

Article

Integration of Risk Thresholds into Enterprise Risk Management (ERM) Implementation in An Energy Company

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Abstract. All state-owned enterprises are obligated to implement risk management effectively. Risk management implementation can be assessed using the Risk Maturity Index (RMI). The 2024 RMI assessment at one of the state-owned energy subsidiaries indicated that the Company is at the "Developing" stage (score 2.9 out of 5). Critical weaknesses occurred because the company had not conducted a comprehensive risk capacity calculation. Risk capacity constitutes a key component of an organization's risk threshold and serves as the basis for determining risk appetite, risk tolerance, and risk limits. This study aims to identify an appropriate method for calculating the risk threshold value and to apply the selected approach for the year 2026. Risk capacity is calculated based on the Company's financial statements from 2019 to 2024 using a Modified Altman Z-Score approach is proposed to determine the financial distress point as a measure of risk capacity. The resulting risk capacity was estimated at IDR 1.42 trillion and subsequently validated using the Value at Risk (VaR) method. The findings of this study are expected to provide a quantitative basis for the Company in formulating its 2026 risk strategy, while also contributing to the improvement of its RMI score.

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1. Introduction

The implementation of risk management within a company constitutes a series of activities carried out in a structured and systematic manner with the objective of identifying, assessing, and managing various risks arising from the company's business operations. This process includes risk planning, monitoring, and evaluation of potential risks that may affect the achievement of organizational objectives. In the context of state-owned energy companies, in this case power and steam generating energy companies, the implementation of risk management is a mandatory requirement that must be carried out effectively to support the strengthening of internal control systems, the adoption of integrated corporate governance practices, the preparation of accurate risk reports, and the measurement of overall corporate performance [1].

Through ministerial regulations concerning Corporate Governance Guidelines and Significant Corporate Activities, the government requires state-owned enterprises to implement risk management practices. These regulations mandate all companies to establish comprehensive risk management policies and standard operating procedures. Such procedures encompass risk identification, risk measurement and assessment, determination of risk treatment or mitigation measures, documentation of risk management processes, periodic monitoring and evaluation, and the reporting of risk management outcomes. Furthermore, companies are required to ensure that internal control systems operate effectively to support the successful implementation of risk management. Through the risk aggregation process, risk management implementation in state-owned enterprises is conducted in an integrated manner, ranging from the corporate level to the ministerial level.

The aggregation process begins at the parent company level, where risks are consolidated from all subsidiaries. Subsequently, these risks are aggregated at the ministerial level to provide a comprehensive overview of the national risk portfolio. Given the complexity and length of this process, risk management implementation must be carried out comprehensively and remain adaptable to the dynamics of the business environment [2].

To enhance the quality of corporate risk management implementation, one of the measures adopted is requiring each company to conduct a Risk Maturity Index (RMI) assessment. This assessment aims to evaluate the quality of the risk management framework and the effectiveness of its implementation in protecting and creating value for the organization [3]. The RMI serves as a tool for measuring the level of maturity of risk management practices within a company. Among the five dimensions assessed in the Risk Maturity Index (RMI), one of the most critical is the risk capacity element. This element influences the company's risk strategy and serves as a benchmark (limit) for assessing the level of each identified risk. Its significance is also reflected in the results of the RMI assessment conducted by external parties in 2024. This state-owned energy subsidiary received a score of only 1 out of 5 for the risk capacity element. The company had not conducted a comprehensive analysis to determine its risk capacity, resulting in the primary risk capacity component being deemed irrelevant.

Risk capacity is defined as the maximum level of risk that a company can withstand. When this level is exceeded or disregarded, the company must be prepared to face unacceptable consequences, including potential bankruptcy. Risk capacity may also be defined as the maximum amount of risk that a company can absorb based on its capital value, net working capital, liquidity, total financing capability, or other relevant threshold values [2]. State-owned enterprises are required to calculate their risk capacity as the basis for determining risk appetite, risk tolerance, and risk limits. These parameters constitute the company's risk threshold values and are incorporated into its risk strategy. Furthermore, they serve as a foundation for establishing business objectives and strategies, as well as for prioritizing risks within the risk assessment process [2].

Numerous previous studies have examined the Risk Maturity Index (RMI). However, most of these studies did not incorporate risk limits into the RMI assessments they conducted. Abdulkareem et al. [4] developed a corporate failure prediction model for private companies without considering

organizational risk limits. Similarly, Arnold et al. [5] assessed investment risks in renewable energy projects but did not calculate corporate risk limits. Delgado et al. [6] developed a probability model for supply chain failure risks; however, their study did not account for risk appetite, risk tolerance, or risk limits. In contrast, Zhdanova et al. [7] performed risk calculations to determine risk appetite and risk tolerance values associated with corporate failure. Abed et al. [8] employed a Fuzzy Logic Inference System (FLIS) approach to assess risk capacity in construction projects. Saputra et al. [9] analyzed risk values using Monte Carlo simulation; however, the study focused solely on calculating risk exposure. Huynh et al. [10] investigated supply chain risks in relation to working capital management and measured risk capacity, although the assessment was not conducted comprehensively. A comparison between the present study and previous research is presented in the table below.

