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Investment Project Analysis of PT ABC External Power Electricity Interconnection with Utilities Power Generation System PT Kilang PT XYZ Internasional Refinery Unit III Plaju

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Abstract

PT Kilang PT XYZ Internasional RU III Plaju operates two gas turbine generators at partial load, resulting in low efficiency, high fuel consumption, and costly maintenance. Aging infrastructure and reliance on a single fuel type exacerbate these issues. This study evaluates the technical and financial feasibility of interconnecting PT ABC's external electricity supply with the utility power generation system of PT Kilang PT XYZ Internasional RU III Plaju. A mixed-method approach was employed, integrating qualitative and quantitative analyses. Technical feasibility was assessed through thematic analysis of semi-structured interviews with six experts from relevant departments, SWOT analysis, and evaluation of operational data. Financial feasibility was evaluated using capital budgeting techniques, sensitivity analysis, and Monte Carlo simulation for risk assessment. The technical analysis confirms that the project can be implemented with an operational configuration of one 12 MW gas turbine generator supplemented by 12 MW of external electricity from PT ABC. This configuration is projected to improve energy efficiency by reducing the Energy Intensity Index (EII) by 6.41–10.03 points. Financial analysis indicates a positive Net Present Value (NPV) of IDR 223.64 billion, an Internal Rate of Return (IRR) of 25.9%—well above the minimum required rate of return of 11.4%—and a Payback Period of 4.1 years. Monte Carlo simulation further demonstrates a 90.85% probability of achieving a positive NPV. The primary residual risk is potential disturbances in the PT ABC grid, which can be mitigated through advanced protection systems and islanding capability. Overall, the PT ABC interconnection project is technically feasible, financially viable, and carries manageable risks. Implementation of this project is recommended to reduce operational costs, enhance energy efficiency, and support the company's decarbonization roadmap.

INTRODUCTION

Energy efficiency in the refining industry is a key strategy for optimizing resources, reducing operational costs, and enhancing environmental sustainability. Challenges such as aging infrastructure, reliance on a single fuel source, and insufficient incentives hinder the optimization of energy efficiency in this sector. Analyzing energy efficiency programs in Indonesian refineries is essential to understand how various factors influence investment decisions and the long-term outcomes of these initiatives (Nita et al., 2023; Simsek & Urmee, 2020; Veza et al., 2025).

In today's industrial environment, companies must operate efficiently while complying with increasingly strict environmental regulations. Effectively managing energy costs and emissions is critical for maintaining competitiveness (Bensouda et al., 2024; Chen et al., 2020; Lee, 2015). PT XYZ, as an energy company, is committed to supporting the 2060 Net Zero Emission target outlined in its Net Zero Emission Roadmap. One strategic initiative related to decarbonization is improving energy efficiency, including programs aimed at reducing the Energy Intensity Index (EII) of refinery operations through electricity utilization, external gas, and equipment refurbishment—presenting significant opportunities for improvement.

The Plaju Refinery faces challenges in energy efficiency and competitiveness relative to modern, high-performance refineries. According to the 2024 Worldwide Fuels Refinery Performance Analysis by Solomon, PT Kilang PT XYZ Internasional RU III Plaju recorded a Q4 EII of 153, compared to the World Best EII of 82 (Q1), indicating a need for investment to reduce energy intensity. The interconnection project for gas turbines with external electricity from PT ABC offers an opportunity to reduce operational expenditure (OPEX). PT Perusahaan Listrik Negara (PT ABC) provides industrial electricity at an average tariff of IDR 1,064/kWh (PT ABC, 2024). However, this modification involves significant challenges, including high capital expenditure (CAPEX) requirements and technical complexities associated with integrating a new power supply into the existing system.

PT XYZ, a state-owned oil company, manages refining and petrochemical business activities through its sub-holding, PT Kilang PT XYZ Internasional (KPI), which focuses on refining petroleum and other materials into high-value products. Its vision is "To be a World Class Refining and Petrochemical Company," and its mission is to operate the oil refinery and petrochemical business professionally and to international standards, combining strong economic principles with an environmental perspective. Refinery Unit III Plaju, located in Palembang, South Sumatera, is the oldest of PT XYZ's refineries, originally built as integrated facilities by Shell in 1904 and Stanvac in 1926, with subsequent developments between 1970 and 1992.

The company's utilities section operates three gas turbine generators for power generation with cogeneration (CHP), converting chemical energy into kinetic energy through combustion. The fuel used is natural gas sourced from PT XYZ EP South Sumatera. Waste heat from each turbine is recovered via Waste Heat Recovery Units (WHRU) to produce high-pressure steam (40K). RU III Plaju also operates two package boilers to generate high-pressure steam, with one normally in operation.

The power generation system at RU III Plaju consists of three gas turbine generators: GT 2015 UA and UB (built in 1983) and GT 2015 UC (built in 1992). Under normal operating conditions, two turbines run while one remains on standby, with load distribution of 14 MW for GT UA/UB and 10 MW for GT UC. Operating two turbines at partial load reduces thermal efficiency (high heat rate), increases fuel consumption, and causes operational issues such as elevated wheelspace temperature, torque converter problems, high exhaust temperatures, and excessive lube oil supply temperatures even after overhauls, as detailed in Table 1.

On July 30, 2024, the GT 2015 UA generator sustained damage to its stator section, leading to a stage-2 load shedding event. The estimated lead time for complete replacement is 16–18 months, while only temporary repairs were implemented. This significantly impacts the reliability of the gas turbine generator system. High maintenance costs associated with the existing gas turbines are summarized in Table 2.

Natural gas supply to RU III currently depends entirely on a single supplier, PT XYZ EP South Sumatera, delivered via the Pertagas pipeline network. RU III's natural gas consumption accounts for approximately 80% of its total energy needs, with roughly 50% used for power generation in the utilities section.

