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Financial Analysis of 10MW Reserve Margin Bergerak (RMB) Provision in Island Power Systems Using LCT Platform

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Abstract: *This study offers a thorough financial and risk analysis of a Reserve Margin Bergerak power plant system installed on Landing Craft Tank (LCT) platforms, aimed at improving energy security in Indonesia's remote and archipelagic areas. The total capital expenditure (CAPEX), which is IDR 77.74 billion including taxes, mainly covers engine generators and associated electrical infrastructure. The project's economic viability is assessed using Net Present Value (NPV) and Internal Rate of Return (IRR) under a fixed tariff structure, with a minimum IRR threshold of 8.24%. Sensitivity tests show that the project's success is highly affected by changes in CAPEX but less influenced by operational expenditure (OPEX) variations. A 10% increase in CAPEX drops the IRR to the viability limit, while a 30% cost reduction greatly improves returns. Changes in operational costs have little effect on IRR but slightly boost NPV. Following ISO 31000:2018 standards, risk analysis highlights critical operational risks including design mismatches, tariff inefficiencies, and low LCT utilisation all of which can be addressed through targeted technical reviews, tariff reforms, and deployment strategies. These results emphasise the importance of controlling investment costs and implementing structured risk management to ensure the long-term viability and financial appeal of mobile energy projects.*

Keywords: *RMB; CAPEX sensitivity; IRR; NPV; LCT platform; Archipelagic energy system*

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INTRODUCTION

Indonesia's electricity system requires adequate reserve capacity to maintain supply reliability during peak demand, generation outages, and other unexpected system disturbances. Reserve margin is an important indicator of generation adequacy because it represents the available generation capacity above peak demand. According to the Directorate General of Electricity, the national reserve margin reached 39.32% in 2024, exceeding the commonly applied ideal level of approximately 30%. However, the national reserve margin does not necessarily represent the condition of individual regional power systems. In 2024, for example, the reserve margin of the West Kalimantan system was approximately 10%, while the Kalseltengtimra system reached approximately 41%. Other regional systems also recorded relatively low reserve margins, including Sulbagsel at 2%, Sumbawa-Bima at 1%, and Flores at 3%. These differences indicate that reserve adequacy varies considerably among regional power systems and that some systems may require additional flexible generation resources despite adequate national-level reserve capacity (Direktorat Jenderal Ketenagalistrikan, 2024).

This regional variation is particularly important in Indonesia because its electricity system consists of geographically dispersed interconnected and isolated systems. Remote and archipelagic areas may face additional constraints associated with geographical separation, limited infrastructure, accessibility, and relatively high transportation and logistics costs. The 2025–2034 Electricity Supply Business Plan (RUPTL) continues to emphasize generation adequacy and reserve margin as important components of electricity system reliability. The plan targets a national reserve margin of at least 34% by 2034 while also providing for substantial generation and transmission development across Indonesia. For the Kalseltengtimra system, which covers South Kalimantan, Central Kalimantan, East Kalimantan, and North Kalimantan, the projected reserve margin varies according to the development of generation capacity and electricity demand during the planning period (PT. PLN (Persero), 2025). These conditions indicate that maintaining adequate reserve capacity requires not only long-term generation expansion but also flexible resources capable of responding to temporary changes in system requirements.

Temporary generation deficits may occur due to generator outages, scheduled maintenance, delays in the commissioning of new generation facilities, unexpected demand growth, or transmission constraints. Conventional approaches to addressing such deficits generally involve the construction or expansion of permanent generation facilities. However, permanent generation development requires substantial capital investment, a relatively long development period, and adequate supporting infrastructure. For isolated or geographically dispersed systems, these requirements may become more challenging because the additional generation capacity must be developed at or near the location where the shortage occurs. Therefore, a mobile reserve generation resource that can be transported between locations according to operational requirements may provide an alternative approach for improving system flexibility and supply reliability.

The use of mobile power sources (MPSs) has increasingly been investigated as a means of improving power system resilience and restoring electricity supply during disturbances. (Li et al., 2022) proposed a resilient outage recovery approach that coordinates mobile power sources with distribution network reconfiguration to improve restoration performance while considering dispatching costs. Their results demonstrate that mobile generation can provide additional flexibility when conventional network restoration resources are insufficient. Similarly, (Fan et al., 2024) developed a pre-allocation and dispatch strategy for mobile power sources in a coupled power-transportation network. Their study considered not only the electrical operation of mobile generation but also investment costs, transportation requirements, and fuel costs. These findings indicate that the effectiveness of mobile generation depends not only on the available generation capacity but also on transportation characteristics, deployment costs, fuel consumption, and resource utilization.