Table 1. Literature review

No	Author(s)	Year	Method	Research Gap
1	Abdulkareem [4]	2015	Altman Z-Score Model	<ul style="list-style-type: none"> • Focused on private companies. • Did not calculate corporate risk limits.
2	Arnold [5]	2015	Monte Carlo Simulation (MCS)	<ul style="list-style-type: none"> • Did not calculate corporate risk limits.
3	Delgado [6]	2022	Altman Z-Score Model	<ul style="list-style-type: none"> • Focused on bankruptcy probability estimation. • Did not calculate risk appetite, risk tolerance, or risk limits.
4	Zhdanova [7]	2022	<ol style="list-style-type: none"> 1. Altman Coefficient 2. Taffler Coefficient 3. Savitskaya coefficient 4. Choice theory approach 	<ul style="list-style-type: none"> • Calculated risk appetite and risk tolerance values.
5	Abed [8]	2024	Fuzzy logic Inference System (FLIS)	<ul style="list-style-type: none"> • Focused on construction companies. • Did not calculate overall corporate risk limits.
6	Saputra [9]	2023	Monte Carlo Simulation (MCS)	<ul style="list-style-type: none"> • Risk exposure measurement only.
7	Huynh [10]	2025	Panel regression and econometric analysis	<ul style="list-style-type: none"> • Did not comprehensively measure risk capacity.
8	This Research	2026	Risk Capacity Calculation using <i>Altman Z-Score</i> Risk Capacity Validation using <i>Value at Risk</i>	<ul style="list-style-type: none"> • Calculates risk capacity. • Calculates risk tolerance. • Calculates risk appetite. • Calculates risk limits.

To conduct a robust Risk Maturity Index (RMI) assessment, a performance-based evaluation must be implemented by integrating two key components, namely the dimensional aspect and the

performance aspect. The dimensional aspect emphasized in this study focuses on the Risk Framework and Compliance components. Within this framework, the risk capacity element is identified as the most critical level that must be carefully considered by the company. Risk capacity serves as the foundation for establishing risk threshold values, which comprise risk capacity, risk tolerance, risk appetite, and risk limits. The incorporation of these parameters enables the company to develop a risk strategy that is measurable and can be quantitatively justified and accounted for.

2. Experimental Section

2.1. Sources and Types of Data

The data used in this study are secondary data derived from the financial statements of a state-owned energy subsidiary for the 2021–2024 period, which have been audited by external auditors. These data include the income statement, balance sheet, cash flow statement, and notes to the financial statements. The use of audited financial statements aims to ensure the reliability and credibility of the data employed in the analytical process. In addition, this study also utilizes historical corporate risk exposure data obtained from Risk Events related to the company's strategic objectives. The risk exposure data were collected for the 2021–2024 period and are used in the determination of risk appetite. Meanwhile, risk tolerance and company risk limits are obtained from the variance/delta of achieving the RJP target from 2021-2024.

2.2. Risk Management Framework

Risk management focuses on averting risks, and if they do arise, it aims to minimize the impact of those risks. Consequently, the organization should ensure that its financial outcomes remain favorable and progressively improve over time [11]. In the implementation of risk management, the internationally recognized standard ISO 31000 is commonly adopted [12]. This standard outlines the principles, framework, and processes that organizations can use to manage risk in a systematic and integrated manner [13].

ISO 31000 was first introduced in 2009 as an effort to harmonize risk management practices across countries and to provide a unified language and approach to risk management [14]. The ISO 31000 framework consists of interrelated principles, a framework, and risk management processes. The Plan–Do–Check–Act (PDCA) cycle is embedded within this framework, emphasizing the importance of top management commitment in the implementation of risk management. The process begins with establishing the context, followed by risk identification, risk analysis, risk evaluation, risk treatment, communication, and continuous monitoring and review. Organizations with varying levels of complexity can adapt the implementation of risk management according to their respective needs due to the flexibility of this framework [14].

2.3. Enterprise Risk Management and Risk Capacity

Enterprise risk management (ERM) plays a vital role in an effective and thorough corporate governance framework [15]. The concept of Enterprise Risk Management (ERM) represents an integrated risk management approach at the organizational level [16-17]. Within the framework developed by the Committee of Sponsoring Organizations (COSO), ERM is defined as a process conducted by the board of directors, management, and all members of an organization to identify, assess, and manage risks that may affect the achievement of organizational objectives [18-19]. ERM can also be defined as a framework that enables organizations to coordinate the management of all existing risks, thereby providing a more comprehensive overview of the organization's risk profile. Consequently, ERM contributes to supporting the achievement of strategic objectives and enhancing firm value through more effective risk management [20].

