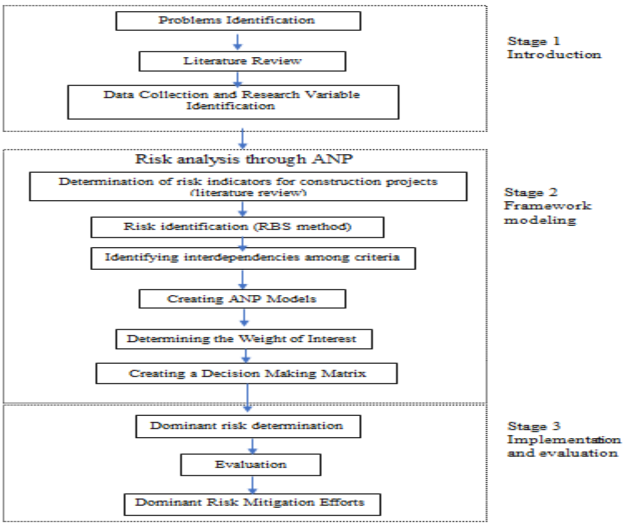

Fig. 2. Research Flowchart

Following the research objectives, the subjects of this research are individuals who have the competence and in-depth understanding of the risks that may arise and are a priority for the implementation of the Turyapada Tower electrical infrastructure construction project. For this reason, the sampling technique used is non-probability sampling and specifically uses purposive sampling with a criterion such as first, having worked for more than 10 years (having the competence and a very good understanding of risks that may arise and become dominant). Second, they were directly involved in the Turyapada Tower project. Respondents for this category consist of 4 top managers and 1 job supervisor.

3.2 Risk Identification Through the Risk Breakdown Structure (RBS) Method

The RBS method will be used as an attempt to categorize each risk and obtain a risk grouping in a risk hierarchical composition that is logical, systematic, and structured according to the project structure. The process of identifying risks begins with conducting a review of literature studies and the results of the study divide the risks into two categories, namely risk groups and risk factors. Respondents who were included in risk identification by the Risk Breakdown Structure (RBS) method were individuals who were considered experts in determining the groups and risk factors that had the most influence on the electrical infrastructure construction of the Turyapada Tower Project, PT. PLN (PERSERO) UP3 North Bali.

3.3 Analytical Network Process (ANP)

The procedure or steps in carrying out the ANP method are as follows:

1. Define the problem and determine the expected solution.
2. Risk category identification and risk factors through the RBS method
3. Determine the interdependence relationship between risk categories and risk factors

Determination of the dependency relationship between criteria and subcriteria is done by using calculations [20]:

$$Q = N/2 \tag{1}$$

N = Number of respondents
Vij = The number of respondents who chose the existence of an interdependence relationship between subcriteria in cell row i and column j.
If Vij ≥ Q then there is an interdependence relationship between criteria, and if Vij < Q then there is no interdependence relationship between criteria. In other words, it is said that there is a relationship if the value (Vij) is more than 50% of respondents (DM) or equal to Q.

4. Determines the priority of the elements

Determining the priority of elements will be done by making pairwise comparisons where the numerical values in all comparisons are obtained from a comparison scale of 1 to 9. The comparison scale used follows the Saaty scale as follows:

Table 1. Pairwise Comparison Scale

Scale	Scale Definitions
1	Equally Importance
3	Moderately Importance
5	Strongly Importance
7	Very Strongly Importance
9	Extremely Importance
2,4,6,8	Intermediate Value

Source: [21]

5. Calculating the weights of elements in decision making

This study uses multiple respondents so that the average calculation to obtain a certain value of all respondent values will be carried out by calculating the geometric average [22].

$$Gij = (Z1 \ X \ Z2 \ X \ Z3 \ldots\ldots\ldots X \ Zn)1/n \tag{2}$$

Gij = Total geometric mean

Z1-Zn = Value of survey results to respondents
n = Number of respondents

6. Creating a Supermatrix

The supermatrix is a matrix consisting of submatrices composed of a set of relationships between the two levels contained in the model. The supermatrix consists of three stages, namely unweighted supermatrix, weighted supermatrix, and limiting supermatrix. When the priority values in each column are the same, then the limit supermatrix has been obtained. From these priority values, it can be concluded that the most influential subcriteria [19].

7. Calculate Global Weight

The global (overall) weight can be obtained by multiplying the risk factor weight by the risk category. Risk factor weights were obtained from pairwise comparisons of risk factors, while risk category weights were obtained from risk category pairwise comparisons. The alternative with the highest priority is a good alternative.