Stakeholders—including client decision-makers, problem owners, and problem solvers—are actively involved in defining and validating the problem. A stakeholder analysis is presented in Table 1.

Table 1. Stakeholder Analysis

Category	Role	Party
Internal	Client – Decision Maker	Director of Operation PT KPI Headquarter
Internal	Client – Decision Maker	General Manager PT KPI RU III Plaju
Internal	Problem Owner	Manager Engineering & Development PT KPI RU III Plaju
Internal	Problem Owner	Manager MPS PT KPI RU III Plaju
Internal	Problem Solver	Sr. Supervisor Energy & Combustion (ECLC)
Internal	Problem Solver	Sr. Group Leader Electrical (EIIE)
External	External Stakeholder	PT ABC South Sumatera
External	External Stakeholder	PT XYZ EP South Sumatera

Source: Research Methodology for Business Course Material

From the description in the business issue above, the core managerial problem which should be addressed by the management as decision maker is not merely operational inefficiency, but determining whether partial substitution of internal gas-turbine power generation with PT ABC external electricity can create sustainable long-term economic and operational value while maintaining refinery reliability and steam adequacy.

Mechanical prime movers such as gas turbines have a typical life cycle of 25–30 years, after which their efficiency declines and maintenance costs rise significantly (Verma et al., 2015). Partial load operation further exacerbates this issue; at 50% load, net thermal efficiency can drop by up to 30.6% compared to full-load operation, while NOx emissions increase substantially (Grigore et al., 2024). This condition directly impacts the Energy Intensity Index (EII), a key performance metric that measures actual energy usage against standard energy in refineries. Solomon worldwide analysis classifies EII into quartiles (Q1 best to Q4 lowest), and a higher EII indicates poor energy efficiency (Solomon, 2025). To address such inefficiencies, grid interconnection offers a viable solution. Refineries typically rely on internal power generation, but external electricity exchange can provide significant economic benefits through "avoided costs," including fuel savings and reduced capital investment in new generating facilities. Studies show that using external electricity becomes economical when its cost is lower than natural gas for over 600 hours (Bielefeld et al., 2025). The Levelized Cost of Electricity (LCOE) is a standard metric for comparing generation technologies; transitioning from off-grid to on-grid electricity has been shown to reduce LCOE by up to 66% (Nurliani & Noveria, 2024). From a financial perspective, common capital budgeting methods include Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PBP), each suited to different certainty conditions (Sokolov, 2024). Additionally, environmental impact is critical, as CO_2 emissions can be calculated using emission factors; grid electricity can reduce emissions significantly—by approximately 15% in some cases—aligning with corporate Net Zero Emission targets (Nurliani & Noveria, 2024). The conceptual framework of this research integrates three analytical pillars: technical analysis (energy efficiency, reliability, operational integration), financial analysis (cost savings, NPV, IRR, PBP, sensitivity analysis), and risk analysis (ISO 3100:2018, Monte Carlo simulation). The current condition of two operating gas turbines results in high fuel dependence, elevated EII, and high maintenance costs. The proposed condition after PT ABC interconnection targets one gas turbine plus 12 MW external electricity, aiming to reduce OPEX, improve EII, lower maintenance costs, enhance reliability through dual power supply, and reduce CO_2 emissions. Together, SWOT analysis, technical assessment, and financial evaluation form the decision-making framework for this investment project.

This research intended to conduct investment project analysis with the following research questions: (1) To what extent is PT ABC interconnection technically feasible in terms of energy efficiency, reliability, and operational integration with existing refinery systems? (2) To what extent does PT ABC interconnection improve the financial feasibility and long-term operational economics of the refinery utility system compared to the existing internal generation configuration? (3) What technical and financial risks could affect project implementation and operational sustainability, and how can these risks be mitigated? This research theoretically enriches the study of energy engineering and investment management of electricity interconnection projects, especially in the utility system of oil refineries. Practically, the results of this study are a reference for the management of PT Kilang PT XYZ Internasional and similar companies in making investment decisions to improve energy efficiency, reduce operational costs, and support the company's decarbonization roadmap.

METHOD

This chapter presents the methodology of research conducted in addressing the research question related to the feasibility of PT ABC External Electricity Power interconnection to the utility system of the company, and it encompasses research design, method of data gathering, as well as the method of data analysis to guarantee that the gathered information is adequate in addressing the research question.

Research Design

This study utilizes a mixed methodology with a combination of qualitative and quantitative research approaches This research design was chosen to allow for the thorough evaluation of the financial as well as the technical aspects of the proposed external electrification connection with PT ABC.

a. Quantitative Research

The maintenance cost, operating cost, consumption of units like electricity, oil, or gas, and the CAPEX are quantified to assess financial viability of the project or the worth of the proposed investment.

b. Qualitative Research

The qualitative data entails the process of examining the technical reports, industry reports, and the technical data of the companies to emphasize the technical analysis. The nature of the technical analysis is to emphasize the operational environment surrounding the project and the technical difficulties that may be encountered during the course of the transition.

In addition, with a mixed methods approach, this research will not only focus on economic factors but will also consider technical/operational factors. Thus, a holistic perspective will be derived for answering research questions. The combination of these two approaches also supports a comprehensive risk analysis, where factors that affect the feasibility of the project can be analyzed.