For an archipelagic country such as Indonesia, the transportation component is particularly important in determining the practicality of mobile reserve generation. Generator sets deployed between islands or remote coastal locations may require considerable mobilization time, loading and unloading activities, and additional transportation expenditure. Conventional transportation arrangements may also require cranes or other heavy lifting equipment, which can increase both deployment time and operational costs. Consequently, the provision of mobile reserve capacity should be evaluated not only from the perspective of electrical generation capability but also from the perspective of logistics, transportation, utilization, and financial feasibility.

One potential solution is the utilization of a Landing Craft Tank (LCT) as a maritime platform for transporting mobile generator sets and associated electrical equipment. LCT vessels are capable of transporting heavy equipment and can access coastal areas where conventional port infrastructure may be limited. In addition, the use of wheel-mounted generator sets can facilitate loading, unloading, and positioning activities and potentially reduce dependence on heavy lifting equipment during deployment. The combination of an LCT platform and mobile generator sets therefore provides flexibility for relocating reserve generation capacity to locations experiencing temporary generation shortages. Nevertheless, the economic feasibility of this configuration depends on the relationship between the initial capital expenditure (CAPEX), operating expenditure (OPEX), revenue structure, transportation requirements, utilization rate, and operational risks.

Previous studies have examined reserve margin from various perspectives, including demand response, transmission reinforcement, renewable generation uncertainty, reserve requirement determination, and generation adequacy. (Nacharoenkul & Chaitusaney, 2017) examined the benefits of demand response in relation to reserve margin requirements, while (Otsubo et al., 2014) investigated the economic evaluation of transmission reinforcement considering power supply reserve margin. (Hedayati-Mehdiabadi et al., 2018) examined reserve margin requirements under increasing uncertainty associated with wind generation, while (Subramanyam & Zhang, 2020 investigated the effect of reserve uncertainty on operating reserve demand. (Chongphipatmongkol & Audomvongseree, 2018) further examined reserve margin determination based on Loss of Load Expectation (LOLE). These studies provide an important foundation for understanding reserve adequacy and reliability; however, their primary focus is on reserve planning, interconnected power systems, demand response, or electricity market mechanisms.

More recent research has shifted attention toward mobile power resources, particularly for resilience and emergency restoration. (Fan et al., 2024; Li et al., 2022) highlighted the operational value of mobile generation and the importance of integrating electrical and transportation considerations. However, these studies primarily focus on operational optimization, outage restoration, and mobile resource dispatch. Meanwhile, research concerning the financial feasibility of mobile reserve generation that combines transportable generating units with a maritime transportation platform remains limited. In particular, the combined effects of CAPEX, OPEX, utilization of the mobile platform, transportation requirements, and operational risks have not been sufficiently evaluated for an archipelagic electricity system such as Indonesia.

This study addresses this research gap by evaluating a 10 MW Reserve Margin Bergerak (RMB) system using an LCT platform and wheel-mounted generator sets for an archipelagic electricity system in Indonesia. Unlike conventional reserve margin studies that primarily assess generation adequacy within a fixed power system, this study considers reserve capacity as a mobile asset that can be relocated according to operational requirements. The proposed approach integrates the financial characteristics of the generating system with the logistical characteristics of maritime transportation. Therefore, the study considers not only the economic feasibility of the generation investment but also the operational risks associated with the deployment and utilization of the LCT platform.

The objective of this study is to assess the financial feasibility and operational risks associated with the provision of a 10 MW Reserve Margin Bergerak using an LCT platform. The financial assessment employs Net Present Value (NPV), Internal Rate of Return (IRR), and sensitivity analysis to evaluate the effects of changes in investment and operating costs on project feasibility (Bhagya, 2016). The risk assessment identifies major operational and logistical risks, including design non-conformity, tariff scheme issues, and low LCT utilization. By integrating financial and risk assessments, this study aims to provide a practical basis for evaluating the economic feasibility, operational resilience, and sustainability of mobile reserve generation for remote and archipelagic electricity systems in Indonesia.

METHOD

Technology and Equipment Specifications

Figure 1 schematically illustrates the equipment used in the proposed Reserve Margin Bergerak system. To ensure reliable reserve power deployment, the mobile step-up transformer system was designed in two capacity options to accommodate different field requirements and synchronize with the installed generation capacity. The Landing Craft Tank (LCT) serves as a versatile transportation platform with a carrying capacity of 500 tons, a maximum draft of 3.1 m, and is powered by B30 biodiesel or High-Speed Diesel (HSD) fuel. Its primary functions include transporting containers, heavy equipment, and serving as temporary storage for water or diesel fuel. The vessel is operated by a crew of 14 personnel.

