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Financial Feasibility Analysis of PLN Electricity Investment in the Palm Oil Industry

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A B S T R A C T

Palm oil mills require a reliable electricity supply to support production and auxiliary operations. Diesel generators are commonly used during boiler start-up, turbine outages, and non-processing periods; however, their operation results in high fuel costs and carbon emissions. This study evaluates the feasibility of installing PLN electricity as an alternative power source using a 10-year investment horizon. Financial feasibility was assessed using Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Return on Investment (ROI), Payback Period (PP), Discounted Payback Period (DPP), and sensitivity analysis. The results indicate that the investment is financially feasible, yielding an NPV of IDR 15.78 billion, an IRR of 180%, a PI of 16.36, an ROI of 2,796%, a PP of 0.59 years, and a DPP of 0.65 years. In addition, annual CO_2 emissions were reduced by 548,430.83 kg, and the investment remained feasible under all sensitivity scenarios.

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INTRODUCTION

Indonesia is the world's largest producer of palm oil, contributing more than half of global crude palm oil (CPO) production. The palm oil industry plays a strategic role in supporting national economic growth, employment, and export earnings. The continuity of palm oil mill (POM) operations therefore depends not only on the availability of fresh fruit bunches (FFB) but also on a reliable and efficient electricity supply to operate processing equipment, utility systems, lighting, and supporting facilities.

Most palm oil mills generate electricity using steam turbines powered by biomass residues, such as fiber and palm kernel shells. This renewable energy system significantly reduces dependence on fossil fuels during normal production. However, steam turbines cannot continuously supply electricity under all operating conditions. During boiler start-up, turbine maintenance, equipment failure, insufficient steam pressure, and mill shutdown periods, electricity demand is commonly supplied by diesel generators. Although diesel generators ensure operational continuity, their operation results in substantial fuel consumption, high operating costs, and increased greenhouse gas emissions. These conditions reduce operational efficiency and increase production costs.

To overcome these challenges, many palm oil mills have considered integrating electricity supplied by PT Perusahaan Listrik Negara (PLN) as an alternative power source. The installation of PLN electricity is expected to reduce dependence on diesel generators while improving power reliability and operational efficiency. Nevertheless, implementing a PLN electricity connection requires considerable capital expenditure, including electrical substations, distribution systems, protection equipment, and network installation. Consequently, investment decisions should be supported by comprehensive feasibility studies to ensure that the expected economic benefits justify the required investment.

Previous studies on electricity investment in palm oil mills have primarily evaluated project feasibility using conventional capital budgeting indicators, including Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Return on Investment (ROI). While these indicators are essential for measuring financial performance, previous studies have generally focused on economic feasibility and have provided limited discussion regarding operational improvements, environmental benefits, and investment robustness under uncertain business conditions. As a result, investment decisions may not fully capture the long-term value created by alternative electricity supply systems.

This study extends previous research by integrating financial, operational, and environmental evaluations into a single investment assessment framework. Financial feasibility is assessed using Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Return on Investment (ROI), Payback Period (PP), and Discounted Payback Period (DPP). In addition, sensitivity analysis is conducted to evaluate investment robustness under variations in electricity tariffs, diesel fuel prices, discount rates, and PLN supply reliability. The environmental impact is also evaluated through the reduction of carbon dioxide (CO_2) emissions resulting from decreased diesel generator operation.

The findings of this study contribute to the literature on investment decision-making and energy management in the palm oil industry by demonstrating that electricity investment appraisal should consider not only financial returns but also operational efficiency, environmental sustainability, and investment resilience. Furthermore, the results provide practical guidance for palm oil mill managers in selecting alternative electricity supply systems that support sustainable industrial operations. Accordingly, this study aims to evaluate the operational, environmental, and financial feasibility of installing PLN electricity as an alternative power source in a palm oil mill using capital budgeting techniques and sensitivity analysis.