The ERM approach emphasizes that risk management is not conducted separately by each organizational unit, but rather in an integrated manner at the enterprise level. Through this approach,

organizations can obtain a more comprehensive understanding of their risk profile, thereby improving the quality of strategic decision-making. One of the key concepts within ERM is risk capacity, which refers to the maximum level of risk that an organization can bear without threatening its operational sustainability. Risk capacity can also be defined as the organization's ability to absorb income uncertainty arising from capacity allocation decisions [21-22]. It serves as the foundation for determining acceptable risk levels through the establishment of risk appetite and risk tolerance. By understanding risk capacity, companies can ensure that business decisions do not exceed the organization's ability to withstand risk impacts [18].

2.4. Risk Maturity Index (RMI)

The Risk Maturity Index (RMI) can be defined as an index used to measure the quality of design and the effectiveness of risk management implementation in state-owned enterprises [3][23]. The aim of the Risk Maturity Index (RMI) evaluation is to pinpoint three important elements: the underlying reasons for failures, the possible consequences that result from these failures, and the significance level of these consequences [24]. The RMI assessment integrates two main components, namely the dimensional aspect and the performance aspect, thereby reflecting the extent to which risk management implementation contributes to the improvement of corporate performance. One of the dimensions assessed within the RMI is the Risk Framework and Compliance dimension, which evaluates policies, procedures, and the integration of risk management into the company's strategic decision-making processes. Within this dimension, risk capacity is considered a key parameter, as it serves as the basis for determining the company's risk appetite and risk limits.

2.5. Risk Threshold Concept

The Government of Indonesia, through the relevant ministries, mandates that all state-owned enterprises establish risk threshold values at the corporate level. These risk threshold values consist of risk capacity, risk appetite, risk tolerance, and risk limits [2]. Risk capacity represents the maximum ability of a company to absorb losses based on its financial condition, such as equity, net working capital, or other financing capabilities. Risk appetite refers to the level of risk that an organization is willing to accept in pursuit of its strategic objectives. Meanwhile, risk tolerance describes the acceptable range of variation in achieving organizational targets, and risk limits refer to the maximum risk values allocated to individual risk owners within the organization.

The upper and lower bounds of risk appetite function as operational thresholds that serve as early warning signals. Corrective actions can be promptly implemented when risk exposure exceeds the lower bound. The upper bound, on the other hand, represents the maximum tolerable level of risk that the company is willing to accept. These upper and lower bounds are typically derived as variations of risk appetite, often determined using two or more standard deviations depending on the objectives of each organization [25].

2.6. Altman Z- Score

The Altman Z-Score method is a model used to predict corporate bankruptcy by calculating several financial ratios and incorporating them into a discriminant function equation. The Altman Z-Score model has undergone three major revisions. The first model (1968) was applicable only to publicly traded manufacturing firms. The revised Altman Z-Score model (1983) expanded its applicability, allowing it to be used for both public and private manufacturing companies. The latest modification, the Altman Z-Score model (1995), was developed based on analysis of firms in emerging markets [26-28]. The modified Z-Score model is expressed in Equation (1) as follows:

$$Z = 6,56X_1 + 3,26X_2 + 6,72X_3 + 1,05X_4 \quad (1)$$

Where the variables X1, X2, X3, dan X4, are defined in Equations (2) to (5) as follows:

$$X_1 = \frac{\text{Working Capital}}{\text{Total Assets}} \quad (2)$$

$$X_2 = \frac{\text{Retained Earnings}}{\text{Total assets}} \quad (3)$$

$$X_3 = \frac{\text{EBIT}}{\text{Total assets}} \quad (4)$$

$$X_4 = \frac{\text{Book Value of Equity}}{\text{Book Value of Debt}} \quad (5)$$

Description:

Z = Z-Score Value

X_1 = Working Capital / Total Assets

X_2 = Retained Earnings / Total Assets

X_3 = Earnings Before Interest and Taxes / Total Assets

X_4 = Book Value of Equity / Book Value of Debt

After obtaining the Z-Score value, companies are classified based on the Z-Score categories as shown in Table 2 below.

