Volume 4, No. 9 September 2025 - (1549-1565)
p-ISSN 2980-4868| e-ISSN 2980-4841
https://ajesh.ph/index.php/gp

Financial Feasibility Study of the Business Model Transition From Captive Power Users in East Java to PT PLN Electricity Based on Renewable Energy

Areta Predikty, Eko Adhi Setiawan
Universitas Indonesia
Email: areta.predikty@ui.ac.id

ABSTRACT

The transition to renewable energy is a top priority to reduce carbon emissions, especially from the industrial sector, which contributes significantly through the use of fossil fuel captive power plants in East Java. This study aims to develop and evaluate a business model that can encourage the captive power user industry to switch to renewable energy-based electricity provided by PT PLN (Persero). The research method integrates a qualitative approach through the Sustainable Business Model Canvas (SBMC) to analyze the elements of the business model and SWOT analysis to identify strategic factors, with a quantitative approach through financial feasibility evaluation. Primary data were obtained from interviews with captive power users in East Java, while secondary data included costs and technical parameters. The results of the SBMC and SWOT analysis were used to design two main business models: (1) Integrated Renewable Energy with Priority Services, and (2) Integrated Renewable Energy with Steam as a Service. A financial feasibility evaluation shows that the Priority Service Model is economically feasible, while the Steam as a Service Model shows very limited feasibility—viable only at a 1 km distance with 8- and 10-inch pipe diameters—and is highly sensitive to small changes in revenue. This research is expected to contribute to the formulation of an effective and sustainable energy transition strategy for the industrial sector in East Java and support the achievement of the Net Zero Emission target.

Keywords: Captive Power, Sustainable Business Model Canvas, SWOT, Model Bisnis

INTRODUCTION

Industry is one of the largest contributors to carbon emissions in the world. According to a report by the International Energy Agency (IEA) in 2021, the industrial sector accounted for around 24% of total CO2 emissions in Indonesia, which is the second-largest contributor after the power sector. The industrial sector contributes significantly to carbon emissions not only from its operational processes but also using captive coal-fired power plants. A captive power plant is a steam power plant operated by an industrial company to meet its own energy needs. According to data compiled by the Ministry of Energy and Mineral Resources, as of 2024, industrial coal-fired power plants in Indonesia owned by companies holding Business Licenses for the Provision of Electricity for Own Use (IUPTLS) have a total installed capacity of approximately 11,372 MW. On the island of Java, these plants are located solely in the provinces of Banten (542 MW), East Java (280 MW), and West Java (142 MW). This makes East Java one of the largest contributors to CO2 emissions in the industrial sector on the island of Java. The use of captive power, while providing energy independence for industry, significantly increases carbon emissions and worsens the quality of the environment in East Java. Some of the province's major companies, such as PT Petrokimia Gresik, PT Cheil Jedang Indonesia, and PT Pabrik Kertas Tjiwi Kimia, rely on captive coal-fired power plants to support their operations, thereby contributing to the region's high carbon emissions.

In a global effort to address climate change, reducing carbon emissions is one of the top priorities (Setiawan & Effendi, 2023). Currently, many countries, including Indonesia, are committed to reducing carbon emissions and increasing the use of renewable energy. Global companies are also participating in this commitment through the Sustainable Development Goals (SDGs) and initiatives such as RE100. The RE100 initiative, which includes leading companies such as Ajinomoto, Unilever, and IKEA, affirms that the use of green energy is not only beneficial to the environment but also supports business sustainability and improves the company's reputation (RE100 Members, 2024).

In response to this challenge, PT PLN (PERSERO) is committed to accelerating the energy transition in East Java by increasing the use of renewable energy. In the 2024-2033 Electricity Supply Business Plan (RUPTL), PT PLN (PERSERO) targets increasing renewable energy generation capacity to reach 75% of the total new capacity, or around 59.1 GW. In East Java, the potential for renewable energy development is vast, especially from solar and geothermal energy sources (Gürel & Tat, 2017). Currently, although most of PT PLN (PERSERO)'s power plants are still dominated by fossil fuels, PT PLN (PERSERO) has started to switch to renewable energy and is trying to invite captive coal-fired power plant owners to switch to using electricity supplied by PT PLN (PERSERO). In the long term, when the power plants of PT PLN (PERSERO) are fully renewable energy-based, this step will be an effective solution to reduce carbon emissions from the industrial sector, thereby creating a cleaner and more sustainable environment in the future.

The Indonesian government has also strengthened its commitment to the energy transition with policies that support the development of renewable energy, including a ban on the construction of new coal-fired power plants that are not integrated with industries or national strategic projects. Presidential Regulation Number 112 of 2022 is an important legal basis that directs this energy transition effort. In addition, demands from the global market are increasingly encouraging companies to switch to clean energy through international regulations related to the requirements of export destination countries for products produced using renewable energy to reduce the global carbon footprint (Export-Import Bank of the United States (EXIM), 2023). This raises awareness among industries in East Java to reduce their dependence on fossil fuel-based captive power and switch to renewable energy-based electricity (Black, 2023; Creswell, 2015).