THEORETICAL REVIEW

Investment Feasibility Study

Investment decision theory provides the fundamental basis for evaluating whether a proposed project should be undertaken by comparing the expected benefits with the required investment costs. The primary objective of investment decision-making is to allocate financial resources efficiently to projects that maximize economic value while considering potential risks and future uncertainties. Therefore, every investment proposal should be evaluated systematically before implementation to ensure that it contributes to the organization's long-term financial and operational objectives.

One of the most widely used approaches in investment decision-making is capital budgeting, which evaluates the financial feasibility of long-term investment projects based on projected cash flows. Capital budgeting consists of two principal evaluation approaches: time value of money (TVM) methods and non-time value of money methods. The TVM approach considers the present value of future cash flows and includes Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), and Discounted Payback Period (DPP). In contrast, non-TVM methods evaluate investment performance without discounting future cash flows, such as Return on Investment (ROI) and Payback Period (PP).

The combination of these evaluation methods enables decision-makers to obtain a comprehensive assessment of project profitability, capital recovery, investment efficiency, and financial risk. Since future economic conditions may change during the project's life cycle, financial evaluation should also be complemented by investment risk assessment through sensitivity analysis. This approach enables management to examine the robustness of investment performance under various scenarios before making the final investment decision.

Figure 1 illustrates the theoretical framework adopted in this study. The framework demonstrates that investment decisions are initiated through capital budgeting analysis, followed by financial feasibility evaluation using both discounted and non-discounted methods. The investment is subsequently tested through sensitivity analysis to assess its resilience under changing assumptions before determining the final investment decision.

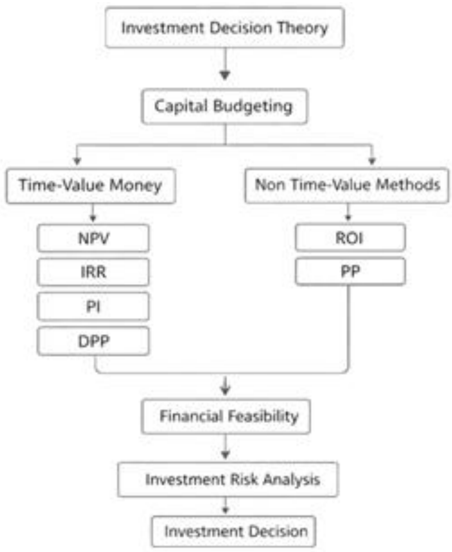

Figure 1. Theoretical Framework of Investment Decision Analysis

Capital Budgeting Theory

Capital budgeting is a systematic financial decision-making process used to evaluate the feasibility of long-term investment projects by comparing the expected future cash inflows with the required initial investment. It enables organizations to determine whether an investment is capable of generating economic value throughout its useful life while supporting efficient allocation of financial resources. Since long-term investments generally involve substantial capital expenditure and operational commitments, comprehensive financial evaluation is essential before project implementation.

Capital budgeting consists of discounted and non-discounted cash flow techniques. Discounted cash flow methods incorporate the time value of money and include Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), and Discounted Payback Period (DPP). These methods evaluate investment feasibility based on the present value of future cash flows. In contrast, non-discounted methods, such as Return on Investment (ROI) and Payback Period (PP), provide complementary information regarding investment profitability and capital recovery without considering the discount factor. The combined use of these indicators provides a comprehensive financial assessment and reduces the limitations associated with relying on a single investment criterion.

The financial indicators employed in this study are described as follows.

Net Present Value (NPV)

Net Present Value (NPV) represents the difference between the present value of future net cash inflows and the initial investment cost. NPV measures the economic value generated by an investment over its project life. An investment is considered financially feasible when NPV > 0, indicating that the expected benefits exceed the investment cost (Purnatiyo, 2014).