Table 2. Company classification based on z-score value

Z-Score Value	Interpretation
$Z > 2,60$	Safe Zone, indicating the company is in a healthy condition
$1,1 < Z \leq 2,60$	Grey Zone
$Z \leq 1,1$	Distress Zone, indicating the company is experiencing financial difficulties

Source: [7][29]

2.7. Value at Risk (VaR)

Value at Risk (VaR) is a prerequisite step before being used to calculate Conditional Value at Risk (CVaR), which serves as a benchmark for validating risk capacity values. VaR is a method used to measure the maximum potential loss over a specific time horizon at a given confidence level [30]. Several commonly used methods for VaR calculation include Historical Simulation, Variance-Covariance, and Monte Carlo Simulation. In this study, the Monte Carlo Simulation method is employed due to its ability to accommodate various probability distributions and provide greater flexibility in analyzing corporate risk exposure. This method operates by running thousands of random scenarios to estimate the distribution of potential losses, thereby producing an approximation of the maximum possible loss that may occur [9]. This method is formulated in Equation (6) as follows:

$$VaR = \mu - (z_\alpha \cdot \sigma) \quad (6)$$

where:

VaR = Maximum potential loss

μ = Mean return (*expected return*)

σ = Standard deviation (*loss variability*)

z_α = Confidence level coefficient (*confidence level*)

2.8. Conditional Value at Risk (CVaR)

Conditional Value at Risk (CVaR) also known as Expected Shortfall (ES), is a measure of potential loss that occurs when losses exceed the Value at Risk (VaR) threshold [31]. CVaR provides information on the average loss in the tail of the loss distribution, thereby capturing extreme risk exposures that cannot be adequately reflected by VaR alone. In this study, the CVaR values of the risk exposures faced by state-owned energy subsidiaries are used as a validation measure through a comparison with the calculated risk capacity values. The CVaR formula can be expressed as Equation (7) as follows:

$$CVaR_{(1-\alpha)} = E(X|X \leq VaR_{(1-\alpha)}(X)) \quad (7)$$

where:

$CVaR_{(1-\alpha)}$	=	Conditional Value at Risk at confidence level α
X	=	Loss variable
$VaR_{(1-\alpha)}$	=	VaR at confidence level α
E	=	Expected value

2.9. Risk Capacity Calculation

Risk capacity is calculated using financial indicators that reflect a company's ability to absorb risk based on its financial condition. The indicator employed in this study is the Altman Z-Score method, which is used to assess the financial health of a company and identify the potential for financial distress. This situation is marked by a lack of positive cash flow from operations, obligations surpassing assets, and a failure to keep sufficient working capital [32-33]. In this study, a simulation is conducted to determine the maximum level of loss that the company can sustain before its Z-Score reaches the critical threshold of 1,1 [7]. Z-score of 1.1 is the lower limit, indicating that a company is approaching financial distress. Therefore, the maximum loss that would cause the Z-score to reach this value can be defined as the company's risk capacity. However, in accordance with the concept of Enterprise Risk Management, companies are not advised to operate near this maximum capacity limit. Therefore, this study also identifies conditions such as $Z = 2.60$ and $Z = 1.5$, which fall within the safe zone, as the threshold for financial security.

2.10. Risk Capacity Validation

After the risk capacity value has been determined, the next step is to conduct a validation process to ensure that the calculated value is realistic and accurately reflects the company's ability to absorb risk. The validation is performed by comparing the company's risk exposure estimates obtained using the Conditional Value at Risk (CVaR) approach, where the data is the generator loss event data from 2021-2024. The CVaR value is obtained by first calculating the Value at Risk (VaR) of the company's risk exposure. The VaR method employed in this study is the Monte Carlo Simulation, as it can accommodate various probability distributions and provides flexibility in risk analysis.

The simulation process is carried out with a total of 10,000 iterations. The simulation stages include identifying the variables affecting risk exposure, determining probability distributions that appropriately represent the characteristics of the data, and conducting simulations to estimate the VaR at a specified confidence level. Subsequently, the CVaR value is calculated. The resulting CVaR value is then compared with the previously calculated risk capacity value. If the risk capacity exceeds the CVaR value, the company is considered to have sufficient risk-bearing capacity, indicating that the risk capacity calculation method applied in this study is valid.

2.11. Risk Appetite Calculation

Risk appetite is calculated by considering the company's historical risk exposure data based on risk events related to the company's strategic objectives [2]. The risk exposure values for each indicator are summed annually for the 2021–2024 period and subsequently compared with the company's risk capacity to determine the percentage of residual risk exposure. The average and maximum residual risk exposure values are then used as the basis for establishing the company's risk appetite threshold.

2.12. Risk Tolerance and Risk Limit Calculation

After the risk appetite has been established, the next step is to determine the risk tolerance and risk limit values. These two parameters serve as operational boundaries in the company's risk management process. The calculation of risk tolerance and risk limits is conducted using statistical analysis of historical data on the achievement of the company's management contract targets. The method employed is the standard deviation calculation, which is used to measure the degree of variation or volatility in target achievement. The risk tolerance and risk limits are obtained using the following formula (8) & (9). This follows the principle of tolerance interval estimation commonly applied in statistical process control [34]:

$$\begin{aligned}
 \text{Risk Tolerance} &= \text{Upper Risk Appetite} + (\text{Upper Risk Appetite} \times \text{upper standar deviation}) \tag{8}
 \end{aligned}$$

$$\begin{aligned}
 \text{Risk Limit} &= \text{Lower Risk Appetite} \times (\text{Lower Risk Appetite} \times \text{lower standar deviation}) \tag{9}
 \end{aligned}$$