To ensure that this transition is effective and efficient, there needs to be a comprehensive and sustainable strategic approach (Badan Kebijakan Fiskal Kementerian Keuangan, 2021). This is where the importance of using the Sustainable Business Model Canvas (SBMC) as the main tool in designing and evaluating business models that not only support the use of renewable energy but also ensure economic sustainability for the industry and PT PLN (PERSERO). SBMC provides a structured framework for identifying opportunities and challenges, as well as designing strategies that can integrate renewable energy into overall business operations. In this context, SBMC analysis is very important for PT PLN (PERSERO) to formulate an effective business strategy in driving this transition. SBMC will help PT PLN (PERSERO) in understanding market dynamics, industry needs, and challenges that may be faced in the energy transition in East Java.

The next important step is to conduct a financial feasibility evaluation of the proposed business model, with the aim of providing a comprehensive picture of the economic implications of the energy transition (Blank, Tarquin, & Coalla, 2012). This evaluation includes an analysis of the potential savings that can be obtained as well as the long-term economic benefits for industrial customers and PT PLN (PERSERO). This evaluation can be reinforced with break-even point analysis to determine the time or scale of production required for the business model to achieve financial balance, as well as sensitivity analysis to evaluate the impact of key variable changes on the feasibility of the business model (Galar, Sandborn, & Kumar, 2017). With this comprehensive approach, the proposed business model is expected to support decision-making in transitioning to renewable energy-based electricity, thereby not only contributing to reducing carbon emissions and improving environmental quality but also providing significant economic added value for all parties involved.

Previous research by Aprilianti and Prasetyo (2021) highlighted that Indonesia's energy transition still faces major challenges, particularly the dominance of fossil fuels and the low adoption rate of renewables in the industrial sector, suggesting the need for business models that balance economic and sustainability aspects. Meanwhile, Handayani et al. (2022) emphasized the critical role of government policies in driving industrial decarbonization but did not specifically examine how state-owned electricity companies can strategically integrate renewable energy into concrete business frameworks. Both studies mainly focused on policy and macro-level challenges, leaving a gap in analyzing practical tools such as the Sustainable Business Model Canvas (SBMC) to support PT PLN (PERSERO) in encouraging industries to shift from coal-based captive power plants to renewable energy.

The objective is to formulate relevant and sustainable business strategies to accelerate the energy transition in East Java's industrial sector. The benefits include providing practical insights for PLN and industrial players to adopt renewable energy, enriching academic literature on sustainable business strategies, and supporting Indonesia's broader agenda of decarbonization and environmental sustainability.

METHOD

This study adopted a mixed-methods approach to develop a suitable business model that encouraged captive power users to transition to renewable energy-based electricity supplied by PT PLN (Persero). The research process was carried out in sequential stages, beginning with data collection and followed by analysis of the *Sustainable Business Model Canvas* (*SBMC*) and financial feasibility. Primary data were obtained through interviews with selected respondents—industry players in East Java who utilized captive power fueled by coal and gas (Chasin, Paukstadt, Gollhardt, & Becker, 2020). Secondary data were sourced from PT PLN (Persero) and other official institutions, including cost assumptions for the proposed business model, captive power capacity, connected power, and customer profiles of captive power users. This combination of primary and secondary data ensured that the analysis was based on both field realities and existing institutional records.

Sample selection was conducted using purposive sampling to ensure that respondents possessed characteristics directly relevant to the research objectives (Reis, Gonçalves, Lopes, & Antunes, 2021). The sample consisted of four industries: two coal-fueled captive power users (Respondent 1/R1 and Respondent 2/R2) and two gas-fueled captive power users (Respondent 3/R3 and Respondent 4/R4). Data collection employed both open- and closed-ended interview questions to capture comprehensive insights into the transition process. The qualitative findings were then integrated with quantitative financial analysis to evaluate the feasibility of the proposed business model. This included calculating cost assumptions, break-even points, and long-term economic benefits to assess how renewable energy-based electricity could provide practical and sustainable solutions for industries and PLN in East Java.

RESULT AND DISCUSSION

Business Model Formulation

Based on a comprehensive analysis of primary data in the form of questionnaires distributed to potential industrial customers and secondary data in the form of analysis of the Sustainable Business Model Canvas (SBMC) and Strengths, Weaknesses, Opportunities, Threats (SWOT) PT PLN (Persero), several strategic business model propositions can be formulated. These business models are intended to address market needs, leverage internal strengths, capitalize on external opportunities, and mitigate potential weaknesses and threats. The following are the business models that can be taken from the questionnaire analysis and SBMC and SWOT analysis:

Renewable Energy Business Model Integrated with Priority Services

This business model is designed as a strategic response to the dual needs of industrial customers, namely the transition to clean energy and the guarantee of supply reliability. Its main value proposition is the provision of electricity from renewable energy sources, which directly supports customer's goals to reduce operational costs and carbon emissions, as reflected in the SBMC and the expectations of the questionnaire respondents. Moreover, the use of renewable energy enhances corporate image and sustainability reputation, an aspect that is also identified as a significant advantage by customers and is part of the Value Propositions within SBMC (Kamran & Fazal, 2020).