The mobile generator system is available in three capacity configurations, consisting of four 1,500 kVA units, nine 1,000 kVA units, and two 500 kVA units, to accommodate various power requirements at deployment sites. To transport generator sets, transformers, and supporting equipment, transport trucks are positioned on the LCT to facilitate the movement and placement of containerized equipment. In addition, a mobile crane with a lifting capacity of 25 tons and an operating reach of approximately 3 m is provided to support loading and unloading activities. The 1,000 DWT Landing Craft Tank (LCT) is a multipurpose vessel specifically designed to support heavy logistics operations in archipelagic and coastal regions. It is capable of carrying up to 500 tons of cargo and has a maximum draft of 3.1 m, allowing it to dock at small ports or simple jetties with limited water depth.

Figure 1. Schematic diagram of the equipment

The LCT operates using B30 biodiesel or High-Speed Diesel (HSD), which are commonly used fuels for medium- to large-sized marine engines. An illustration of the LCT is presented in Figure 2. With its ability to transport heavy loads and operate in shallow waters, the 1,000 DWT LCT is highly suitable for supporting a 10 MW Reserve Margin Bergerak system, particularly within Indonesia's archipelagic power systems.

Figure 2. Landing Craft Tank (LCT)

Case Study / Study Area

The 3T regions, an abbreviation for Frontier, Outermost, and Underdeveloped Areas, refer to regions identified by the Government of Indonesia as having significant geographical, social, and economic challenges. These areas are characterized by remote locations, limited accessibility, low population density, and inadequate basic infrastructure, including roads, electricity, and clean water (PERPRES No. 63, 2020). Consequently, they face substantial obstacles in development, particularly in ensuring a reliable electricity supply. The archipelagic regions considered in this study under the Reserve Margin Bergerak 1 (RMB1) program include West Kalimantan, East Kalimantan, South Kalimantan, Central Kalimantan, and North Kalimantan, as illustrated in Figure 3. These provinces consist of extensive coastlines, numerous small islands, and remote locations that are not yet fully integrated into the national electricity grid.

As a result, many power systems remain isolated and rely heavily on small local generating units. Simultaneously, the expansion of industrial activities, coastal economic zones, and strategic national projects, including the development of Indonesia's new capital city (IKN) in East Kalimantan, continues to increase electricity demand. Therefore, the deployment of a 10 MW Reserve Margin Bergerak utilizing an LCT platform is considered an appropriate solution to overcome system isolation while maintaining a reliable electricity supply throughout these regions (PT. PLN (Persero), 2025).

Figure 3. Round-trip route of the LCT (RMB1)

Financial Analysis Method

The financial feasibility of the proposed 10 MW Reserve Margin Bergerak (RMB) system was evaluated using a cash flow approach based on the initial capital expenditure and projected net cash flows during the operating period. The analysis considers the time value of money and evaluates the investment using Net Present Value (NPV) and Internal Rate of Return (IRR). The baseline financial model uses a total capital expenditure (CAPEX) of IDR 77.74 billion, including 11% Value Added Tax (VAT), a discount rate of 6.24%, and a minimum acceptable IRR of 8.24%.

Cash Flow Model

The financial model considers the initial investment as a cash outflow at period 0, while the subsequent operating periods generate net cash flows from the provision of reserve power after accounting for the applicable operating expenditures. The net cash flow in each operating period is discounted to its present value using the applicable discount rate. The resulting discounted cash flows are then used to determine the project's NPV and IRR.

The net cash flow in period (t) can generally be expressed as:

$$Ct = Rt - OPEXt \quad (1)$$

Where:

Ct = Net cash inflow during period (t)

Rt = Revenue generated in period (t)

OPEXt = Operating expenditure in period (t)

The initial investment, represented by (C_0), is recorded as a cash outflow at period 0. This structure enables the financial model to evaluate the relationship between the initial investment and the future operating cash flows of the proposed RMB system.

Net Present Value (NPV)

Net Present Value (NPV) is used to determine the present economic value of the investment by comparing the initial investment with the present value of future net cash flows. The NPV is calculated using the following equation:

$$NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t} - C_o \tag{2}$$

Where:
NPV = Net Present Value
Ct = Net cash inflow during period (t)
C_0 = Initial investment (cash outflow at time zero)
r = Discount rate (required rate of return)
t = Time period (Year 1, 2, ..., n)
n = Total number of periods

A positive NPV indicates that the present value of the project's future cash flows exceeds the initial investment at the applied discount rate, indicating financial feasibility. Conversely, a negative NPV indicates that the project does not generate sufficient economic value to recover the initial investment at the applied discount rate.

Internal Rate of Return (IRR)

Internal Rate of Return (IRR) represents the discount rate at which the project's NPV equals zero. IRR is used to determine whether the expected return from the investment exceeds the minimum acceptable return. The IRR is determined from the following equation:

$$0 = \frac{C_0}{(1+IRR)^0} + \frac{C_1}{(1+IRR)^1} + \frac{C_2}{(1+IRR)^2} + \cdots + \frac{C_n}{(1+IRR)^n} \tag{3}$$

The project is considered financially feasible when the calculated IRR exceeds the minimum target IRR of 8.24%. In the baseline scenario, the proposed project produces an IRR of 10.73%, which is above the minimum acceptable threshold.