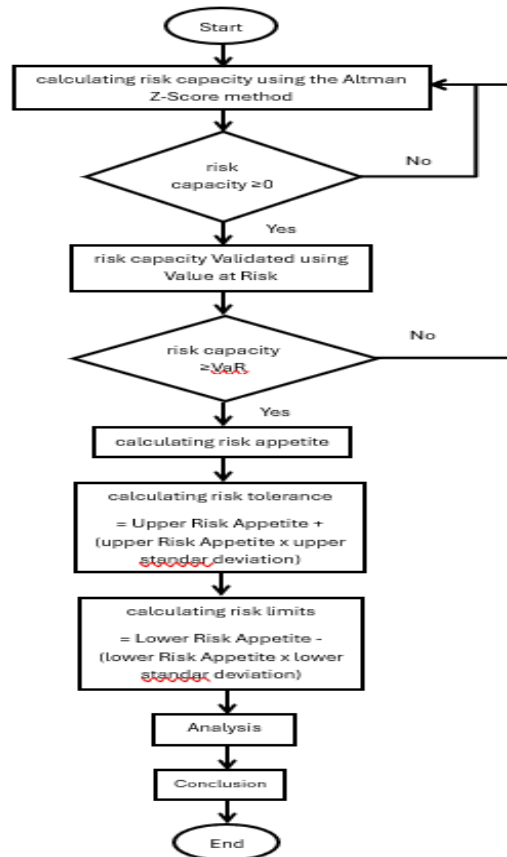


Figure 1. Research Flowchart

3. Results and Discussion

3.1 Financial Statement Analysis

In determining the risk threshold values (risk capacity, risk appetite, risk limit, and risk tolerance), the data used in this study consist of the audited financial statements of a state-owned energy subsidiary for the period 2021–2024. These financial statements have been audited by an external auditor. The following table presents the company's financial statements, comprising the Income Statement and Balance Sheet for the period 2021–2024.

Table 3. Company's income statement (2021-2024)

Description	2021	2022	2023	2024
Revenue	713.851	659.692	804.420	911.552
Operating Expenses	464.639	220.200	173.275	312.188
Operating Profit	249.212	439.492	631.145	599.364
Other Expenses	(483)	2.965	16.237	(5.053)
EBIT	249.695	436.527	614.908	604.417
Income Tax Expense (Benefit)	(5.183)	(96.906)	(155.559)	(132.189)
Net Profit	244.512	339.621	459.349	472.228
EBITDA	35.080	201.480	381.480	656.570

*All figures are presented in billions of Indonesian Rupiah (IDR).

Table 3 presents the income statement data of a state-owned energy subsidiary for the 2021–2024 period. The company's revenue declined by 7.59% in 2022, from IDR 713.85 billion to IDR 659.69 billion; however, it returned to growth in 2023 and 2024, reaching IDR 804.420 billion and IDR 911.5 billion, respectively, with a cumulative growth of 27.69% over the observation period. Operating expenses decreased significantly from IDR 464.6 billion (2021) to IDR 173.3 billion (2023), indicating cost restructuring during this period, before increasing again to IDR 312.2 billion in 2024 in line with operational expansion. EBIT increased from IDR 249.7 billion (2021) to IDR 604.4 billion (2024), with the EBIT-to-total-assets ratio ranging between 44.52% and 55.41%. Net profit grew consistently from IDR 244.5 billion (2021) to IDR 472.2 billion (2024), with the net profit margin increasing from 34.25% to 51.80%. EBITDA recorded the highest growth, rising from IDR 35.08 billion (2021) to IDR 656.6 billion (2024), with the EBITDA margin increasing from 4.91% to 72.02%.

Table 4. Company's balance sheet (2021-2024)

Description	2021	2022	2023	2024
Cash and Cash Equivalents	154.930	329.070	605.201	776.968
Accounts Receivable	59.862	168.232	74.151	76.973
Inventories	64.979	72.690	71.182	67.023
Prepaid Taxes	62.602	46.060	10.293	3.153
Other Current Assets	13.482	15.258	11.067	6.803
Total Current Assets	355.855	631.310	771.894	930.920
Property, Plant, and Equipment	70.005	95.423	209.276	214.472
Deferred Tax Assets	124.807	114.458	78.354	76.718
Other Non-Current Assets	505		50.224	135.588

Description	2021	2022	2023	2024
Long-term Receivables from Employees and Deposits		496		
Total Non-Current Assets	195.317	210.377	337.854	426.778
Total Assets	551.172	841.687	1.109.748	1.357.698
Payables to Related Parties	-	28	-	-
Accounts Payable	588	943	1	21
Unearned Revenue	-	-	8.102	-
Corporate Income Tax Payable	8.431	21.598	40.825	18.801
Other Taxes Payable	1.304	1.320	2.439	845
Total Current Liabilities	62.677	91.484	85.966	66.993
Post-Employment Benefit Liabilities	7.590	10.858	194	960
Total Non-Current Liabilities	7.590	10.858	194	960
Total Liabilities	70.267	102.342	86.160	67.953
Retained Earnings	259.552	517.992	802.235	1.046.443
Number of Shares	237.600	237.600	237.600	225.733
Treasury Shares	(33.816)	(33.816)	(33.816)	
Foreign Currency Translation Adjustment	17.569	17.569	17.569	17.569
Total Equity	480.905	740.454	1.021.008	1.289.780

* All figures are presented in billions of Indonesian Rupiah (IDR).