Integration with priority services is a crucial element of this model. This service offers a guarantee of increased reliability of electricity supply via a dual-feeder system and compensation mechanism-an identified strength according to the SWOT analysis. This effectively answers concerns about the reliability of PT PLN (Persero) compared to captive power, which is one of the weaknesses identified. From SBMC's perspective, this model strengthens Customer Relationships through dedicated support for Priority Customers. The socio-ecological benefits of this model include a reduction in the company's carbon footprint and an improvement in the company's reputation, in line with the Eco-Social Benefits within the SBMC.

Integrated Renewable Energy Business Model with Steam as a Service

This second business model offers an innovative and comprehensive solution for industries that not only require renewable electricity but also rely heavily on steam for their production processes (Osterwalder & Pigneur, 2013). Its core value proposition is the provision of electricity based on renewable energy, with the benefits of reducing carbon emissions and improving the company's image, which is then combined with steam supply services (Steam as a Service) (Kementerian ESDM, 2024).

The development of this model is based on a SWOT analysis that identifies the dependence on captive power for the needs of industrial processes that require steam as a significant drawback (Namugenyi, Nimmagadda, & Reiners, 2019). Furthermore, the threat of corporate dependence on steam from captive coal-fired power plants that creates technological lock-in and large investments in captive power infrastructure that cause change resistance are the main drivers of this innovation. By offering Steam as a Service, PT PLN directly targets the Customer Segments in SBMC, which are companies with high dependency due to the use of steam from captive power (Lazell, Lang, Silbert, Feldman, & Stainer, 2024). The implementation of this model will help captive power users who need to develop technology and infrastructure that are in accordance with the energy transition, in accordance with the Key Resources in SBMC, as well as help provide solutions for the initial investment costs for the provision of technology and infrastructure as recorded in the Cost Structures. Thus, PT PLN not only supplies clean electricity but also helps customers overcome their dependence on steam from fossil sources, facilitating a more holistic energy transition (Lüdeke-Freund, Carroux, Joyce, Massa, & Breuer, 2018).

Financial Feasibility Study of Business Model

After formulating and validating the business model through the analysis of the Sustainable Business Model Canvas (SBMC) and SWOT in the previous chapter, the next stage in this study is to conduct quantitative testing to assess the financial viability of the model from a financial perspective. This analysis is a crucial step to transform the business conceptual framework into a measurable business projection, which serves as a basis for investment decisions by stakeholders (Mukoro, Sharmina, & Gallego-Schmid, 2022).

The Basic Assumptions of Financial Analysis

To calculate the financial feasibility of the business model that has been created, there are variables used in the calculation, including:

a. The Basic Electricity Tariff used in the calculation is the electricity tariff for group L customers which is IDR 1644.52/kilowatt-hour (kWH). (Minister of Energy and Mineral Resources Regulation No.28 of 2016)
b. The Cost of Supply (BPP) of Renewable Energy (NRE) is set at IDR 1,392.58/ kilowatt-hour (kWH). This value is obtained through the calculation of a weighted average that is specific to the NRE energy mix in East Java. This calculation refers to production data per type of plant (PLTP, PLTA, PLTS and PLTB) and BPP data is taken from the upper limit (highest value) in the confidential BPP data range per technology provided by PT PLN (Persero). (PERDIR No.022.P.DIR.2020, 2020)
c. The Discount Rate is assumed at 9.80%. (PERDIR No.022.P.DIR.2020, 2020)
d. Operating and Maintenance costs are estimated at 3% of Investment per year. (PERDIR No.022.P.DIR.2020, 2020)
e. Lifetime 10 years. (PERDIR No.022.P.DIR.2020, 2020)
f. Income Tax of 22% based on (Law No. 7 of 2021, 2021) concerning the Harmonization of Tax Regulations (HPP Law)
g. Depreciation is calculated using the straight-line method, where total investment is divided by its lifespan.
h. The cost of steam is IDR 2,623/ton of steam (Jounas et al., n.d.)

i. The steam tariff is the cost of steam plus a 10% margin
j. Killowatt-hour (kWh) sold is derived from the electricity consumption of a captive power user company if it switches to using PT PLN (Persero) electricity, amounting to 27,404,000 killowatt-hour.

Investment Cost Component

Priority Service Investment Costs

The initial capital expenditure (CAPEX) for the Priority Services business model is focused on building the electricity infrastructure needed to ensure a superior level of supply reliability as promised by the service. Based on the needs analysis, the main investment component identified is the construction of a new dedicated feeder network from the nearest Substation (GI) to the location of industrial customers.

The total length of the new feeder network modeled in this case study is 2,860 meters of circuit (ms) or the equivalent of 2.86 km. The structure and cost details for the construction of this new feeder refer to the construction cost standards and the Cost Budget Plan (RAB) that is commonly used within PT PLN (Persero). However, given that the detailed details of cost per material and unit price are confidential internal company data, this study cannot present them explicitly.