Research design flowchart is shown in figure III.1, which outlines the steps are as follows:

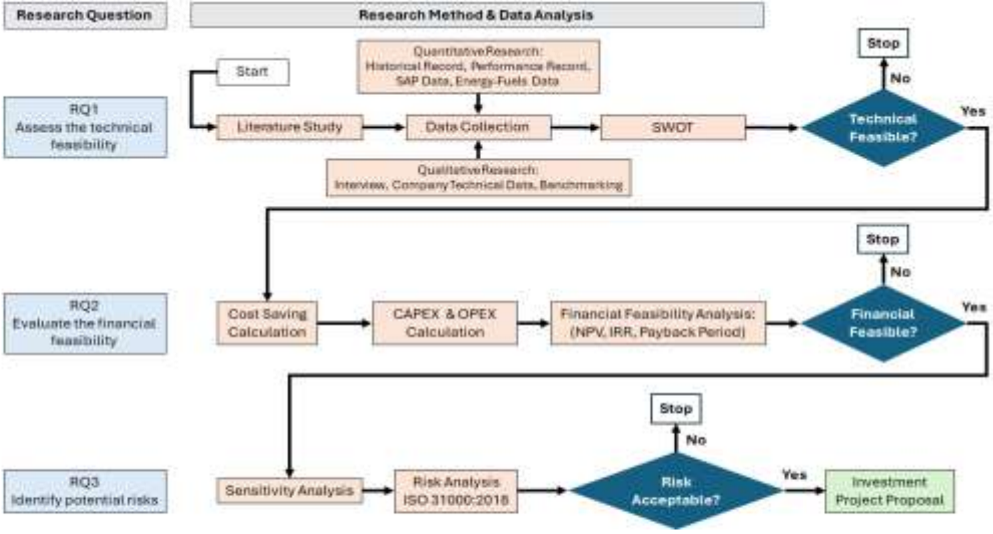

Figure III.1. Research Design Flowchart

Data Collection Method

For answer research questions, various techniques are used in data collection in order to facilitate in-depth research analysis.

a. Primary Data

Primary data include details that are collected directly, which is essential for gaining insight into the study subject.

- **Observation**

These observations are carried out by monitoring the gas turbines, operation, and performance conditions. This will help in examining operational inefficiencies and will enable observations related to potential challenges which may emerge after the implementation of the PT ABC electricity interconnection.

- **Interviews and consultations with experts**

This research uses interviews and consultations involving experts in the subject area as an important means of data acquisition. The process of interacting or consulting is viewed as effective for gaining technical knowledge in depth, for confirming assumptions, or for gaining insight into system changes. Interviews and consultations with Subject Matter Experts will be conducted using a semi-structured method.

Five experts are efficient for the discovery more than 80% of the issues (Nielsen & Landauer, 1993). Given the exploratory nature of expert consultation in this applied industrial study, five key informants representing different functional domains were considered sufficient to achieve practical thematic saturation.

Five expert selected were interviewed with detail in table III.1 below.

Table 2. Parties to Be Interviewed and Consulted

No	Interviewee	No of Interview	Objective
1	Equipment Reliability Expert	1	Explore information regarding technical and non-technical aspects of PT ABC external power interconnection at utilities
2	Electrical Engineering Expert	1	

3	Project Engineering Department	1	Explore information regarding implementation of project work and CAPEX-OPEX estimation
4	Energy Conservation & Loss Control Department	1	Explore information regarding process parameters, and energy cost calculations
5	PT PT ABC South Sumatera Expert	1	Explore information regarding electricity supply in south Sumatera

Source: Researcher's Processed Results

- SWOT Analysis

SWOT analysis was used as a complementary strategic assessment tool to contextualize internal and external project factors beyond purely technical-financial evaluation.

- Validity and Reliability

Data triangulation process have been employed which involved validating information obtained from expert interview, operational data, engineering documents, and financial calculations. The reliability of this study has been strengthened by referring to expert validation and the company’s operational record.

b. Secondary Data

Secondary data are the data that are already known and are collected from both internal and external sources. The secondary data that can be obtained from within the company include data on operations, data related to energy consumption, maintenance data, and many more.

In the cost estimate of the investment, the relevant standard price information is used in a mix of the company's past internal information and other external sources. Furthermore, the data of recent years regarding the energy and maintenance cost of the gas turbines are also analyzed to provide information to assess the operating cost of the current internal power generation system in the company against the proposed project of electricity interconnection between the company and the PT ABC.

Technical documentation, industry standards, research studies, and feasibility studies are analyzed to make sure that the analysis done is in synchronize with the industry standards. Secondly, this analysis not only helps to determine the challenges that could arise with the execution of the proposed project of PT ABC External Power Electricity Interconnection to utilities section of PT KPI RU III Plaju. The data collection flowchart is shown in Figure III.2 below.

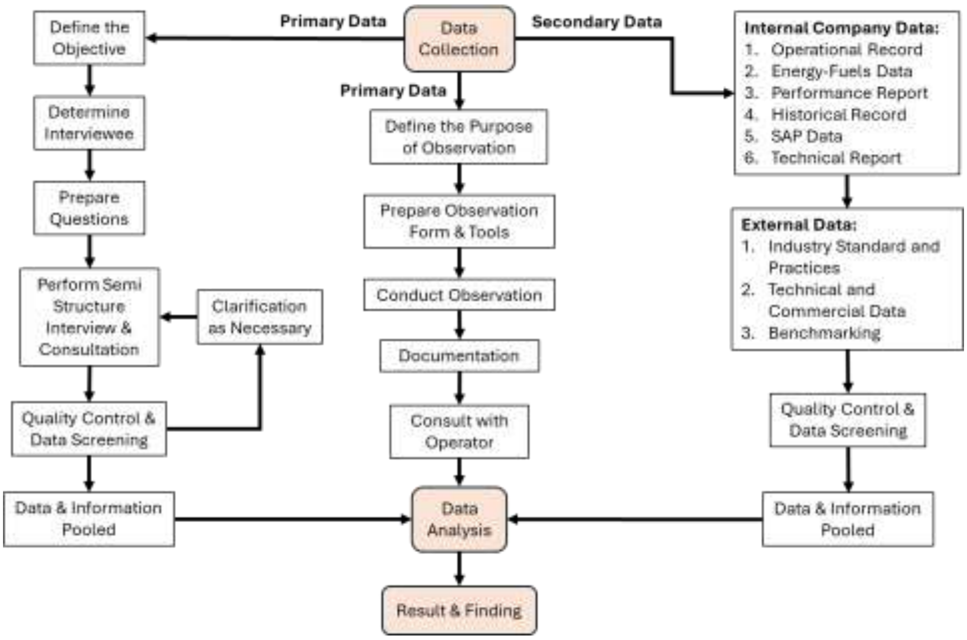

Figure III.2. Data Collection Method Flowchart

Data Analysis Method

This study uses the following methods and analysis tools:

a. Technical Analysis

The data was collected by conducting semi-structured interviews among five experts who possess knowledge regarding the organization as stated in III.2 Data Collection Method. This interview aims to get an information for better understanding of technical, operational, energy, and strategic aspects of the proposed external power interconnection from PT ABC with the existing power generation system.