Tabel 4. presents the balance sheet data of a state-owned energy subsidiary over the same period. Total assets increased from IDR 551.17 billion (2021) to IDR 1.36 trillion (2024), primarily driven by the accumulation of cash and cash equivalents, which rose from IDR 154.9 billion to IDR 776.97 billion, accounting for approximately 57.2% of total assets in 2024. Net working capital increased from IDR 293.2 billion (2021) to IDR 863.9 billion (2024). Total liabilities remained at a low level, ranging from IDR 70.27 billion (2021) to IDR 67.9 billion (2024), and consisted entirely of non-interest-bearing operational liabilities, resulting in a decline in the liabilities-to-total-assets ratio from 12.7% to 5%. Retained earnings increased from IDR 259.5 billion (2021) to IDR 1.046 trillion (2024), with the ratio to total assets rising from 47.09% to 77.07%. Total equity grew from IDR 480.9 billion (2021) to IDR 1.290 trillion (2024). Overall, these financial conditions indicate that the state-owned energy subsidiary has a strong financial foundation, providing a reliable basis for estimating risk capacity.

3.2 Risk Capacity Value Analysis

Predicting corporate bankruptcy is a critical component of financial risk management. Altman Z score [34]. The Altman Z-Score is one of the most widely used financial distress models and has demonstrated considerable effectiveness in assessing corporate bankruptcy risk [35]. Based on the actual calculation of the company's Z-Score from 2021 to 2024 using four parameters according to the existing equation, the company is categorized as healthy with a Z-Score greater than 2.6. Specifically,

the Z-Score values for 2021, 2022, 2023, and 2024 were 8.06, 9.75, 10.33, and 9.63, respectively. Next, a simulation is carried out on the financial report with the assumption that the company incurs risk costs which cause the company's financial condition to be in a high risk of financial distress/bankruptcy and grey area (uncertain result).

The simulation was conducted using the Goal Seek function in Microsoft Excel, with the target Z-Score values set at 2.6, 1.5, and 1.1, representing different levels of financial distress conditions. The simulation was conducted by increasing operating expenses, resulting in a significant decline in Earnings Before Interest and Taxes (EBIT). This scenario caused the X3 variable to become negative, which in turn reduced the overall Z-Score value. The following presents the results of risk capacity calculations using the Altman Z-Score approach under three different scenarios.

Table 5. Summary of company risk capacity under three altman z-score scenarios

Scenario	Z-Score	Description	2021	2022	2023	2024
Grey Area (upper bound)	2.60	Upper limit of safe zone	447.589	895.256	1.276.791	1.420.017
Grey Area (lower bound)	1.50	Financial pressure zone	537.811	1.032.841	1.458.446	1.642.260
Financial distress	1.10	Distress threshold	570.619	1.083.0223	1.524.502	1.723.075

Based on Table 5, it can be observed that the lower the simulated Z-Score value, the greater the resulting risk capacity, as a higher level of loss exposure is required to drive the company toward such a condition. In 2024, the difference between the grey area scenario ($Z = 2,60$) and the financial distress scenario ($Z = 1.10$) reaches approximately IDR 303 billion, representing the financial buffer between a safe condition and a crisis state. The risk exposure value under the financial distress condition, amounting to IDR 1.72 trillion, is interpreted as the risk capacity, namely the maximum level of risk that the company can still absorb before experiencing failure.

However, in Enterprise Risk Management (ERM) practice, companies are not recommended to operate near such extreme thresholds. Therefore, this study sets $Z = 2.60$ as the financial safety threshold, with a corresponding exposure value of IDR 1.42 trillion, as a more conservative operational limit. Compared to other approaches, the Altman Z-Score method is considered the most representative because it integrates liquidity, profitability, and capital structure aspects, thereby providing a more comprehensive reflection of the company's risk capacity.

3.3 Risk Capacity Validation Analysis

The validation of the risk capacity value is conducted by comparing the selected risk capacity with the CVaR value derived from the VaR of risk exposure, which is obtained using the Monte Carlo Simulation method. The simulation uses the company's loss event data for the 2021–2024 period as input. The simulation is executed with 10.000 iterations per run. The following presents the results of simulation runs conducted in this study.