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - I_0$$

where:
NPV = Net Present Value
CF_t = Net cash flow in year t
I_0 = Initial investment
r = Discount rate
n = Project life (years)

Internal Rate of Return (IRR)

Internal Rate of Return (IRR) is the discount rate that makes the Net Present Value equal to zero. It represents the project's expected rate of return and is commonly used to evaluate investment attractiveness. An investment is considered feasible when IRR exceeds the required rate of return (discount rate) (Rasid, 2020).

$$0 = \sum_{t=1}^{n} \frac{CF_t}{(1+IRR)^t} - I_0$$

where:
CF_t = Net cash flow in year t
IRR = Internal Rate of Return
I_0 = Initial investment
n = Project life (years)

Profitability Index (PI)

Profitability Index (PI) measures the ratio between the present value of future cash inflows and the initial investment. PI indicates the economic value created for every unit of capital invested. A project is financially acceptable when PI > 1 (Brigham & Ehrhardt, 2017).

$$PI = \frac{\sum_{t=1}^{n} \frac{CF_t}{(1+r)^t}}{I_0}$$

where:
PI = Profitability Index
PV = Present value of future cash flows

Return on Investment (ROI)

Return on Investment (ROI) measures the profitability generated from the invested capital by comparing the net profit with the initial investment. Higher ROI values indicate better financial performance and investment efficiency (Meilian, 2012).

$$ROI = \frac{\text{Net Saving} - \text{Initial Investment}}{\text{Initial Investment}} \times 100\%$$

where:
ROI = Return on Investment
Net Profit = Total profit generated during the project
Initial Investment = Total investment cost

Payback Period (PP)

Payback Period (PP) estimates the time required to recover the initial investment from future net cash inflows. A shorter payback period indicates faster capital recovery and lower investment risk (Angray, 2019).

$$PP = \frac{I_0}{CF}$$

where:
PP = Payback Period
Annual Net Cash Flow = Average annual net cash inflow

Discounted Payback Period (DPP)

Discounted Payback Period (DPP) is an extension of the conventional Payback Period that incorporates the time value of money by discounting future cash flows before calculating the investment recovery period. Consequently, DPP provides a more realistic estimate of capital recovery than the conventional Payback Period (Brigham & Ehrhardt, 2017).

$$DPP = \frac{I_0}{CF}$$

where:
DPP = Discounted Payback Period
Discounted Annual Cash Flow = Present value of annual net cash inflow

The six capital budgeting indicators complement one another in evaluating investment performance. NPV measures the economic value created by the investment, IRR estimates the expected rate of return, PI evaluates investment efficiency, ROI measures overall profitability, PP estimates the capital recovery period, and DPP incorporates the time value of money into the investment recovery analysis. Therefore, the combined application of these indicators provides a comprehensive and reliable assessment of investment feasibility.

In this study, capital budgeting serves as the primary analytical framework for evaluating the financial feasibility of investing in PLN electricity infrastructure for palm oil mill operations. The investment is assessed using NPV, IRR, PI, ROI, PP, and DPP over the project life to determine its long-term financial viability.

Sensitivity Analysis

Although capital budgeting provides an estimate of investment feasibility based on projected cash flows, future economic and operational conditions are inherently uncertain. Variations in electricity tariffs, diesel fuel prices, discount rates, and power supply reliability may influence project performance throughout its operational life. Therefore, investment evaluation should also consider the potential effects of changing assumptions to improve the reliability of investment decision-making.

Sensitivity analysis is a risk assessment technique used to evaluate the impact of changes in key investment variables on financial performance while keeping other assumptions constant. This approach enables decision-makers to identify the variables that have the greatest influence on investment feasibility and to determine whether the project remains financially viable under different operating conditions. In this study, sensitivity analysis was performed by varying four key variables that are considered to have the greatest influence on project cash flows: PLN electricity tariff, diesel fuel price, discount rate, and PLN supply reliability.

The sensitivity scenarios were developed based on optimistic, moderate, and pessimistic assumptions to represent possible future operating conditions. The simulation framework adopted in this study is presented in Table 1.

Table 1. Sensitivity Analysis Assumptions

Variable	Optimistic Scenario	Moderate Scenario	Pessimistic Scenario
PLN electricity tariff	Base tariff	+5%	+10%
Diesel fuel price	Base price	+10%	+20%
Discount rate	8%	10%	12%
PLN supply reliability	99% availability	97% availability	95% availability

Source: Research assumptions based on financial projection scenarios.