The thematic analysis method by Braun and Clarke (2006) was used to analyze the interview data. Thematic analysis is a systematic and flexible method for identifying, organizing, and interpreting patterns (themes) in qualitative data. This method offers an easily accessible and theoretically flexible approach to analyzing qualitative data (Ahmed et al, 2025).

Thematic analysis was preferred in this study due to its flexibility and not bound with specific theoretical framework, make it versatile and allow it to deal with the complexity of qualitative data effectively. This makes it highly suitable to apply in engineering research that has multidisciplinary aspects with many viewpoints. Thematic analysis of Braun and Clarke (2006) consist of six phases/steps with described below.

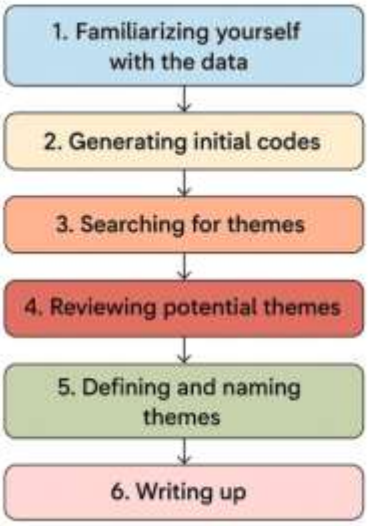

Figure III.3. Braun and Clarke Thematic Analysis Flowchart
(Source: Ahmed et al, 2025)

b. Cost Saving Calculation

This calculation aims to know the benefits of the proposed project by compare the existing power generation configuration system operational cost of 2 (two) gas turbines vs the project proposed 1 (one) gas turbine plus external power from PT ABC.

Operational Energy Cost

This analysis aims to compare the operational costs related to the fuel consumption and electricity price associated with the current configuration and load of power generation system, which are operation 2 (two) gas turbines existing vs 1 (one) gas turbine plus external power from PT ABC of project proposed.

Maintenance Cost

This analysis aims to compare the maintenance costs related to the overhoul cost of gas turbine associated with the current configuration and load of power generation system, which are operation 2 (two) gas turbines existing vs 1 (one) gas turbine plus external power from PT ABC of project proposed.

Financial Analysis

Capital budgeting is the technique that is adopted by the company to allocate financial resources to different projects. There are different types of capital, and those types are classified into capital expenditure and operational expenditure. Capital expenditures are investments, the benefits of which are realized for a period of more than one year. After assigning economic values, both costs and benefits, results can be calculated using of Discounted Cash Flow (DCF) method.

Discount Factor

The discount factor represents the interest rate at which the future cashflows must be discounted to determine their present value. The Discount factor is a function of the discount rate (r) and the time (t).

$$\text{Discount Factor} = \frac{1}{(1+\mathrm{r})^{\mathrm{t}}}$$

Weighted Average Cost of Capital (WACC)

The weighted average cost of capital (WACC) is the average future expected cost of capital over a time horizon. It is calculated by assigning a weight for the cost of capital based on the capital structure composition in the firm (Gitman & Zutter, 2015)

$r_a = (w_i \times r_i) + (w_p \times r_p) + (w_s \times r_{r\text{ or }n})$

Where:

w_i = Portion of long term debt

r_i = Cost of long term debt

w_p = Portion of preferred stock

r_p = Cost of preferred stock

w_s = Portion of common stock equity

$r_{\text{or }n}$ = Cost of retained earnings (r_o) / new common stock (r_n)

Note: $w_i + w_p + w_s = 1.0$

To determine after-tax cost of debt (r_i), it is necessary to incorporate the tax shield associated with debt financing. This cost of debt is calculated by adjusting before-tax cost of debt (r_d) using the corporate tax rate (T), as shown in formula below:

$$r_i = r_d \text{ x } (1 - T)$$

The Capital Asset Pricing Model (CAPM) is a technique applied in the world of finance to estimate the cost of equity. This estimate describes the expected return on a particular asset based on the risk-free interest rate and a risk premium, taking into consideration the beta value for the asset. The CAPM equation uses the formula below:

$$\mathbf{r_j = R_F + \left[\beta_j \text{ x } (r_m - r_f)\right]}$$

Where:

r_j = Cost of equity

R_F = Risk-free rate

β_j = Beta coefficient

$r_m - r_f$ = Market risk premium

According to Damodaran (2012), the alternative approach to estimate beta that does not require historical stock prices of a specific firm is the bottom-up beta method. The four key steps are as follows:

1. Identify the business or business the firm operates in
2. Select publicly listed companies that have identical business segment and estimate the levered beta
3. Calculate the unlevered beta

$$\beta_{\text{unlevered}} = \frac{\beta_{\text{comprable firm}}}{(1 + (1 - T)\frac{D}{E}\text{ratio comparable firm}}$$

4. Estimate a levered beta

$$\beta_{\text{levered,firm}} = \beta_{\text{unlevered}} \left[1 + (1 - T).\frac{D}{E}\text{project}\right]$$

Net Present Value (NPV)