Financial Assumptions

The total CAPEX of IDR 77.74 billion represents the initial investment required for the proposed RMB system, including VAT. The discount rate of 6.24% is adopted as the financial evaluation assumption representing the required return used in PLN-related investment assessment. This rate represents the required return used to discount future cash flows and evaluate investment feasibility. While an IRR of 8.24% is used as the minimum investment feasibility threshold. Under the baseline scenario, the calculated NPV is IDR 23.724 billion and the IRR is 10.73%, indicating that the proposed project is financially feasible because the NPV is positive and the IRR exceeds the minimum target.

Table 1. Baseline Financial Assumptions

Parameter	Value
RMB capacity	10 MW
Total CAPEX	IDR 77.74 billion
VAT	11%
Discount rate	6.24%
Minimum target IRR	8.24%
Baseline NPV	IDR 23.724 billion
Baseline IRR	10.73%

The financial model uses a fixed tariff structure for the provision of reserve power. Project revenues are calculated based on the applicable reserve power tariff and the assumed operating or availability period of the RMB system. Operating expenditure includes the costs associated with generator operation, fuel consumption, maintenance, LCT operation, and other supporting activities. The annual net cash flow is subsequently determined as the difference between project revenue and operating expenditure.

The discount rate of 6.24% is adopted as the financial evaluation rate in the baseline scenario based on the internal Weighted Average Cost of Capital (WACC) assumption applied in PLN project financial assessments. This rate represents the required return used to discount future cash flows and evaluate the economic feasibility of the proposed Reserve Margin Bergerak (RMB) system. The minimum acceptable IRR of 8.24% is applied as the investment feasibility threshold to determine whether the project provides an adequate return compared with the required rate of return.

Sensitivity Analysis

Sensitivity analysis was performed to evaluate the robustness of the project's financial feasibility against changes in investment and operating costs. The analysis varies CAPEX and OPEX while maintaining the other baseline parameters constant. Four sensitivity scenarios were evaluated: an increase in CAPEX, a reduction in CAPEX, an increase in OPEX, and a reduction in OPEX.

The CAPEX sensitivity analysis evaluates changes ranging from 0% to +30% and from 0% to −30%. Similarly, the OPEX sensitivity analysis evaluates changes ranging from 0% to +30% and from 0% to −30%. The resulting changes in NPV and IRR are compared with the baseline values of IDR 23.724 billion and 10.73%, respectively. This sensitivity approach is used to identify the extent to which changes in investment and operating costs affect project feasibility and to determine which cost component has the greatest influence on the financial performance of the proposed RMB system.

Risk Assessment

Risk assessment was conducted to identify and evaluate the operational and logistical risks associated with the proposed RMB system. The assessment follows the principles of ISO 31000:2018, covering risk identification, risk evaluation, and risk treatment. The identified risks were assessed based on their current residual risk level, target risk level after mitigation, and the proposed Risk Mitigation Plan (RMP). The assessment focuses on three major risks: design non-conformity, tariff or service scheme issues, and low LCT utilization.

RESULT AND DISCUSSION

Financial Analysis

Figure 4 presents the percentage distribution of the Capital Expenditure (CAPEX) for the proposed 10 MW LCT-based Reserve Margin Bergerak (RMB) system.

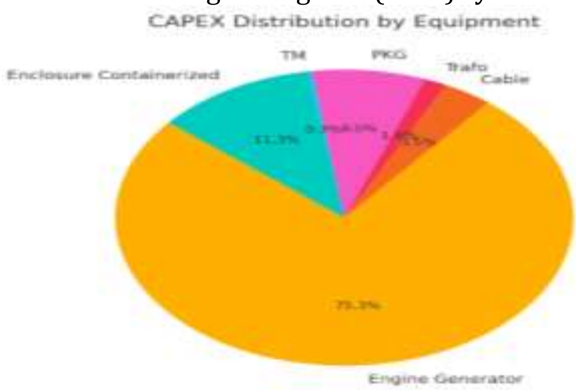

Figure 4. Capital Expenditure (CAPEX) Percentage Distribution

The total capital expenditure (CAPEX) of the proposed power generation system amounts to IDR 77.74 billion, including 11% Value Added Tax (VAT). As illustrated in Figure 4, the engine generators account for the largest investment component, representing approximately 75.3% of the total CAPEX, highlighting the dominant contribution of the generating units to the overall mobile power plant investment. The remaining investment consists of the containerized enclosure (11.3%), PKG (8.0%), cables (3.5%), transformers (1.6%), and medium-voltage equipment (0.3%).