The optimistic scenario assumes relatively stable economic conditions with minimal increases in operating costs and high electricity supply reliability. The moderate scenario represents the most probable operating conditions and serves as the baseline for financial evaluation. The pessimistic scenario assumes higher operating costs, increased discount rates, and reduced PLN electricity reliability, requiring greater dependence on diesel generators. The financial feasibility of the investment is subsequently evaluated under each scenario using Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Return on Investment (ROI), Payback Period (PP), and Discounted Payback Period (DPP).

Previous Studies and Research Gap

Previous studies have demonstrated that capital budgeting techniques are effective tools for evaluating long-term investment decisions in industrial projects. Financial indicators such as NPV, IRR, ROI, and PP have been widely applied to determine project feasibility by comparing expected financial returns with investment costs. In the palm oil industry, these methods have been used to evaluate investments related to production facilities, supporting infrastructure, and electricity supply systems.

Despite these contributions, previous studies have primarily emphasized financial feasibility and have generally evaluated investment performance using a limited number of financial indicators. Relatively little attention has been given to integrating operational improvements, environmental benefits, and investment robustness within a single evaluation framework. Furthermore, the application of sensitivity analysis to assess the influence of key economic variables on investment feasibility remains limited in studies concerning electricity supply systems for palm oil mills.

This study addresses these limitations by developing an integrated investment evaluation framework that combines financial, operational, and environmental considerations. Financial feasibility is evaluated using NPV, IRR, PI, ROI, PP, and DPP, while investment robustness is examined through sensitivity analysis under variations in electricity tariffs, diesel fuel prices, discount rates, and PLN supply reliability. In addition, this study considers environmental benefits through the reduction of carbon dioxide (CO_2) emissions resulting from decreased diesel generator operation. This integrated approach provides a more comprehensive basis for investment decision-making than conventional financial evaluations alone.

Conceptual Framework

Based on the theoretical foundation presented in the previous sections, this study develops a conceptual framework to illustrate the overall research process and the relationship between the key analytical components. The framework begins with a preliminary observation and literature review to identify the operational issues related to electricity supply in the palm oil mill. Following the identification of the research problem, relevant data are collected, including diesel generator operating costs, electricity consumption, PLN installation investment costs, and operational data of the palm oil mill.

The collected data are subsequently analyzed from three complementary perspectives, namely operational, environmental, and investment aspects. The operational aspect evaluates the potential reduction in diesel generator utilization and improvements in electricity supply efficiency. The environmental aspect assesses the reduction in carbon dioxide (CO_2) emissions resulting from decreased diesel fuel consumption. Meanwhile, the investment aspect focuses on estimating the required capital expenditure and the expected economic benefits of the proposed PLN electricity installation.

The results of these analyses are integrated into the project cash flow, which serves as the basis for financial feasibility evaluation using capital budgeting techniques. The investment is assessed through Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Return on Investment (ROI), Payback Period (PP), and Discounted Payback Period (DPP). To evaluate investment robustness under uncertain economic conditions, sensitivity analysis is performed by examining changes in key variables, including electricity tariffs, diesel fuel prices, discount rates, and PLN supply reliability.

The conceptual framework adopted in this study is presented in Figure 2, which illustrates the sequential process from problem identification and data collection to financial feasibility analysis, investment risk assessment, and the final investment decision regarding the implementation of PLN electricity in the palm oil mill.