4 RESULTS and DISCUSSION

4.1 Risk Breakdown Structure (RBS)

Construction of electrical infrastructure for the Turyapada Tower Project, PT. PLN (PERSERO) UP3 North Bali is a dynamic and risky activity. An important initial step to take in managing risk management is to identify existing risks. This risk identification is carried out using the Risk Breakdown Structure (RBS) method through a literature study. The sources of the literature study that is the basis for identifying existing risks are [5], [23], [24], [25], [26], [27], and [28]. Based on the results of a literature study, there are 5 risk groups and 31 risk factors. After identifying the risks using the RBS method, 5 risk groups were obtained consisting of, technical risk had a total of 6 risk factors from the previous total of 8 risks. Second, management risk had a total of 5 risk factors from the previous total of 9 risks. The third is Bureaucracy risk had a total of 3 risk factors from the previous total of 5 risks.

The fourth is financial risk had a total of 5 risk factors from the previous total of 6 risks. Fifth, safety risk had a total of 2 risk factors from the previous total of 3 risks. Respondents who were included in risk identification using the RBS method were individuals who were considered experts in determining the groups and risk factors that had the most influence on the electrical infrastructure construction of the Turyapada Tower Project, PT. PLN (PERSERO) UP3 North Bali.

4.2 Analytical Network Process (ANP)

The steps taken in carrying out the ANP method are as follows:

- **Relationship Between Risk Categories and Risk Factors**

Determining the relationship between risk categories and risk factors is carried out using a questionnaire that will be completed by individuals who are considered experts in the Turyapada Tower project development. The categorization of this relationship will be carried out on two types of relationships, namely dependence on one risk factor (inner dependence) and relationships between risk categories (groups) or what is known as outer dependence. The relationship between inner dependence and outer dependence is determined by using calculations [26].

$$Q = N/2 \quad (3)$$

N = 5 (total research respondents)
Q = 5 / 2 = 2.5
where
Vij = The number of respondents who chose the existence of an interdependence relationship between subcriteria in cell row i and column j

If $V_{ij} \geq Q = 2.5$ then there is an interdependence relationship between criteria, and if $V_{ij} < Q = 2.5$ then there is no interdependence relationship between criteria. In other words, there is a relationship if the value (Vij) is at least 3 respondents (DM). The description of the relationship between risk categories and risk factors can be seen in Fig. 3:

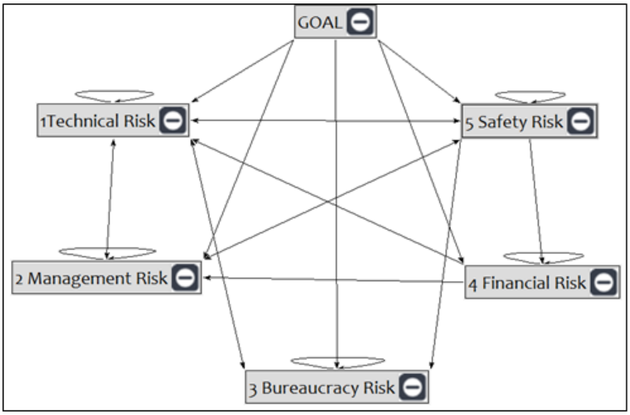

Fig 3. Research Model

- **Pairwise Comparison Matrix**

The next stage after the research model was formed is to create a pairwise comparison matrix. The creation of this matrix was carried out by collecting data from respondents who are experts in the electrical infrastructure construction of the Turyapada Tower Project, PT. PLN (PERSERO) UP3 North Bali. Experts who were the respondents of this study consisted of five respondents consisting of UP3 managers, assistant construction managers, assistant planning managers, assistant network managers UP3, and work supervisors. This study uses more than 1 expert or multiple respondents, while the super decisions application does not provide multi-respondent data processing (more than 1 expert), so a single assessment must be made. For this reason, it is necessary to calculate the average value known as the geometric mean. The calculation of the geometric mean of the pairwise comparison matrix is carried out between construction risk groups, technical risks, management risks, bureaucracy risks, financial risks, and safety risks.