The Net Present Value (NPV) is quite a popular investment appraisal tool that recognizes the time value of money because it discounts the future cash flows of the business based on its cost of capital. The tool ensures that capital expenditures are made only if the net present value of the investment is more than the cost incurred initially. An investment program that generates more return than the cost for capital will enhance the value of the business; in contrast, if it generates lower returns, the value will decrease. The Net Present Value (NPV) is calculated by subtract the project's initial investment (CF_0) from the present value of its cash inflows (CF_t) discounted at firm's cost of capital (r) (Gitman & Zutter, 2015):

NPV = Present Value of Cash Inflows – Initial Investment

$$\mathrm{NPV} = \sum_{t=1}^{n} \frac{\mathrm{CF_t}}{(1+\mathrm{r})^{\mathrm{t}}} - \mathrm{CF_0}$$

The decision criteria when NPV is used to make accept–reject are as follows (Gitman & Zutter, 2015):

- NPV > 0, accept the project.
- NPV < 0, reject the project.

Internal Rate of Return (IRR)

Internal Rate of Return (IRR) is a well-known method of investment analysis. It has been indicated that in a particular sector, the application of IRR is the fundamental method of investment analysis. An investment's Net Present Value (NPV) has a discount rate referred to as the internal rate of return when it becomes equal to zero. The formula of NPV is equated to zero to find the discount rate in the calculation of IRR (Thomas, 2017).

IRR can be defined as the value of "r" satisfying the equation NPV = \$0; with the formula below:

$$\mathbf{\$0} = \sum_{\mathbf{t=1}}^{\mathbf{n}} \frac{\mathbf{CF_t}}{(\mathbf{1+IRR})^{\mathbf{t}}} - \mathbf{CF_0}$$

The decision criteria when IRR is used to make accept–reject are as follows:

IRR > WACC, accept the project.

IRR < WACC, reject the project.

Payback Period (PBP)

The payback period is the time needed to recover its initial investment in a project based on calculated cash inflows (Gitman & Zutter, 2015).

$$\text{Payback Period} = \frac{\textbf{Initial Investment}}{\textbf{Anual Cash Inflow}}$$

The decision criteria when Payback Period is used to make accept–reject are as follows:

PBP < Equipment Service Life, accept the project.

PBP > Equipment Service Life, reject the project.

RESULTS AND DISCUSSION

Interview Results and Thematic Analysis

Semi-structured interviews were conducted with six (6) participants from relevant departments: two from PT ABC South Sumatera (regarding electricity supply capacity and grid reliability), two from the Engineering & Development Department (regarding project technical feasibility and investment planning), one from the Energy Conservation & Loss Control Department (regarding steam-power balance and EII improvement), and one from the Electrical & Instrument Inspection Engineering Department (regarding grid protection system and commissioning requirements). The thematic analysis of the interview data identified four main themes that consistently emerged across respondents:

(1) Technical Feasibility Confidence: All respondents from technical departments expressed confidence that the PT ABC 150 kV interconnection is technically feasible, provided that proper engineering analyses including load flow study, protection coordination study, and harmonic analysis are completed prior to implementation. The synchronization between the PT ABC grid and the internal gas turbine generator was identified as a critical technical challenge requiring careful design and testing. (2) Economic Value Recognition: All respondents acknowledged the significant economic benefits of the project, including reduction of natural

gas consumption, reduction of maintenance costs for gas turbines, and lower electricity tariff from PT ABC compared to the current internal generation cost. The rising natural gas price trend was cited as a major driver for the urgency of the project. (3) Operational Risk Awareness: Respondents highlighted the need for robust risk mitigation measures, particularly for power grid disturbances. The implementation of an islanding system and adaptive load shedding were consistently mentioned as essential safeguards. (4) SOE Synergy and Strategic Alignment: The partnership between PT XYZ and PT ABC as state-owned enterprises was viewed positively as a factor that facilitates coordination and government policy alignment, contributing to the strategic importance of the project.

SWOT Analysis

The SWOT analysis identifies the internal and external factors that influence the feasibility of the PT ABC interconnection project. The strengths of the project include the potential for significant reduction in operational costs through lower electricity tariffs from PT ABC (Rp. 996.74/kWh vs. higher internal generation cost), reduction in EII from 153 (Q4) to an improved level, and decreased dependency on a single natural gas fuel source which currently accounts for 80% of total energy needs. Furthermore, this project directly supports PT XYZ's strategic initiative on decarbonization and energy efficiency improvement.

The weaknesses involve high initial capital investment of approximately Rp. 173 billion, complex engineering and system integration requirements including load flow study, stability analysis, and protection coordination, steam-power balance complexity due to the close linkage between gas turbines and WHRUs (a reduction in turbine operation will affect the steam supply, requiring increased boiler usage), and dual system operation complexity requiring more sophisticated control mechanisms and higher operator skill levels. The opportunities include a large PT ABC electricity surplus in South Sumatera of approximately 1,800 MW against a peak load of only 1,221 MW, high PT ABC 150 kV grid reliability at approximately 99%, lower electricity tariff rates compared to internal production costs, SOE synergy between PT XYZ and PT ABC facilitating coordination and approvals, and the potential for sustainable EII improvement contributing to ESG objectives. The threats encompass PT ABC grid disturbance risk (voltage sag, frequency fluctuation), PT ABC electricity tariff volatility subject to government regulation through the Ministry of Energy and Mineral Resources, increased dependency on PT ABC power, integration and synchronization risk particularly during commissioning, and project implementation risks such as cost overruns and schedule delays.