To overcome this, while maintaining the validity of the analysis, this study presents a representative cost model. The model is based on the actual component structure, but the unit cost figures have been adjusted proportionally to protect the confidentiality of the original data. This approach ensures that the total investment value remains realistic and reflects the actual scale of the project, so that the results of the financial feasibility study can still be accounted for. Details of the main components of the investment costs for this representative model are presented in table 1

Table 1. Representative Model

No.	Cost Component Categories	Estimated Cost (IDR)
1.	Main Networking Materials (Poles, Conductors & Accessories)	1.338.163.600
2.	Main Equipment (Transformer, LBS, FCO & Arrester)	758.950.000
3.	Grounding System	94.200.000
4.	Construction, Installation, and Testing Services	875.000.000
	SUBTOTAL DIRECT COSTS	3.066.313.600
5.	Indirect Costs (Licensing & Project Management)	406.631.360
	TOTAL PROJECT COST	3.472.944.960
6.	Contingency (10%)	447.294.496
	TOTAL ESTIMATED COST OF INVESTMENT (CAPEX)	3.920.239.456

Based on the details in the representative cost model, the total estimated Investment Cost (CAPEX) to implement this Premium Service business model is IDR 3,920,239,456,- (Three billion nine hundred and twenty million two hundred thirty-nine thousand four hundred fifty-six rupiah). The total value of this investment will then be the main basis in the calculation of depreciation expenses and cash flow analysis to determine the financial feasibility of the project.

Steam as Service Investment Cost

The initial cost of investment (CAPEX) for the Steam as a Service business model is fundamentally different from other models, as it focuses on building thermal distribution infrastructure. The scope of cost analysis in this model expressly does not include the cost of building the Geothermal Power Plant (PLTP) itself. The assumption used is that investment starts from the connection point at the existing PLTP facility to the customer's facility.

The largest and most dominant component of the investment cost is the construction of a major insulated steam pipeline to convey steam. The total cost for this network is very sensitive and is a direct function of the two main variables that this study focuses on: distribution distance (1, 2, and 3 km) and pipe diameter (8, 10 and 12 inches). An increase in these two variables will directly increase the total cost of materials and construction costs.

In addition to the pipeline itself, the investment cost also includes essential supporting infrastructure at both ends of the network. This includes upstream side infrastructure at the PLTP site such as the initial metering station and control valve, as well as the downstream side infrastructure at the customer site consisting of receiving stations, pressure reducing valve (PRV) equipment to adjust steam specifications, and the final meter as the billing base. Other costs such as licensing, technical design, civil works, and contingency costs are also taken into account as part of the total investment.

Cost estimates for such components are based on industry benchmarks for steam piping projects, engineering literature studies, and vendor data. The total cost of investment (CAPEX) will be calculated specifically for each of the 9 scenarios analyzed. To provide an in-depth understanding of the methodology of calculating cash flow and feasibility, an example of a detailed calculation for the scenario of investment costs with a pipe with a diameter of 8 Inch and a distance of 1 km can be seen in Table 2.

Table 2. Estimated Investment Cost of 8" Pipe - Distance 1 km

Cost Component	Unit	Volume/Quantity	Unit Price (IDR)	Total Cost (IDR)	Data Sources/Assumptions
A. Direct Material Costs					
Carbon Steel Pipe (8", SCH 40)	metre	1000	5.850.880	5.850.880.000	(*Pipa Seamless 8"SCH40 ASTM Grade B* , n.d.)
Insulation Material (CaSi 50mm, 8" Pipe)	metre	1000	981.147	981.147.000	(*Calcium Silicate Insulation Pipa*, n.d.)
Main Valve (Gate Valve 8")	Unit	1	22.400.000	22.400.000	(*8" 300 FLANGED RAISED FACE GATE VALVE WCB*, n.d.)
Steam Trap (1")	Unit	14	1.500.000	21.000.000	(*Steam Trap*, n.d.)
Supporting Materials (15% of Pipe Cost)				877.632.000	General Estimates
Subtotal A				*7.753.059.000*	
B. Installation & Construction Costs					
Civil Works - Pipe Foundation	unit	100	2.000.000	200.000.000	(*Pipe Hangers and Supports - Pipe Supports* , n.d.)
Mechanical Works - Pipe Erection	Inch-metre	8.000	25.000	200.000.000	(*PENGELASAN PIPA (Stainless Steel)* , n.d.)
Mechanical Works - Pipe Welding	inch-joint	1.328	60.000	79.680.000	(*PENGELASAN PIPA (Stainless Steel)* , n.d.)
Mechanical Works - Valve Installation	Unit	1	6.720.000	6.720.000	(30% of 8" valve material cost)