This distribution indicates that although engine generators require the highest capital investment, supporting components also contribute significantly to the overall project cost, particularly in ensuring mobility, operational safety, and deployment readiness. Sensitivity analysis is widely applied in energy infrastructure investment assessment because project feasibility is strongly affected by uncertainties in capital expenditure, financing conditions, operational parameters, and market assumptions (Karamoozian et al., 2022; Polzin et al., 2021).

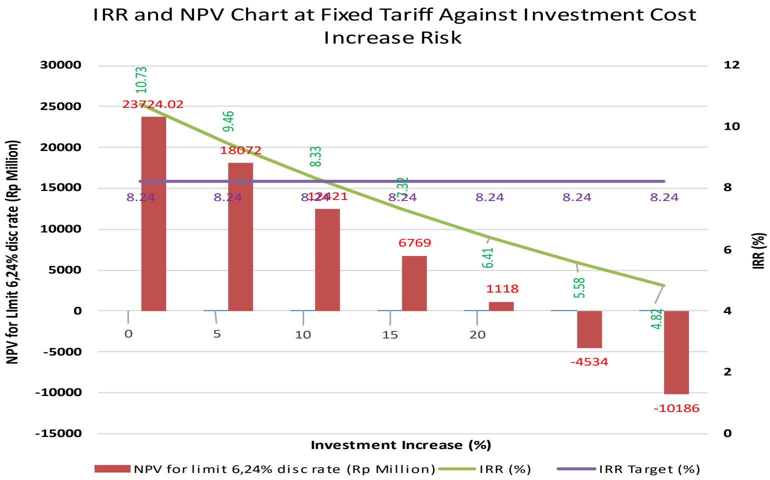

Figure 5. First Sensitivity Analysis

Figure 5 illustrates the sensitivity of the project's two principal financial indicators, namely Net Present Value (NPV) and Internal Rate of Return (IRR), to increases in investment costs under a fixed tariff scheme. The analysis adopts a discount rate of 6.24% and a minimum acceptable IRR (target IRR) of 8.24%. The results demonstrate that increasing investment costs from 0% to 30% leads to a continuous decline in both NPV and IRR. Under the baseline scenario (0% increase), the project generates an NPV of IDR 23,724 million and an IRR of 10.73%, indicating strong financial feasibility.

When investment costs increase by 10%, the IRR declines to 8.24%, which represents the minimum acceptable threshold for project feasibility. Further increases in investment costs, reaching 30%, reduce the IRR to 3.78%, while the NPV becomes negative at IDR −10,186 million, indicating that the project is no longer economically viable. These findings demonstrate that the project is highly sensitive to increases in capital investment. The IRR declines rapidly, particularly once investment costs exceed 15%, at which point the NPV approaches zero. This substantial reduction in IRR reflects the project's strong dependence on efficient CAPEX management because IRR is significantly influenced by the initial investment cost, particularly in fixed-tariff energy projects.

Similar findings have been reported in energy investment studies, where capital cost escalation significantly reduces project attractiveness due to increased initial investment burden (Polzin et al., 2021). Since project revenues remain fixed while initial capital costs directly influence future cash flows, fluctuations in investment expenditure substantially affect project feasibility. Similarly, (De Albornoz et al., 2018) stated that an IRR below the target return indicates that an investment is no longer financially attractive and therefore serves as a negative indicator for potential investors. Furthermore, (Wolff & Nieße, 2023) emphasized that large-scale energy projects operating under fixed tariff schemes require strict cost control during both planning and construction phases, as any cost overrun may significantly reduce project profitability.

Figure 6 illustrates the sensitivity of Net Present Value (NPV) and Internal Rate of Return (IRR) to reductions in investment costs under a fixed tariff scheme. The analysis employs a 6.24% discount rate, corresponding to the project's Weighted Average Cost of Capital (WACC), while maintaining an IRR target of 8.24% as the minimum investment criterion. Overall, the results demonstrate that reducing investment costs from 0% to −30% substantially improves both financial indicators. The NPV increases from IDR 23,724 million to IDR 57,634 million, while the IRR rises from 10.73% to 25.12%.

This trend indicates a strong positive relationship between reductions in capital expenditure and improvements in project economic feasibility. Similar findings have shown that capital costs and the cost of capital can substantially influence the economic performance and investment attractiveness of energy projects (Polzin et al., 2021). Throughout all simulated scenarios, the project remains financially feasible because the IRR consistently exceeds the minimum target of 8.24%. Even a relatively modest 5% reduction in investment costs results in an IRR of 12.18% and an NPV of IDR 29,376 million, providing a comfortable profitability margin for investors.