Technical Analysis

The following design requirements were established as the basis for the installation/interconnection of the PT ABC 150 kV system within Plaju Refinery Unit III: (1) The PT ABC 150 kV grid interconnection adds 2×31.5 MVA of power capacity at a secondary voltage of 12 kV, with a total effective additional capacity of approximately 37 MW at power factor 0.8. (2) Interconnection is achieved through a 150/12 kV 2×31.5 MVA step-down transformer designed in accordance with IEC 60076 Standard. (3) Installation requires a 150 kV Gas Insulated Switchgear (GIS) as the handover point. (4) The protection system scheme is designed in accordance with IEEE Standard 242, with back-flow export protection. (5) The GTG's operational pattern will be base-load at 12 MW, with the remaining 12 MW supplied by PT ABC through the 150 kV transformer. (6) Upgrading/reconfiguration of the System Load Shedding to Adaptive Load Shedding is required.

Based on the Subject Matter Expert from PT ABC South Sumatera, the total generation capacity installed in South Sumatra amounts to 3,322 MW, while the dependable (net) capacity stands at 3,142 MW. The highest peak load recorded during 2024 amounts to 1,221 MW, implying a surplus capacity of approximately 1,800 MW — more than sufficient for the 31.5 MVA load requirement of RU III Plaju.

Table 3. Steam-Power Configuration Before and After Project

Power and Steam Configuration	Before Project	After Project
Operating Equipment	2 units GT, 2 units WHRU, and 1 unit PB: GT 2015 UB load 14 MW + WHRU UB GT 2015 UC load 10 MW + WHRU UC PB 2011 UA/UB	1 unit GT, 1 unit WHRU, and 2 units PB: GT 2015 UA/UB/UC load 12 MW + WHRU UA/UB/UC PB 2011 UA PB 2011 UB

Source: Based on Company Internal Data

Table 4. Steam Balance in Utilities Section After Project

Steam Production (Ton/hour)	Case GT UA Operate 12 MW	Case GT UB Operate 12 MW	Case GT UC Operate 12 MW
WHRU UA	58.2	-	-
WHRU UB	-	58.2	-
WHRU UC	-	-	56.2
PB UA	32.6	32.6	33.6
PB UB	32.6	32.6	33.6
TOTAL	123.4	123.4	123.4

Source: Based on Author Calculation

Table 5. Steam Spare Capacity in Utilities Section After Project

Steam Spare Capacity (Ton/Hour)	Case GT UA Operate 12 MW	Case GT UB Operate 12 MW	Case GT UC Operate 12 MW
PB 2011 UA	17.4	17.4	16.4
PB 2011 UB	17.4	17.4	16.4
Total	34.8	34.8	32.8

Source: Based on Author Calculation

The steam needs of RU III Plaju after the PT ABC interconnection project can be met by maximum extra firing of one (1) WHRU unit and operating two (2) Package Boilers, with a spare steam production capacity of approximately 32–34 Ton/hour. The project implementation will take place in four years starting from 2027 until 2030, with major construction and installation works in 2028, system commissioning and operation at the end of 2029, and normal operation in early 2030.

Cost Saving Calculation

The energy cost savings are calculated based on the difference in total fuel consumption before and after the project. The total fuel consumption formula in the utilities section is: Total Fuel Consumption = FPG + FSG = FGT + (FWHRU + FPB), where FPG is Fuel Consumption for Power Generation, FSG is Fuel Consumption for Steam Generation, FGT is Fuel Consumption of Gas Turbine, FWHRU is Fuel Consumption of Waste Heat Recovery Unit, and FPB is Fuel Consumption of Package Boiler. The fuel consumption estimation results are presented in Table 6.

Table 6. Fuel Consumption Estimation Before vs After Project

Parameter	Total Fuel Consumption
Total Fuel Consumption Existing (Before) GT 2015 UB load 14 MW and WHRU UB GT 2015 UC load 10 MW and WHRU UC PB 2011 UB	16,669 MMSCFD
Total Fuel Consumption (After) - GT 2015 UA in Operation PT ABC 12 MW + GT 2015 UA load 12 MW + WHRU UA PB 2011 UA and PB 2011 UB	12,863 MMSCFD
Total Fuel Consumption (After) - GT 2015 UB in Operation PT ABC 12 MW + GT 2015 UB load 12 MW + WHRU UB PB 2011 UA and PB 2011 UB	13,382 MMSCFD
Total Fuel Consumption (After) - GT 2015 UC in Operation PT ABC 12 MW + GT 2015 UC load 12 MW + WHRU UC PB 2011 UA and PB 2011 UB	13,188 MMSCFD

Source: Author's Calculation

Table 7. Energy Savings After Project Implementation

Case of GT Operates	Energy Saving (MMSCFD)	Energy Saving (BSRF/Day)
GT 2015 UA	3.806	602.76
GT 2015 UB	3.286	520.54
GT 2015 UC	3.481	551.33

Note: Conversion: BSRF/Day = MMSCFD × 22 × 1.1 × 6.545

Source: Author's Calculation

With a natural gas price basis of 51 USD/BSRF (new gas price formula), a USD exchange rate of Rp. 16,500, and 330 operational days per year, the energy cost savings per year for each case are presented in Table 8.

Table 8. Energy Cost Savings per Year After Project Implementation

Case	Energy Cost Saving (IDR/Year)
GT 2015 UA	167,383,438,200
GT 2015 UB	144,551,355,300
GT 2015 UC	153,101,584,350

Source: Author's Calculation

After project implementation, with one gas turbine operating and two on standby (versus two operating and one on standby previously), the maintenance cost saving is Rp. 6,791,706,290 per year.

CAPEX and OPEX Calculation

This project proposes the interconnection of the existing utility power generation system with an external electricity supply from PT ABC. The estimated investment costs are summarized in Table 9.

Table 9. Summary CAPEX Estimation

No.	Description	Total (IDR)
1	Electromechanical Works – GIS	142,051,126,026
2	Civil Works – GIS	27,431,619,646
3	Testing and Commissioning Works	1,668,423,508
4	Engineering Works	1,948,830,820
	Total Price	173,100,000,000

Source: PT ABC Quotation, 2025

After project implementation, the OPEX that the company needs to spend every year includes PT ABC electricity cost and maintenance cost. The basis for OPEX calculation is shown in Table 10.