Cost Component	Unit	Volume/Quantity	Unit Price (IDR)	Total Cost (IDR)	Data Sources/Assumptions
Mechanical Works - Steam Trap Installation	Unit	14	500.000	7.000.000	(33% of steam trap price)
Insulation Installation	metre	1.000	250.000	250.000.000	(50% of steam trap installation price)
Subtotal B				*743.400.000*	
Total Direct Costs (A+B)				*8.496.459.000*	
C. Indirect Costs					
Engineering, Design, Survey (10% of Total Direct Costs)	%	10%		849.645.900	General Estimates
Land Acquisition & ROW (5% of Total Direct Costs)	%	5%		424.822.950	General Estimates
Project Management & Supervision (7.5% of Total Direct Costs)	%	7,5%		637.234.425	General Estimates
Mobilization & Demobilization (3% of Total Direct Costs)	%	3%		254,893,770	General Estimates
Subtotal C				*2.166.597.045*	
D. Project Cost Subtotal (A+B+C)				10.663.056.045	General Estimates
Contingency (10% of D)	%	15%		1.066.305.605	General Estimates
TOTAL ESTIMATED INVESTMENT COST (8", 1 km)				**11.729.361.650**	

Furthermore, the final results of the overall scenario can be seen in table 4.3 to allow for effective comparative analysis. The investment value of each scenario will be the main basis in calculating depreciation expense and will be an input in the cash flow analysis to determine financial feasibility in the next section

Table 3. Investment Costs of each Scenario for Steam as Service

No	Pipe Diameter (inch)	Distance (km)	Investment Fee (IDR)
1	8	1	11.729.361.650
2	8	5	23.389.952.894
3	8	10	35.029.425.756
4	10	1	15.928.178.354
5	10	5	31.679.372.934
6	10	10	47.601.328.357
7	12	1	23.646.386.588
8	12	5	47.071.510.398
9	12	10	70.702.133.689

Calculation of Financial Feasibility Study

Based on two business models that have been developed, namely the Integrated Renewable Energy Business Model with Priority Services and the Integrated Renewable Energy Business Model with Steam as a Service Service, this section presents a quantitative analysis to test the financial feasibility of each proposal. The analysis will be discussed sequentially, starting with a study for the Premium Service model based on electricity network investment, then continued with the Steam as a Service model based on thermal infrastructure. To ensure an objective comparison, both studies are based on a consistent basic financial framework and assumptions, including Discount Rates, tax rates, and project lifespan.

Financial Feasibility Study of Integrated Renewable Energy Business Model with Priority Services

The first business model, which focuses on the provision of premium services, shows very high financial viability. As can be seen in table 4.4, this model is projected to produce a positive NPV value of IDR 1,876,016,686,-. This positive NPV value indicates that the present value of the total expected future cash flow exceeds the initial investment cost, so the project can create value for the company.

The feasibility of this model is strengthened by the IRR value of 37%. This figure far exceeds the Discount Rate set at 9.8%, indicating that the project's internal rate of return is very attractive and well above the cost of capital. In addition, the payback period for this business model is also very short, which is only 1.46 years. This indicates that the initial investment issued can be returned in less than 2 years, indicating low liquidity risk. Thus, it can be concluded that this premium service business model is very feasible to implement from a financial perspective.

Table 4. Financial Feasibility Study of Integrated Renewable Energy Business Model with Priority Services

Year	Cost of Supply	Investment	O&M	Total Operating Costs	Gross Revenue	EBITDA	Depreciation	EBT	Income Tax	Net Profit	Net Cash Flow
0		3920239456									-3920239456
1	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
2	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
3	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
4	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
5	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
6	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
7	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
8	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449
9	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449

Year	Cost of Supply	Investment	O&M	Total Operating Costs	Gross Revenue	EBITDA	Depreciation	EBT	Income Tax	Net Profit	Net Cash Flow
10	38162252602		59782800	38222035402	45066426080	6844390678	199276000	6645114678	1461925229	5183189449	5183189449

Financial Feasibility Study of Integrated Renewable Energy Business Model with Steam as a Service

The steam as a service business model is different from priority services because the focus of investment is on the development of thermal infrastructure to distribute hot steam. The feasibility of this model depends largely on two main factors: the distance of steam delivery and the diameter of the pipe used. Therefore, its financial feasibility analysis will be evaluated in 9 different scenarios that are a combination of distance (1 km, 2 km, 3 km) and pipe diameter (8, 10, and 12 inches). To run a consistent financial model, several key assumptions need to be established as the basis for calculation:

a. Investment Scope: The calculated cost of investment (CAPEX) only covers the steam distribution infrastructure from the connection point in the geothermal power plant (PLTP) to the customer. This analysis does not include the cost of building the PLTP itself.
b. Inlet Steam Specification: The steam entering the pipeline is assumed to be dry saturated steam at a pressure of 10 bar (equivalent to 1.1 MPa) with a temperature of approximately 184.1°C. This specification is representative of industrial applications and corresponds to commonly used technical data.