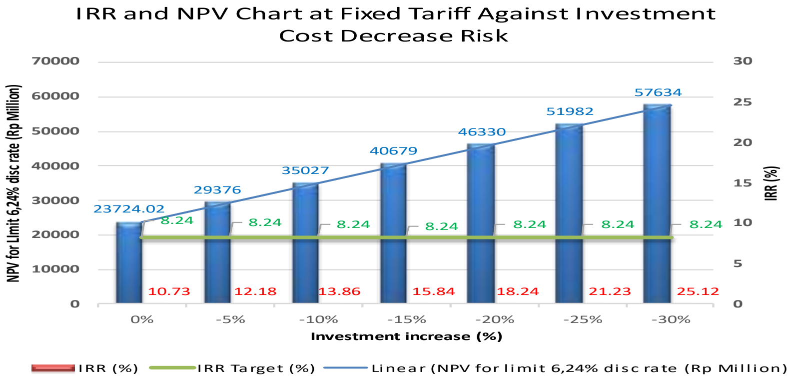

Figure 6. Second Sensitivity Analysis

These findings agree with (Polzin et al., 2021), who concluded that reducing capital costs has a greater positive effect on IRR than increasing electricity tariff revenues, particularly for projects operating under fixed-cost structures. Consequently, investment cost optimization should be considered during the earliest stages of project planning. Strategies such as value engineering, procurement optimization, and fiscal incentives capable of reducing initial capital expenditure can substantially improve project attractiveness while accelerating investment decisions. Overall, these results indicate that the proposed project demonstrates strong resilience to reductions in capital costs and offers significantly improved economic returns when investment efficiency is enhanced.

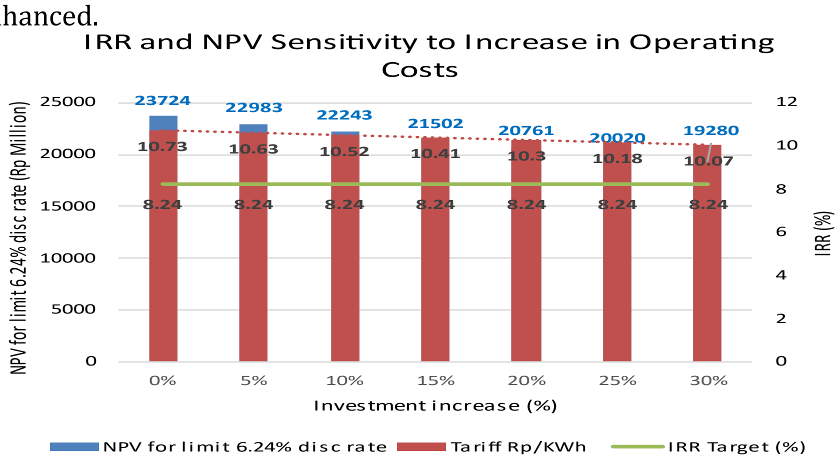

Figure 7. Third Sensitivity Analysis

Figure 7 illustrates the influence of increasing operating costs on the project's financial feasibility indicators, namely Net Present Value (NPV) and Internal Rate of Return (IRR), under a fixed tariff scheme with a 6.24% discount rate. The minimum acceptable IRR is maintained at 8.24%. The results show that increasing OPEX from 0% to 10% reduces the IRR from 10.73% to 10.52%, while a 30% increase in OPEX further reduces the IRR to 10.07%. Over the same range, the NPV decreases from IDR 23,724 million to IDR 19,280 million. Although higher operating costs reduce the project's economic value, the effect on IRR remains relatively limited, as the IRR remains above the minimum target of 8.24% even under the 30% OPEX increase scenario.

These results indicate that the proposed project has relatively strong financial resilience to increases in operating costs. Compared with the CAPEX sensitivity analysis, the change in IRR resulting from OPEX variation is considerably smaller. This indicates that the project's financial feasibility is more sensitive to changes in initial investment costs than to changes in annual operating expenditure. Nevertheless, the decline in NPV demonstrates that sustained increases in OPEX can reduce the economic value generated by the project. Therefore, operational efficiency, particularly in fuel consumption, maintenance, and supporting activities, remains important for maintaining long term project performance (Internasional Energy Agency, 2023; O'Connor et al., 2013).