Table 11. OPEX Estimation

No.	Description	Unit of Measurement	Value
A	Electricity Supply from PT ABC	MW	12
B	PT ABC Electricity Tariff	Rp/kWh	996.74
C	Operational Utilization	Days/Year	330
D	Maintenance Cost	Rp/Year	750,000,000

Source: PT ABC & Company Internal Data

The electricity cost is calculated as: 12 MW × 1,000 × Rp. 996.74/kWh × 330 days × 24 hours = Rp. 94,730,169,600 per year. The PT ABC electricity tariff refers to the Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia No. 7 of 2024 — Electricity Tariffs for group I-4/TT (≥30,000 kVA). Maintenance cost is Rp. 750,000,000 per year, referring to the average maintenance cost for electrical equipment at RU III Plaju.

Financial Feasibility Analysis

This investment project is categorized as Non-Business Development, meaning it is not intended to increase the unit's production capacity and therefore does not impact the company's income. The financial feasibility analysis uses the following basis data and assumptions, as presented in Table 12.

Table 12. Financial Analysis Basis and Assumptions

Parameter	Unit of Measurement	Value
CAPEX	IDR	173,100,000,000
OPEX – Electricity Cost	IDR/Year	94,730,169,600
OPEX – Maintenance Cost	IDR/Year	750,000,000
Benefits – Energy Cost Saving (GT UB as base case)	IDR/Year	144,551,355,300
Benefits – Maintenance Cost Saving	IDR/Year	6,791,706,290
Inflation Rate	%	3.40
Project Financing – Equity (E)	%	50
Project Financing – Debt (D)	%	50
Asset Life	Year	20
Cost of Debt before Tax (rd)	%	8.26
Corporate Tax (T)	%	22
Risk Free Rate (RF) – PHEI Yield Bond 20 Years	%	6.6342
Equity Risk Premium (rm–rf) – Damodaran	%	6.87

Source: Internal Company Data, Damodaran, PHEI

This investment project is categorized as Non-Business Development, meaning it is not intended to increase the unit's production capacity and therefore does not impact the company's income. The WACC calculation incorporates the cost of debt and the cost of equity using the Capital Asset Pricing Model (CAPM). Since PT Kilang PT XYZ Internasional is not publicly listed, the beta is estimated using the bottom-up beta approach (Damodaran, 2012) based on PT Perusahaan Gas Negara (PGAS) as the comparable company.

Table 13. Public Company and Beta Value

Company Name	Stock Code	Beta	D/E Ratio
PT Perusahaan Gas Negara	PGAS	0.2772	0.47

Source: PGAS Annual Report & Author's Calculation

The unlevered beta for the firm is calculated as: βunlevered = 0.2772 / (1 + (1−0.22) × 0.47) = 0.2029. The levered beta for the firm is: βlevered = 0.2029 × (1 + (1−0.22) × 1) = 0.3612. The after-tax cost of debt is: ri = 8.26% × (1−0.22) = 6.44%. The cost of equity is: rj = 6.6342% + (0.3612 × 6.87%) = 9.12%. The WACC is therefore: WACC = (0.5 × 6.44%) + (0.5 × 9.12%) = 7.78%. Referring to internal company preference, WACC for PT XYZ oil refining investment in 2024 is 11.40%, which is used as the most conservative basis for this analysis. The equipment's service life is estimated at 20 years. The project EPCC phase is in 2028–2029, with benefits beginning in 2030. Benefits and maintenance OPEX projections use an inflation rate of 3.40% per year. The capital budgeting analysis results are presented in Table 13.

Table 14. Resume of Capital Budgeting Analysis

Parameter	Results	Requirement	Decision
NPV	Rp. 223,643,774,610	Accept if > 0	Accept
IRR	25.90%	Accept if > WACC 11.40%	Accept
PBP	4.1 years	Accept if < Equipment Service Life (20 years)	Accept

Source: Author's Calculation

The project's IRR substantially exceeds the WACC, indicating that the electricity interconnection with PT ABC creates economic value beyond the company's minimum required return and provides a financially attractive alternative to continued dependence on aging internal generation assets.

Sensitivity Analysis

The sensitivity analysis examines changes in NPV with respect to changes in input assumptions of ±20%. Several parameters identified as sensitive include: inflation rate, natural gas price, PT ABC electricity tariff, capital expenditure (CAPEX), maintenance-overhaul cost saving, and maintenance cost. The Tornado Chart analysis shows that natural gas price and PT ABC electricity tariff have the highest impact on NPV. Natural gas price was identified as the dominant sensitivity variable, implying that the economic attractiveness of the project increases significantly with future gas price escalation. The lowest NPV of Rp. 25,268,075,085 occurs when the natural gas price decreases by 20%.

Risk Analysis

The risk assessment for the technical/operational aspect refers to the results of thematic interview results and the SWOT analysis, following ISO 3100:2018 risk assessment procedures. The result of risk assessment is summarized in Table 15.

Table 15. Risk Assessment Summary

Risk Description	Likelihood	Impact	Risk Level	Risk Mitigation
PT ABC Grid Disturbance	Medium	High	Medium (Highest RPN)	Install advanced protection system, implement islanding system, maintain minimum GT reserve, provide UPS backup power, update power-steam shedding procedure

PT ABC Tariff Volatility	Medium	Medium	Medium	Establish long-term Power Purchasing Agreement (PPA); close monitoring of tariff policy
Integration & Synchronization Risk	Low	High	Medium	Strict commissioning quality assurance; protection system coordination
Project Cost Overrun & Delay	Low	Medium	Low	Detailed engineering design; effective project management and change management
Increased Dependency on PT ABC	Medium	Medium	Medium	Maintain gas turbine operational readiness as backup

Source: Author's Analysis

PT ABC Grid Disturbance has been identified as the main residual risk with the highest Risk Priority Number (RPN) at a medium risk level. The risk mitigation includes: (1) installing an advanced protection system with under-voltage, over-voltage, and frequency relays; (2) implementing an islanding system so the refinery can operate independently via internal GTGs in case of disturbances outside the refinery; (3) maintaining minimum GT reserve; (4) providing UPS and backup power for critical control and safety systems; and (5) updating the power-steam shedding procedure.