- **Determine the Element Priority**

Element priority is determined by calculating global weight by looking at risk factor weights obtained from pairwise comparisons of risk groups (between construction risks), while risk factor weights are obtained from pairwise comparisons of risk categories (between technical risks, between technical risks, between management risks, between Bureaucracy risks, between financial risks, and between safety risks) or what is known as local weights. By using the super decision application, you can see a comparison between the results of calculating local weights and global weights from the research model formed, namely:

Table 2. Results Of Local Weights and Global Weights

Risk Group	Local Weight	Risk Factor	Local Weight	Global Weight
Technical Risk	0.156	RT1	0.214	**0.0592**
		RT2	0.170	**0.0568**
		RT3	0.274	**0.0625**
		RT4	0.119	**0.0541**
		RT5	0.096	**0.0528**
		RT6	0.127	**0.0510**
Management Risk	0.156	RM1	0.170	**0.0313**
		RM2	0.257	**0.0360**
		RM3	0.170	**0.0313**
		RM4	0.257	**0.0360**
		RM5	0.145	**0.0299**
Bureaucracy Risk	0.142	RP1	0.333	**0.0935**
		RP2	0.333	**0.0935**
		RP3	0.333	**0.0935**
Financial Risk	0.131	RF1	0.313	**0.0143**
		RF2	0.293	**0.0143**
		RF3	0.103	**0.0143**
		RF4	0.175	**0.0143**
		RF5	0.116	**0.0143**
Safety Risk	0.416	RK1	0.250	**0.0734**
		RK2	0.750	**0.0734**

4.3 Dominant Risk Mitigation Efforts for the Turyapada Tower Project

The dominant risk mitigation efforts for delays in the implementation of the Turyapada Tower projects will be carried out against risk factors that have the 5th largest rating. The following is a ranking of the dominant risk factors for delays in the construction of the Turyapada Tower electrical infrastructure project:

Table 3. The Five Rankings of Dominant Risk Factors

Risk Factor	Group Risk	Ranking
Extensive and complicated the bureaucratic system	Bureaucracy Risk	1
Difficulties to get approval from the local government	Bureaucracy Risk	2
Regulatory changes that resulted in the project being hampered	Bureaucracy Risk	3
Work accident	Safety Risk	4
Lack of worker knowledge related to work safety	Safety Risk	5

Risk mitigation efforts will be carried out by expert opinions obtained through in-depth interviews as a form of recommendation for appropriate risk management strategies. Mitigation efforts for the extensive and complicated bureaucratic system and difficulties obtaining approval from the local government are establishing good and positive relations with the bureaucracy at the local or national level and preparing administrative and procedural completeness so that it will facilitate and speed up the bureaucratic process. Mitigation efforts against regulatory changes that result in the project being hampered are forming a team that always updates information related to regulations related to project development permits and recruiting legal staff who have good competence so that they understand all forms of project development permit rules.

Mitigation efforts against work accident risk include recruiting experienced employees and supervisors, using complete and modern safety equipment or equipment, supervising the implementation of strict Standard Operational Procedures (SOP), and awarding the best employees who are disciplined in implementing K3. Mitigation efforts towards the lack of knowledge workers related to work safety are recruiting employees and supervisors who are experienced (having K3 certification), continuous K3 education and training, and making sign boards as reminders of the technical aspects of work safety SOPs or warnings about the importance of K3.

These results are in line with research conducted [25], [26], [29] which places bureaucracy (political or legal and regulatory) risk and safety risk as the dominant risk factors (high risk), while [5] places construction delay and inadequate soil investigation as the dominant risk factors (high risk). The existence of this priority difference can be caused by the different goals to be achieved where [5], focuses more on risk factors that can be the cause of the emergence of cost overrun projects while [25], [26], [29] focus more on risk factors that emerge and become dominant from power plant construction projects. The existence of full support from the national government can also be a determinant of differences in the results. The results of this study may be able to complement research related to the risk factors that emerge and become dominant in power plant construction projects using the ANP method as a different method from various previous studies.

The positive impact of the risk assessment using the ANP method is first, obtaining risks that have a direct impact on the Turyapada Tower project through the risk identification process using the RBS method. Second, analyzing risks in a more comprehensive manner where the risks that arise will consider the linkages between risks so that it is hoped that the dominant risks obtained will be closer to the actual conditions and the mitigation that is carried out focuses precisely on the dominant risks. The negative impact that can arise from a risk analysis using the ANP method is the need for readjustments where new risks arise which will require risk mitigation efforts that will of course take time and cost.

5 CONCLUSIONS

Based on the analysis and discussion that has been carried out, the research conclusions that can be submitted are first, identifying risks using the Risk Breakdown Structure (RBS) method obtained 5 risk groups and 21 risk factors. Second, the results of the analysis using the ANP method yielded five dominant risk ratings and mitigation efforts were made for these five dominant risks to reduce delays in the implementation of the Turyapada Tower electrical infrastructure construction project.

The suggestions that can be submitted related to the results of this study are that the management of PT PLN (Persero) UP3 North Bali needs to prioritize safety and bureaucracy risk groups as a mitigation effort considering that these risks are the dominant risks that can arise in this project. For further research, you can expand infrastructure projects or expand the research sample so that you can produce more generalized research.

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