Table 6. CVaR calculation results using monte carlo simulation

CVaR Simulation Results	
VaR 95% (from simulation)	9.523
Min loss (best scenario)	0.92
Max loss (worst scenario)	664.091
Expected Shortfall 95%	29.209
Number of Simulations	10.000

*All figures are expressed in millions of Indonesian Rupiah (IDR).

Based on Table 6, the simulation results show a relatively consistent output, with values of IDR 29.209 billion. Based on these values, all risk capacity values derived from the different approaches significantly exceed the CVaR 95% of the risk exposure. In other words, the company's risk capacity is proven to be sufficient to absorb the maximum potential risk exposure estimated through the Monte Carlo simulation.

Considering all aspects, the Altman Z-Score approach is demonstrated to be the most robust, as it is the only method that simultaneously: (1) is capable of absorbing the entire historical risk exposure across all periods, (2) is multidimensional, incorporating liquidity, profitability, and capital structure components, (3) is derived from operational activities that do not pose potential losses to the state, and. Therefore, the company's risk capacity is defined based on the Altman Z-Score approach, specifically IDR 1.42 trillion in 2024, as the most recent value reflecting the company's maximum ability to absorb losses before entering a state of financial distress.

3.4 Risk Exposure Analysis

The calculation of risk appetite begins with the estimation of risk exposure using the company's risk events. The resulting exposure values are then compared with the risk capacity derived from the Altman Z-Score approach to obtain the percentage of residual exposure relative to risk capacity [2]. The average percentage is used as the lower bound of risk appetite, while the maximum value is used as the upper bound. The use of risk events as the basis for risk exposure estimation is applied due to the unavailability of a sufficiently comprehensive loss event database. This approach enables risk exposure to be estimated in a structured manner while ensuring that the established risk capacity is capable of accommodating the company's risk profile. The results of the risk exposure calculation are presented in the following table.

Table 7. Risk exposure results based on key risk indicator

No	Risk Name	2021	2022	2023	2024
1	HRSG (Steam) Performance Risk	14.764	1.574	387	124
2	Power Plant Performance Risk	546	1.356	1.548	3.140
3	Unabsorbed Bisdev Operating Cost Risk	0	0	0	32.022
4	Taxation Risk	1.890	1	5.337	10.748
5	Budget & Accounting Risk	0	0	0	26.248
6	Risk of Mergers, Acquisitions, Strategic Cooperation and Privatization	0	0	0	59.547
7	Maintenance Risk	73.910	0	0	2.366
Total Risk Exposure		91.111	2.931	7.272	134.483

*All figures are expressed in millions of Indonesian Rupiah (IDR).

Based on Table 7, the company's risk exposure pattern shows a highly uneven distribution across the observed years. In 2021, total risk exposure was relatively high at IDR 91.1 billion; however, it declined significantly during 2022–2023, ranging only between IDR 2.9 billion and IDR 7.3 billion. A sharp increase then occurred in 2024, reaching IDR 134.5 billion. This surge was primarily driven by the emergence of three new risk categories in 2024, namely Unabsorbed Bisdev Operating Cost Risk (IDR 32 billion), Budget & Accounting Risk (IDR 26.2 billion), and the most dominant category, Mergers, Acquisitions, Strategic Cooperation, and Privatization Risk (IDR 59.5 billion). The appearance of these high-value new risk categories in 2024 indicates that the company is undergoing a phase of significant transformation or business expansion, which inherently introduces new dimensions of risk that were previously absent from the company's risk profile.

3.5 Risk Appetite Analysis

The risk appetite value is derived from the Capacity at Risk calculation by determining the ratio between the company's risk capacity and its risk exposure [2]. This ratio is used to quantify the proportion of risk exposure relative to the company's ability to absorb risk [20]. The following presents the results of the risk appetite calculation.

Table 8. Results of risk appetite calculation

No	Year	Historical Risk Exposure (IDR billion)	Risk Capacity (IDR billion)	Residual Exposure to Risk Capacity (%)
1	2021	91.111	656.542	13.88
2	2022	2.931	502.309	0.58
3	2023	7.272	447.589	1.62
4	2024	134.483	895.065	15.02
		Average		7.78
		Maximum		15.02

Based on Table 8 and considering the company's risk profile, the proposed risk appetite is set at a moderate level, ranging from 7.78% to 15.02%. These values represent the average and maximum percentages of residual exposure relative to risk capacity over the 2021–2024 period. The estimated risk capacity was determined through a financial distress simulation employing the Altman Z-Score model, utilizing the company's audited financial statements [7]. In this case, the analysis was based on the company's audited financial statements from two years prior. The establishment of a moderate level reflects a balanced and prudent approach, consistent with the company's growth phase while maintaining profitability. This positioning indicates that the company is neither overly conservative, which could constrain expansion, nor overly aggressive, which could threaten sustainability, but instead operates within a well-managed risk level.