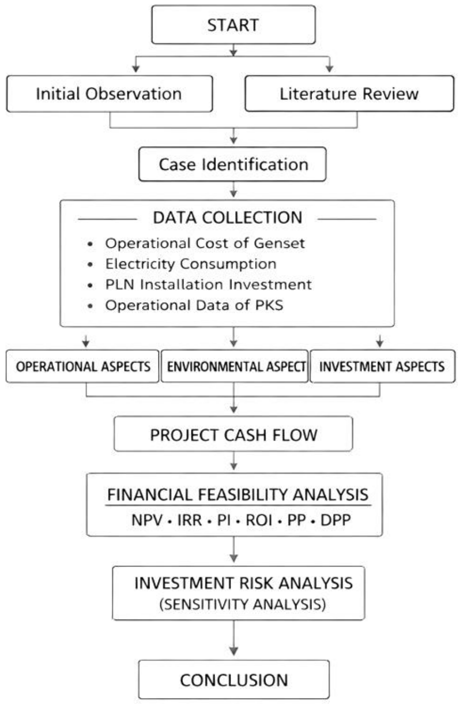

Figure 2. Conceptual Framework of the Research

METHODOLOGY

Research Design

This study employed a quantitative case study approach to evaluate the feasibility of installing PLN electricity as an alternative power source in a palm oil mill. The research focused on assessing the financial, operational, and environmental implications of replacing diesel generator operation with PLN electricity. The evaluation was conducted using capital budgeting techniques and sensitivity analysis to determine whether the proposed investment was economically feasible under different operating conditions.

The research procedure consisted of problem identification, data collection, project cash flow estimation, financial feasibility analysis, sensitivity analysis, and investment decision evaluation. The overall research framework adopted in this study is illustrated in Figure 3.

Data Collection

Data used in this study were obtained through the following methods.

1. Field Observation

Field observations were conducted to understand the existing electricity supply system, operational characteristics of the palm oil mill, and the utilization of steam turbines, diesel generators, and PLN electricity during mill operations.

2. Document Analysis

Historical operational and financial records were collected from the company, including diesel generator operating costs, electricity consumption, PLN installation investment costs, operating hours, and other technical data required for estimating project cash flows.

3. Literature Review

Relevant information regarding investment evaluation, capital budgeting, electricity systems, and sensitivity analysis was collected from scientific journals, books, government regulations, and other academic publications to establish the theoretical basis for the study.

Data Analysis

The collected data were analyzed through several sequential stages. First, project cash flows were estimated based on investment costs, operational cost savings, and projected benefits over the project life. Second, financial feasibility was evaluated using Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Return on Investment (ROI), Payback Period (PP), and Discounted Payback Period (DPP). Finally, sensitivity analysis was performed by varying electricity tariffs, diesel fuel prices, discount rates, and PLN supply reliability to evaluate the robustness of the proposed investment under different scenarios.

The research methodology adopted in this study is summarized in Figure 3.

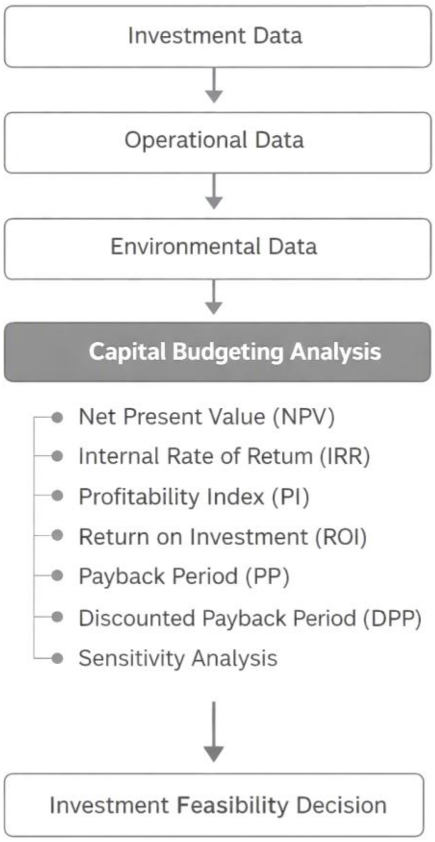

Figure 3. Research Methodology

RESULTS

Operational and Environmental Analysis

The proposed installation of PLN electricity was intended to improve the operational efficiency of the palm oil mill by reducing dependence on diesel generators during conditions in which steam turbine generation was unavailable or insufficient, such as boiler start-up, turbine maintenance, and production interruptions. Under the existing operating system, diesel generators served as the primary backup power source, resulting in considerable diesel fuel consumption, high operating expenses, and increased maintenance requirements.