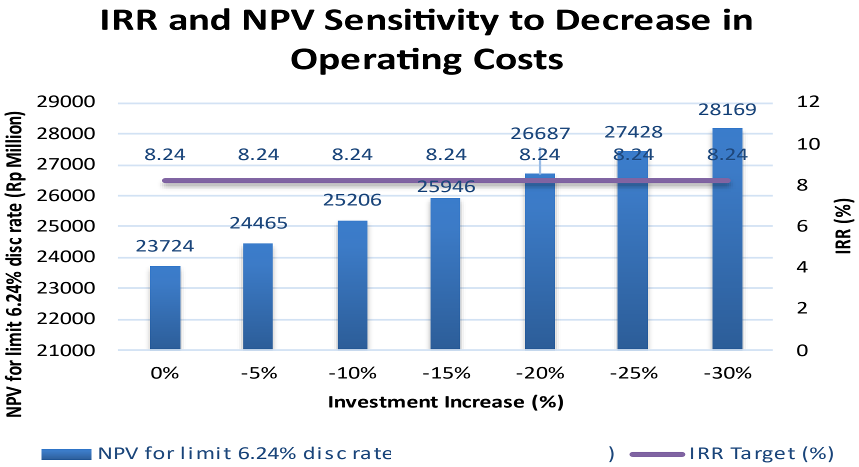

Figure 8. Fourth Sensitivity Analysis

Figure 8 presents the sensitivity of the project's Net Present Value (NPV) to reductions in operating costs under the baseline financial scenario with a discount rate of 6.24%. The analysis evaluates operating cost reductions ranging from 0% to −30% while maintaining other financial assumptions constant. The results show that the NPV increases progressively from IDR 23,724 million at the baseline scenario to IDR 28,169 million at a 30% reduction in operating costs. These results indicate that operational cost efficiency contributes positively to the project's economic value by improving future net cash flows.

The increase in NPV resulting from improved operational efficiency represents a favourable outcome for project owners, particularly from a long-term economic perspective. Continuous reductions in operating costs can improve cash flow performance and enhance the overall economic value of the project.

Risk Analysis

Risk assessment in maritime logistics, particularly for Landing Craft Tank (LCT) fleets, is essential to ensure operational continuity and cost efficiency. In addition to logistical risks, maintaining sufficient operating reserve capacity is critical for ensuring electricity system adequacy. Insufficient reserve availability may increase the risk of supply interruption, especially during unexpected generation outages or demand fluctuations (Subramanyam & Zhang, 2020).

Table 3 identifies three primary risk categories, namely design non-conformity, tariff scheme issues, and low LCT utilization. Each risk was assessed using a semi-quantitative risk matrix approach based on likelihood of occurrence and potential impact. The likelihood and impact values were assigned using a 1–5 scale, where higher values represent greater probability and consequence severity. The risk score was calculated by multiplying the likelihood and impact values to determine the current residual risk level and the target risk level after mitigation.

Table 2. Probability and Impact Scales

Score	Probability	Impact
1	Rare	Insignificant
2	Unlikely	Minor
3	Possible	Moderate
4	Likely	Major
5	Almost Certain	Severe

Table 3. Risk Assessment

Risk ID	Risk Description	Proba-bility	Impact	Risk Score	Current Risk Level (Residual Risk)	Target Risk Level (After Mitigation)	Main Risk Causes	Risk Mitigation Plan (RMP)
1	Design non-conformity	4	5	20	High	Low to Medium	**P1.** Varying maritime conditions. **P2.** LCT load exceeds capacity. **P3.** LCT has exceeded its operational service life.	Conduct technical design reviews, specification studies, and maritime condition assessments during KKP planning (P1, P2, P3).
2	Tariff Scheme Issues	3	4	12	Medium to High	Medium	**P1.** Machine operation differs from the planned schedule. **P2.** Delayed maintenance. **P3.** Limited standby machine capacity.	1. Implement fixed and variable cost payment schemes (P1). 2. Conduct routine coordination with related units for ROT and ROB planning (P2).
3	Low LCT Utilization	4	4	16	High	Low to Medium	**P1.** Excessive standby days. **P2.** Limited LCT sailing frequency adjusted to operational	1. Optimize LCT deployment schedules according to actual operational requirements (P1, P2).

			requirements.	2. Conduct routine coordination to maximize operational LCT utilization (P1, P2).

Based on the risk score obtained from the likelihood-impact matrix, higher scores indicate higher risk priority and require more intensive mitigation actions. The mitigation strategies are designed to reduce both the likelihood and impact of each identified risk, thereby improving the operational resilience of the RMB system.

The first risk, design non conformity, is classified as High due to variations in water conditions, overloading beyond the LCT's carrying capacity, and vessel age exceeding its operational service life. The loading condition and vessel operating environment are important considerations in assessing LCT operational safety and performance. To reduce this risk to Low or Medium, detailed technical studies are recommended, including design verification, vessel specification reviews, and adjustments to water conditions during the Project Planning Framework (KKP) stage.

The second risk concerns the tariff scheme for reserve power provision, which is classified as Medium to High because of delays in generator commissioning, inadequate maintenance scheduling, and limited backup generating capacity. The proposed Risk Mitigation Plan (RMP) includes implementing a combination of fixed and variable payment schemes, together with improved coordination among operational units to ensure LCT readiness, thereby reducing the risk to a Medium level.