The main objective of this multi-scenario financial feasibility analysis is to quantify the economic impact of these distance and diameter variables, as well as determine at what point a scenario becomes no longer commercially viable in terms of investment and operational costs. An example of a basic calculation is a pipe with a diameter of 8 inches and a distance of 1 km is shown in table 5 which can then be seen in appendix 1. The results of the overall financial feasibility study can be seen in table 6.

Table 5. Financial Feasibility Study of Renewable Energy Business Model Integrated Renewable Energy with Steam as a Service Service Diameter 8 inch Distance 1 km

Year	Cost of Supply	Investment	Steam Cost	O&M	Total Operating Costs	Gross Revenue	EBITDA	Depreciation	EBT	Income Tax	Net Profit	Net Cash Flow
0		11729361650										-11729361650.0
1	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
2	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
3	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
4	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72

Year	Cost of Supply	Investment	Steam Cost	O&M	Total Operating Costs	Gross Revenue	EBITDA	Depreciation	EBT	Income Tax	Net Profit	Net Cash Flow
5	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
6	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
7	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
8	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
9	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72
10	38162252601.55		229774800	351880849.5	38743098251.05	45319178360	6575270108.95	1172936165	5402333943.95	1188513467.67	4213820476.28	6342605008.72

Table 6. Financial Feasibility Study of Renewable Energy Business Model Integrated Renewable Energy with Steam as a Service

No	Scenario	NPV	IRR	STATUS
1	8 inch 1 km	10.973.750.350,98	21,66%	FEASIBLE
2	8 inch 5 km	-11.407.863.853,95	2,86%	NOT FEASIBLE
3	8 inch 10 km	-26.909.593.718,95	1,04%	NOT FEASIBLE
4	10 inch 1 km	2.914.442.411,98	12,23%	FEASIBLE
5	10 inch 5 km	-27.318.772.437,88	-3,21%	NOT FEASIBLE
6	10 inches 10 km	-57.879.749.682,40	-10,12%	NOT FEASIBLE
7	12 inch 1 km	-11.900.068.742,03	2,63%	NOT FEASIBLE
8	12 inch 5 km	-56.862.804.579,96	-10%	NOT FEASIBLE
9	12 inches 10 km	-105.307.112.004,06	-17,16%	NOT FEASIBLE

At a distance of 1 km, an 8-inch diameter pipe (Scenario 1) shows excellent feasibility with a positive NPV of IDR 10.97 billion and an IRR of 21.66%. A 10-inch diameter pipe (Scenario 4) at the same distance is also declared FEASIBLE, generating an NPV of IDR 2.91 billion with an IRR of 12.23%. However, the 12-inch diameter pipe scenario at a distance of 1 km (Scenario 7) does not achieve feasibility, with a negative NPV of -IDR 11.9 billion and an IRR of only 2.63%. This finding indicates that even at the shortest distance, the investment cost for a 12-inch diameter pipe is already too large to be covered by the potential revenue in this model.

All scenarios for distances of 2 km and 3 km are declared NOT FINANCIALLY FEASIBLE, regardless of the pipe diameter tested. At a distance of 2 km, the negative NPV ranges from -IDR 11.40 billion for an 8-inch diameter to -IDR 56.86 billion for a 12-inch diameter. This condition worsens significantly at a distance of 3 km, where the negative NPV for a 12-inch pipe reaches -IDR 105.3 billion. This trend confirms that increasing distribution distance significantly undermines project viability, caused by an increase in the investment cost of the pipeline infrastructure that cannot be compensated by the revenue generated.

Sensitivity Analysis
To test the robustness of the business models, a sensitivity analysis was conducted on key variables that could affect profitability

Sensitivity Analysis of the Priority Service Model

To test the robustness of the Priority Service Business Model, a sensitivity analysis was conducted on three key variables that have the most potential to affect project profitability: Investment Cost (CAPEX), Electricity Tariff, and Kilowatt-hour Sold. The test was conducted by looking at the impact of percentage changes in each variable on financial feasibility indicators, especially NPV and IRR.

Table 7. Sensitivity Analysis of the Integrated Renewable Energy Business Model with Priority Services

Sensitivity Analysis on Investment	Base	+19%	+20%	+21%
Investment	3.920.239.456	4.665.084.953	4.704.287.347	4.743.489.742
IRR	37,30%	20,34%	14,40%	9,22%
NPV	1.876.016.685,92	804.704.640,00	376.928.689,12	- 50.847.261,76
Sensitivity Analysis on Production	Base	-19%	-20%	-21%
kWh Sold	27.404.000	22.197.240	21.923.200	21.649.160
IRR	37,30%	11,20%	9,83%	8,45%
NPV	1.876.016.685,92	95.439.918,63	1.725.351,93	- 91.989.214,77
Sensitivity Analysis on Electricity Tariff	Base	-2%	-3%	-4%
Electricity Tariff	1.645	1.612	1.595	1.579
IRR	37,30%	19,37%	10,40%	1,43%
NPV	1.876.016.685,92	652.588.391,15	40.874.243,76	- 70.839.903,62