The analysis indicates that integrating PLN electricity substantially improves the reliability of the mill's electricity supply while reducing generator operating hours. The decrease in diesel generator utilization lowers fuel consumption and maintenance costs, thereby improving overall operational efficiency. In addition to operational improvements, reduced diesel fuel consumption contributes directly to lower carbon dioxide (CO_2) emissions, supporting environmental sustainability and cleaner energy utilization within the palm oil mill. These operational and environmental benefits become additional considerations supporting the proposed investment beyond purely financial returns.

Financial Feasibility Analysis

The financial feasibility of the proposed PLN electricity installation was evaluated using six capital budgeting indicators: Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Return on Investment (ROI), Payback Period (PP), and Discounted Payback Period (DPP). These indicators collectively measure investment profitability, efficiency, capital recovery, and long-term financial performance. The results of the financial feasibility analysis are presented in Table 1.

Table 1. Financial Feasibility Results

Financial Indicator	Result	Acceptance Criterion	Decision
Net Present Value (NPV)	Rp 15,784B	NPV > 0	Feasible
Internal Rate of Return (IRR)	180%	IRR > Discount Rate (10%)	Feasible
Profitability Index (PI)	16.36	PI > 1	Feasible
Return on Investment (ROI)	2,796%	ROI > 0	Feasible
Payback Period (PP)	0.59 year	Shorter than project life	Feasible
Discounted Payback Period (DPP)	0.65 year	Shorter than project life	Feasible

Source: Research data processing.

As presented in Table 1, the evaluation results demonstrate that the proposed investment satisfies all established financial feasibility criteria. The project generates a positive Net Present Value, indicating that the present value of future benefits exceeds the initial investment cost. The Internal Rate of Return is substantially higher than the required discount rate, while the Profitability Index exceeds one, confirming that the investment creates additional economic value. Furthermore, the Payback Period and Discounted Payback Period indicate that the invested capital can be recovered within an acceptable timeframe. Overall, these findings demonstrate that the proposed PLN electricity installation is financially feasible and economically attractive for long-term implementation in palm oil mill operations.

Sensitivity Analysis

Investment decisions are inherently exposed to uncertainties arising from future economic and operational conditions. Therefore, sensitivity analysis was conducted to evaluate the robustness of the proposed PLN electricity installation by examining the effects of changes in key investment variables while maintaining the remaining assumptions constant. Four variables were analyzed, namely PLN electricity tariff, discount rate, PLN supply reliability, and diesel fuel price. Among these variables, changes in the PLN electricity tariff produced the largest variation in project value and were therefore identified as the most critical factor affecting investment feasibility. The detailed financial results of the tariff simulation are presented in Table 2, while the relative influence of all variables is summarized using the diagram in Figure 3.

Table 2. Sensitivity Analysis Results for PLN Electricity Tariff

Financial Indicator	Optimistic	Moderate (Base Case)	Pessimistic
Net Present Value (Rp Billion)	17,802	15,784	13,766
Internal Rate of Return (%)	170	180	159
Profitability Index	15.38	16.36	14.40
Return on Investment (%)	2,524	2,796	2,352
Payback Period (Year)	0.63	0.59	0.68
Discounted Payback Period (Year)	2.30	0.65	2.97

Source: Research data processing (2026).