The third risk, low LCT utilization, is classified as High due to extended standby periods and travel restrictions. The proposed mitigation strategy focuses on improving operational efficiency by optimizing voyage schedules according to actual field requirements, thereby reducing the risk to Low or Medium. This risk assessment follows the principles of ISO 31000:2018 – Risk Management Guidelines (ISO 31000, 2018), which emphasize systematic risk identification, evaluation, and treatment within an organizational context. Applying this internationally recognized framework provides a robust basis for risk-informed decision-making while improving operational resilience in complex and dynamic environments.

Practical Implications on Occupational Health, Safety, and Environmental (OHSE)

a. Based on the identified operational risks, the implementation of Occupational Health, Safety, and Environmental (OHSE) practices in the operation and deployment of the Reserve Margin Bergerak (RMB) system for isolated diesel power plants (PLTD) becomes an important mitigation measure to ensure personnel safety, operational reliability, and environmental protection.
b. Occupational safety is supported through Job Safety Analysis (JSA), Work Permit (WP) procedures, safety briefings, and the mandatory use of complete Personal Protective Equipment (PPE) to support the achievement of a Zero Accident target (ISO 45001, 2018).
c. Occupational health measures include shift scheduling, periodic medical examinations, and mitigation of noise and high-temperature exposure to maintain personnel health and productivity.
d. Environmental protection is implemented through proper hazardous waste (B3) management, prevention of biodiesel fuel spills using oil trap systems, and the utilization of biodiesel fuel to reduce exhaust gas emissions.

e. The implementation of OHSE reflects the company's commitment to Environmental, Social, and Governance (ESG) principles in supporting safe, reliable, and environmentally sustainable power generation operations.

Practical Implications on Engineering Ethics

The practical implications of engineering ethics in the provision of the Reserve Margin Bergerak (RMB) system for isolated power systems are reflected through the prioritization of public safety, professional integrity, environmental sustainability, and continuous engineering competency development (National Society of Professional Engineers, 2019). All activities, including planning, mobilization, construction, and power plant operation, have been conducted through risk-based engineering decision-making in accordance with applicable occupational safety standards and national electricity regulations to ensure system reliability while minimizing operational disturbances and workplace accidents.

Furthermore, all technical decisions have been made objectively, transparently, and based on actual field data as part of the implementation of the Code of Ethics of the Institution of Engineers Indonesia (PII) and the principles of responsible engineering practice. Engineering professionalism is also reflected through the consistent implementation of technical standards, multidisciplinary collaboration, and accountability in reporting power plant performance and operational achievements.

The adoption of biodiesel fuel and continuous efforts to improve system efficiency demonstrate the engineers' commitment to sustainability and environmental preservation. Consequently, the implementation of the Reserve Margin Bergerak (RMB) not only enhances the reliability of isolated power systems but also represents the practical application of engineering ethics and professionalism in supporting the provision of reliable, safe, and sustainable electrical energy for society.

CONCLUSIONS

This study demonstrates that the financial feasibility of implementing a 10 MW Reserve Margin Bergerak (RMB) power generation system using a Landing Craft Tank (LCT) platform primarily depends on efficient capital expenditure (CAPEX) management. Of the total investment of IDR 77.74 billion, the largest proportion is allocated to engine generators and supporting electrical infrastructure. The sensitivity analysis indicates that the Internal Rate of Return (IRR) is highly sensitive to changes in CAPEX. A 30% reduction in investment costs substantially improves project profitability, whereas a 10% increase in CAPEX reduces the IRR to the minimum acceptable feasibility threshold of 8.24%. In contrast, variations in operating expenditure (OPEX) have only a limited effect on IRR but significantly influence the project's Net Present Value (NPV), emphasizing the importance of optimizing initial investment costs. The risk assessment identifies three major risks, namely design non-conformity, tariff scheme inefficiency, and low LCT utilization, which are classified as High or Medium-to-High. These risks can be addressed through design validation, improvements in cost allocation mechanisms, and enhanced operational scheduling coordination. Furthermore, the implementation of ISO 31000:2018 provides a systematic framework for risk management, thereby improving the resilience and long-term sustainability of mobile power generation projects in remote and archipelagic regions.

This study has several limitations that should be considered. The financial evaluation was conducted based on a fixed tariff structure, predefined operational assumptions, and predefined financial parameters. Therefore, variations in future fuel prices, tariff adjustments, and dynamic operational conditions were not fully considered in the current analysis. Future research may incorporate dynamic tariff scenarios, fuel price uncertainty analysis, and optimization of LCT deployment strategies to provide a more comprehensive evaluation of the long-term feasibility and operational performance of the Reserve Margin Bergerak (RMB) system.

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