This model shows good robustness to increases in investment costs, remaining feasible even if investment costs rise by 20%. The critical point occurs at a 21% increase in investment costs, at which point the project is no longer financially feasible. The model is also proven to be sensitive to changes in revenue components. The project can withstand a decrease in kilowatt-hour sold of up to 20% or a decrease in the electricity tariff of up to 3% before becoming unfeasible. Overall, the analysis confirms that the success of the Priority Service Model depends on the ability to keep investment costs from swelling by more than 20% and ensuring that revenues from kilowatt-hour sold do not decrease by more than 20% and the electricity tariff does not fall by more than 3%

Sensitivity Analysis of the Steam as a Service Model

To explore the risk profile and profitability drivers, a sensitivity analysis was conducted on three key variables for each scenario of the Steam as a Service Business Model: kilowatt-hour (kWh) sold, electricity tariff, and steam tariff. Using a switching value approach, the tipping point was identified for each variable.

The tipping point refers to the critical threshold at which a change in a single variable causes the financial feasibility status of the project to shift—either from feasible to unfeasible, or vice versa. It represents the minimum percentage change in a variable that alters the project's economic viability under the assumed scenario. Table 8 summarizes the sensitivity of the business model under different pipeline distance and diameter configurations.

Table 8. Sensitivity Analysis of the Integrated Renewable Energy Business Model with Steam as a Service

Scenario (distance, diameter)	Initial Status	Most Critical Variable	kWh Sold Tipping Point	Electricity Tariff Tipping Point	Steam Tariff Tipping Point
1 km, 8 inches	Feasible	Electricity Tariff	Decrease -33%	Decrease -6%	Remains feasible despite a decrease of up to 30%
1 km, 10 inches	Feasible	Electricity Tariff	Decrease -9%	Decrease -1%	Remains feasible despite a decrease of up to 30%
1 km, 12 inches	Not Feasible	Electricity Tariff	Increase +40%	Increase +6%	Remains not feasible even with an increase of up to 30%
2 km, 8 inches	Not Feasible	Electricity Tariff	Increase +40%	Increase +6%	Remains not feasible even with an increase of up to 30%
2 km, 10 inches	Not Feasible	Electricity Tariff	Remains not feasible even with an increase of up to 40%	Increase +13%	Remains not feasible even with an increase of up to 30%
2 km, 12 inches	Not Feasible	Electricity Tariff	Remains not feasible even with an increase of up to 40%	Increase +27%	Remains not feasible even with an increase of up to 30%
3 km, 8 inches	Not Feasible	Electricity Tariff	Remains not feasible even with an increase of up to 40%	Increase +16%	Remains not feasible even with an increase of up to 30%
3 km, 10 inches	Not Feasible	Electricity Tariff	Remains not feasible even with an increase of up to 40%	Increase +10%	Remains not feasible even with an increase of up to 30%
3 km, 12 inches	Not Feasible	Electricity Tariff	Remains not feasible even with an increase of up to 40%	Increase +47%	Remains not feasible even with an increase of up to 30%

The sensitivity analysis identifies a clear order of influence of the three variables tested: Electricity Tariff, kilowatt-hour Sold, and Steam Tariff. The Electricity Tariff proved to be the single most critical variable with the most significant influence on financial feasibility. The second most influential variable is kilowatt-hour Sold, although its impact is lower. In the most optimal scenario (1 km, 8-inch), a decrease in the electricity tariff of only 6% is enough to make the project unfeasible, while the project can still tolerate a decrease in sales volume of up to 32% and still show feasibility. Meanwhile, the analysis confirms that changes in the Steam Tariff have the smallest (marginal) influence, as the total revenue contribution from steam sales is less than 1% of the total revenue from electricity sales.

Discussion and Interpretation of Results

The financial feasibility analysis of the two business models formulated from the SBMC and SWOT findings shows significantly different profitability and risk profiles, which will be comprehensively interpreted in this section.

The Integrated Renewable Energy Business Model with Priority Services shows very high financial viability, with a positive NPV of IDR 1.876 billion, IRR of 37%, and a Payback Period of only 1.46 years. This superior profitability stems from a strong value proposition—guaranteed supply reliability through dedicated feeders and clean energy imagery—that enables the implementation of priority service rates. Assuming that PLN's Cost of Supply (BPP) of Renewable Energy (IDR 1,392.58/kilowatt-hour) is competitive compared to the operating costs of fossil-based captive power, the difference in revenue generated is able to cover infrastructure investment (IDR 3.92 billion for 2.86 km feeders) and O&M costs (3% of investment) very quickly. The sensitivity analysis further shows that this model has good robustness, where feasibility is maintained even when investment costs rise up to 20% or when the electricity tariff decreases up to 3% or kilowatt-hour sales decrease up to 20%. However, the model has a tolerance limit, indicating that although it is very profitable, cost control and revenue stability remain important factors in its implementation.