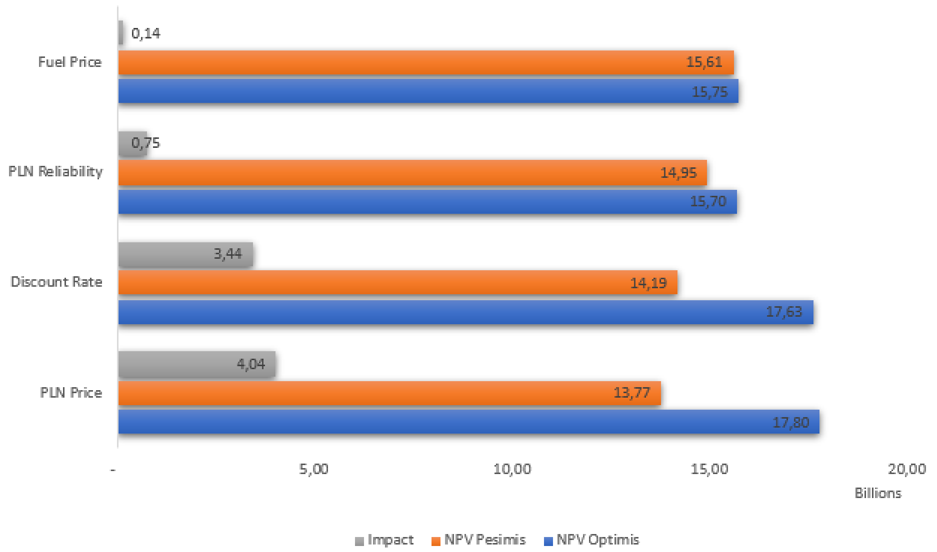

Figure 3. Diagram of Sensitivity Analysis Based on Changes in Net Present Value (NPV)

As presented in Table 2, the proposed investment remains financially feasible under all electricity tariff scenarios. Although an increase in PLN electricity tariffs reduces the project's financial benefits, all evaluated scenarios continue to generate positive Net Present Values (NPV), Internal Rates of Return (IRR) substantially exceeding the required rate of return, Profitability Index (PI) values greater than one, and relatively short Payback Periods (PP) and Discounted Payback Periods (DPP). These results indicate that the investment maintains satisfactory financial performance even under less favorable electricity pricing conditions.

The Scenario analysis Diagram presented in Figure 3 illustrates the relative influence of the four evaluated variables on project value. The analysis indicates that the PLN electricity tariff is the most sensitive variable, producing an NPV variation of approximately Rp 4.04 billion between the optimistic and pessimistic scenarios. The discount rate ranks as the second most influential variable, followed by PLN supply reliability, while diesel fuel price exhibits the smallest impact on investment performance. These findings suggest that long-term project value is primarily affected by electricity pricing policies and financing assumptions rather than operational uncertainties.

Overall, the sensitivity analysis confirms that the proposed PLN electricity installation is financially robust under a range of plausible future conditions. Although variations in key assumptions influence the magnitude of financial returns, all simulated scenarios continue to satisfy the established investment acceptance criteria. Therefore, the proposed investment demonstrates strong resilience and remains economically attractive for long-term implementation in the palm oil industry.

DISCUSSION

Operational Implications

The findings demonstrate that the installation of PLN electricity provides significant operational advantages for palm oil mills by reducing dependence on diesel generators during conditions where steam turbine generation is unavailable or insufficient. Lower generator utilization decreases diesel fuel consumption, minimizes maintenance requirements, and improves the reliability of electricity supply during critical operating periods. These improvements contribute to more efficient mill operations and reduce interruptions associated with conventional backup power systems.

From an operational perspective, integrating PLN electricity also supports more effective energy management by enabling the mill to optimize the utilization of available energy sources according to operational requirements. Rather than functioning solely as an alternative electricity supplier, PLN becomes an integral component of the mill's overall energy management strategy, improving operational flexibility while maintaining production continuity.

Financial Implications

The positive financial indicators obtained in this study demonstrate that investment in PLN electricity installation creates substantial economic value over the project life. The combination of a positive Net Present Value, a high Internal Rate of Return, a Profitability Index greater than one, and relatively short capital recovery periods indicates that the proposed investment is financially attractive according to widely accepted capital budgeting criteria.