From a financial risk perspective, Monte Carlo simulation with 1,000 iterations shows a distribution close to normal (kurtosis −0.05, skewness −0.10), indicating the simulation model is stable and does not show extreme risks. The probability of positive NPV is 90.85%, while the probability of negative NPV is 9.15%. The mean NPV (Rp. 225,245,811,590.51) and median NPV (Rp. 228,502,407,412.63) are both higher than the NPV base case of Rp. 223,643,774,610, further confirming the financial resilience of the project.

The findings of this research comprehensively address the three research questions. Regarding technical feasibility, the operational integration configuration of one 12 MW gas turbine-generator supported by 12 MW of external PT ABC electricity is technically viable. The PT ABC South Sumatera grid offers a surplus capacity of approximately 1,800 MW, ensuring adequate supply for the 31.5 MVA requirement of RU III Plaju. The steam-power balance analysis confirms that the utilities section can maintain the required steam production of 123.4 Ton/hour through one WHRU and two Package Boilers operating simultaneously, with a spare capacity of 32–34 Ton/hour to accommodate process fluctuations. The project's operational integration satisfies all technical design requirements including IEC 60076, IEC 61850, and IEEE Standard 242 compliance.

Regarding financial feasibility, the project demonstrates strong investment viability across all three capital budgeting metrics: NPV of IDR 223.64 billion (positive), IRR of 25.90% (significantly exceeding WACC of 11.40%), and PBP of 4.1 years (well within the 20-year asset life). The net annual cost benefit — total cost savings of approximately IDR 151.34 billion minus OPEX of IDR 95.48 billion — yields a net annual benefit of approximately IDR 55.86 billion, providing a strong basis for the positive NPV result. The sensitivity analysis reveals that natural gas price is the dominant sensitivity variable; however, even at a −20% swing in natural gas price, the NPV remains positive at Rp. 25,268,075,085, indicating robustness of the investment case.

Regarding energy efficiency improvement, the project reduces the Energy Intensity Index (EII) by 6.41–10.03 points depending on which gas turbine is kept in operation. Given the current EII of 153 (Q4), this improvement represents meaningful progress toward the industry's quartile benchmark, though further investment and quick-win programs may still be required to reach Q1 levels (EII = 82). The reduction in natural gas consumption of approximately 3.20–3.80 MMSCFD also directly reduces the refinery's CO_2 emissions, contributing to PT XYZ's 2060 Net Zero Emission roadmap and ESG performance metrics.

The comparison of this project with the existing case of on-grid transition studies in the literature supports the findings. Nurliani & Noveria (2024) documented a 66% reduction in LCOE and a 15% reduction in CO_2 emissions from transitioning to on-grid electricity, which is directionally consistent with the findings of this study. The significant economic advantage of external grid electricity over internal fossil fuel-based generation is also consistent with the theoretical framework by Bielefeld et al. (2025), who showed that electrification of industrial utility systems is economical when external electricity prices are lower than natural gas costs for more than 600 hours — a threshold easily exceeded by the proposed 330-day/year, 24-hour operational schedule of this project. These comparative references provide confidence that the quantitative projections of this study are well-founded.

The risk assessment results align with the findings of Kurniawan et al. (2025), which highlighted the importance of protection system coordination and contingency planning in 150/275 kV interconnected power systems in South Sumatra. The proposed mitigation measures — advanced protection systems, islanding capability, minimum GT reserve maintenance, UPS backup, and updated power-steam shedding procedures — collectively address the primary residual risk of PT ABC grid disturbance at a manageable medium risk level. The Monte Carlo simulation further quantifies the financial risk, providing management with a 90.85% confidence level of positive financial returns, which is a strong basis for investment approval.

CONCLUSION

Based on the research findings, the PT ABC interconnection project is technically feasible, financially viable, and manageable in terms of risk. From a technical perspective, the project can be implemented with a configuration of one 12 MW gas turbine-generator supported by 12 MW of external PT ABC electricity, improving energy efficiency by reducing the EII by 6.41–10.03 points and lowering fuel consumption by approximately 3.20–3.80 MMSCFD; in addition, the integration creates a dual power supply system that improves reliability while the refinery can still meet steam demand through WHRU and package boilers. From a financial perspective, the project generates total cost savings of approximately IDR 151.34 billion per year despite annual OPEX of IDR 95.48 billion, yields a positive NPV of IDR 223.64 billion, an IRR of 25.90% substantially above the required WACC of 11.40%, and a Payback Period of 4.1 years, with Monte Carlo simulation confirming financial resilience at a 90.85% probability of positive NPV. From a risk perspective, the most significant technical risk is PT ABC grid disturbance, which is manageable through installation of advanced protection systems, islanding capability, maintenance of minimum GT reserve, provision of UPS backup power, and updated power-steam shedding procedures; while financial risks are well within acceptable bounds as confirmed by the Monte Carlo simulation results. As recommendations, management should prepare a comprehensive Investment Project Proposal coordinated with all stakeholders, ensure all planning documents comply with national grid codes and the requirements of PT XYZ, PT ABC, and relevant international standards, implement effective project monitoring during EPCC phase with attention to high-voltage equipment installation and change management, establish an MoU and a long-term Power Purchasing Agreement (PPA) with PT ABC with negotiation for priority customer status given the refinery's nature as a national strategic asset, and plan normal configuration of one gas turbine plus PT ABC external electricity with 330 operational days per year and a structured maintenance schedule for package boilers and electrical equipment.

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