The defined risk appetite implies that the company is willing to accept risk exposure of up to 15.02% of its total risk capacity, corresponding to the upper bound of risk appetite, or approximately IDR 213.4 billion, and 7.78% of total risk capacity, corresponding to the lower bound of risk appetite, or approximately IDR 110.4 billion. This range still provides an adequate safety buffer. In nominal terms, the company's risk appetite lies between IDR 110.4 billion and IDR 213.4 billion, with the 2026 risk capacity amounting to IDR 1.42 trillion

3.6 Risk Tolerance and Risk Limit Analysis

The calculation of the company's risk tolerance and risk limit (corporate level) is based on the standard deviation derived from historical data comparing the long-term plan targets and their actual realizations [20]. This standard deviation is used as the basis for establishing the upper bound (risk tolerance) and the lower bound (risk limit). This approach is selected because deviations between targets and realizations are considered capable of representing performance variability while also reflecting the level of risk faced by the company [36]. Accordingly, the use of standard deviation provides an objective quantitative basis for determining risk boundaries that remain acceptable and controllable by the company. The results of the calculation are presented below.

Table 9. Results of standard deviation of long-term plan targets (RJP) and realization

Metric	Revenue (%)	COGM (%)	Electricity Sales (TWh) (%)	Electricity Sales (GWh) (%)	Steam Production (%)	EAF (%)	Average (%)
% Upper Bound	6.13	15.40	9.72	40.71	29.46	207.68	51.52
% Lower Bound	0.51	-0.34	-0.43	5.73	9.27	38.28	8.84

Based on Table 9, the average percentage values for the upper bound (risk tolerance) and lower bound (risk limit) are obtained and subsequently used to calculate the nominal risk thresholds. The risk tolerance value is calculated by multiplying the upper bound of risk appetite by the upper-bound percentage, whereas the risk limit value is obtained by multiplying the lower bound of risk appetite by the lower-bound percentage. This approach produces risk thresholds that are more measurable and consistent with the company's risk profile. The final results of the risk tolerance and risk limit calculations are presented in the following table.

Table 10. Risk tolerance and risk limit values

Metric	Risk Appetite (IDR billion)	Standard Deviation (%)	Result (IDR billion)
Risk Tolerance	213.356	51.52	323.274
Risk Limit	110.444	8.84	100.684

Based on Table 10, the Risk Tolerance value of IDR 323.3 billion is obtained by multiplying the upper bound of Risk Appetite (IDR 213.4 billion) by the upper-bound standard deviation percentage (51.52%). This value represents the maximum threshold of risk deviation that can still be tolerated by the company before requiring escalation or intervention from top management. Proportionally, the Risk Tolerance value of IDR 323.3 billion is equivalent to approximately 23% of the total Risk Capacity (IDR 1.42 trillion). This indicates that the company allows a tolerance margin of up to 23% of its maximum risk-bearing capacity.

Furthermore, the Risk Limit value of IDR 100.7 billion is derived from multiplying the lower bound of Risk Appetite (IDR 110.4 billion) by the lower-bound standard deviation percentage (8.84%). This value represents an early warning threshold at which management is required to conduct a thorough review of the risk position and the effectiveness of implemented mitigation measures. The relatively wide gap between the Risk Limit (IDR 100.7 billion) and the Risk Tolerance (IDR 323.3 billion) creates a broad alert zone, with a difference of approximately IDR 222.6 billion. This zone provides sufficient room for management to carry out gradual interventions before risk exposure

reaches the upper tolerance boundary, enabling mitigation actions to be planned and executed in a controlled rather than reactive manner [37].

4. Conclusion

The 2026 Risk Capacity estimated using the Altman Z-Score approach was sufficient to absorb the company's historical risk exposure throughout the 2021–2024 period. The estimated risk capacity exhibited a positive growth trend over the years, reaching IDR 1.42 trillion in 2024. Validation was conducted using Monte Carlo Simulation, which produced a 95% CVaR of IDR 29.209 billion. These results indicate the potential impact of a single risk event could reach IDR 29.209 billion. This approaches also exceeded the highest historical risk exposure value, which occurred in 2024, of IDR 134.48 billion, thus meeting the nominal parameter acceptance criteria. The Altman Z-Score approach was omprehensive and representative approach because it met all criteria for consideration components, including current liabilities, non-current liabilities, profitability, liquidity, and capital aspects.

Based on the established risk capacity, the company's risk appetite is set at a moderate level, ranging from 7.78% to 15.02% of its risk capacity, which is nominally equivalent to IDR 110.444 billion to IDR 213.356 billion. This moderate level is considered appropriate considering the company's growth phase, which requires a balance between risk acceptance and financial prudence. Furthermore, the Risk Tolerance is set at IDR 323.274 billion (equivalent to 23% of its risk capacity), and the Risk Limit is set at IDR 100.444 billion, creating a caution zone of IDR 222.589 billion, allowing for gradual and planned management intervention.

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