These findings suggest that reducing diesel generator operating costs provides long-term financial benefits that exceed the required initial investment. Consequently, the investment contributes not only to cost reduction but also to improved financial performance and more efficient capital allocation. For palm oil mill management, these results provide quantitative evidence supporting investment decisions in alternative electricity infrastructure

Investment Robustness

Investment decisions are often influenced by uncertainty in future operating conditions. Therefore, evaluating investment robustness through sensitivity analysis is essential to determine whether the project remains financially feasible under changing economic assumptions. The results indicate that variations in electricity tariffs, diesel fuel prices, discount rates, and PLN supply reliability influence the magnitude of financial returns but do not alter the overall investment decision.

This finding indicates that the proposed investment possesses a relatively high level of resilience against fluctuations in key economic variables. Such robustness is particularly important for long-term infrastructure projects because future operational environments cannot be predicted with complete certainty. Accordingly, the investment can be considered financially sustainable under a range of plausible operating scenarios

Comparison with Previous Studies

The findings of this study are generally consistent with previous research reporting that capital budgeting techniques provide reliable indicators for evaluating long-term investment feasibility. Similar to earlier studies, the present research confirms that Net Present Value, Internal Rate of Return, Payback Period, and Return on Investment remain effective tools for supporting investment decision-making in industrial projects.

However, this study extends previous research by integrating operational performance, environmental benefits, and sensitivity analysis into the investment evaluation framework. Rather than focusing solely on financial indicators, the study demonstrates that investment feasibility should also consider reductions in diesel generator utilization, carbon dioxide (CO_2) emissions, and project resilience under changing economic conditions. This integrated evaluation provides a more comprehensive basis for decision-making and represents the principal contribution of this research to investment evaluation in the palm oil industry.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study, the proposed installation of PLN electricity as an alternative power source in the palm oil mill is financially feasible and operationally beneficial. The investment reduces dependence on diesel generators, improves electricity supply reliability, lowers operating costs, and contributes to the reduction of carbon dioxide (CO_2) emissions. These findings indicate that the proposed investment supports both operational efficiency and environmental sustainability in palm oil mill operations.

The financial evaluation demonstrates that the proposed investment satisfies all capital budgeting acceptance criteria. The project generates a positive Net Present Value (NPV), an Internal Rate of Return (IRR) exceeding the required rate of return, a Profitability Index (PI) greater than one, and acceptable Payback Period (PP) and Discounted Payback Period (DPP), confirming its economic attractiveness. Furthermore, sensitivity analysis indicates that the investment remains financially feasible under variations in electricity tariffs, diesel fuel prices, discount rates, and PLN supply reliability, demonstrating the resilience of the investment under different operating conditions.

Overall, this study extends previous investment feasibility research by integrating operational performance, environmental benefits, financial evaluation, and investment risk assessment within a single analytical framework. The proposed approach provides a more comprehensive basis for electricity infrastructure investment decisions in the palm oil industry and may serve as a practical reference for both industrial practitioners and future researchers.

Recommendations

Palm oil mill management is encouraged to consider PLN electricity installation as a strategic long-term investment to improve operational efficiency, reduce dependence on diesel generators, and support sustainable industrial operations. Investment decisions should continue to be supported by comprehensive capital budgeting analysis and sensitivity analysis to ensure investment resilience under future economic uncertainty.

Since this study was conducted as a single case study, future research should expand the analysis to multiple palm oil mills with different production capacities and operational characteristics. Comparative evaluations involving other alternative energy sources, such as biogas and solar photovoltaic systems, are also recommended to strengthen decision-making regarding sustainable energy investments in the palm oil industry.

FURTHER STUDY

Future research is recommended to validate the proposed investment evaluation framework across multiple palm oil mills with different production capacities, operational characteristics, and geographical locations. Comparative studies involving alternative electricity supply systems, such as biogas, solar photovoltaic (PV), and hybrid energy systems, are also encouraged to broaden the application of sustainable energy investment strategies in the palm oil industry. Furthermore, future research may incorporate additional decision-support approaches, including life-cycle cost analysis and uncertainty assessment, to enhance the robustness of long-term investment planning.

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