In contrast, the Integrated Renewable Energy Business Model with Steam as a Service shows feasibility dynamics that are greatly influenced by technical and very limited feasibility dynamics that are critically dependent on technical-geographical parameters. Based on the scenario analysis, financial feasibility is only achieved at a distance of 1 km, specifically for 8-inch pipe diameters (NPV IDR 10.97 Billion, IRR 21.66%) and 10-inch pipe diameters (NPV IDR 2.91 Billion, IRR 12.23%). Even at this shortest distance, the 12-inch diameter pipe scenario is not feasible, indicating that the investment cost for large diameter pipes outweighs the revenue benefits. At distances of 2 km and 3 km, all scenarios are significantly unfeasible financially. This ineligibility is caused by the CAPEX load on the steam pipeline infrastructure which jumps exponentially with increasing distance. The cost of pipeline materials, insulation, civil works, and the number of supporting components (such as expansion joints and steam traps) becomes too large to be covered by revenue from steam sales. The sensitivity analysis further underscores the high-risk profile of this model. For the feasible scenarios (1 km distance), the margin is very slim; a tariff reduction of as little as -6% (for 8-inch) or -1% (for 10-inch) is enough to render the project unfeasible. This confirms that the model is extremely sensitive to revenue variables, with electricity tariff identified as the most influential determinant of project viability (Uhunamure & Shale, 2021).

Comparatively, the Priority Service Model offers a much more attractive investment profile and can be implemented more widely, driven by the added value of services and PLN's energy cost efficiency. Meanwhile, the Steam as a Service Model, while conceptually addressing the industrial steam needs identified in the SBMC and SWOT, is severely constrained by geographical factors (Sullivan, Wicks, & Koelling, 2015). This reliance on distance confirms that this model is only relevant as a niche solution for industries located very close (≤ 1 km) to the source of PLTP, where the cost of thermal infrastructure can be minimized. The strategic implications for PT PLN (Persero) are the importance of careful market segmentation; Priority services can be a common solution for the transition of captive power users, whereas Steam as a Service requires integrated planning between the development of the PLTP and the surrounding industrial clusters to ensure viability

CONCLUSION

The analysis of the Sustainable Business Model Canvas (SBMC) elements revealed that key factors influencing captive power users in East Java to switch to PT PLN (Persero)-based electricity include operational cost reduction, carbon emission reduction, supply reliability, and improved corporate image, alongside customer dependence on captive steam and preferences for communication and tariff models. SWOT analysis highlighted PT PLN's strengths in renewable energy potential and supply reliability, with challenges related to customers' steam dependency and transition costs. Two business models were designed: Integrated Renewable Energy with Priority Services, which proved financially feasible with a positive NPV, high IRR, and short payback period, and Integrated Renewable Energy with Steam as a Service, which was only viable for very short steam distribution distances due to high infrastructure costs and sensitivity to revenue fluctuations. Future research could explore innovative technologies or financing mechanisms to reduce steam distribution costs and risks, enhancing the feasibility of the Steam as a Service model and supporting broader industrial energy transitions.

REFERENCES

Amazon.com: Gate Valve, Class 300, 1-1/2 In. : Industrial & Scientific. (n.d.). Retrieved May 26, 2025, from https://www.amazon.com/Gate-Valve-Class-300-1-1/dp/B071RT54LP

ASTM A106 Gr.B SCH40 Pipa Baja Karbon Seamless. (n.d.). Retrieved May 26, 2025, from https://www.gneesteel.com/id/products/steel-pipe/seamless-steel-pipe/1053.html

Badan Kebijakan Fiskal Kementrian Keuangan. (2021). Kenalkan Pajak Karbon untuk Mengendalikan Perubahan Iklim, Indonesia Ambil Manfaat Sebagai Penggerak Pertama di Negara Berkembang.

Black, J. (2023). Policy Brief: Criteria For Green Hydrogen And Its Derivatives In Export Markets Scaling Up Renewable Energy Project.

Blank, L., Tarquin, A., & Coalla, M. (2012). Ingeniería económica. https://www.academia.edu/download/54442283/Ingenieria_Economica_-_Blank_-_6ta.pdf

Chasin, F., Paukstadt, U., Gollhardt, T., & Becker, J. (2020). Smart energy driven business model innovation: An analysis of existing business models and implications for business model change in the energy sector. Journal of Cleaner Production, 269. https://doi.org/10.1016/j.jclepro.2020.122083

Creswell, J. W. (2015). Educational research : planning, conducting, and evaluating quantitative and qualitative research (5th ed.). Pearson.

Export-Import Bank of the United States (EXIM). (2023). Carbon Policy and Renewable Energy Incentives.
F.G. Reis, I., Gonçalves, I., A.R. Lopes, M., & Henggeler Antunes, C. (2021). Business models for energy communities: A review of key issues and trends. In Renewable and Sustainable Energy Reviews (Vol. 144). Elsevier Ltd. https://doi.org/10.1016/j.rser.2021.111013
Galar, D., Sandborn, P., & Kumar, U. (2017). Maintenance Costs and Life Cycle Cost Analysis. https://doi.org/https://doi.org/10.1201/9781315154183
Gürel, E., & Tat, M. (2017). SWOT Analysis: A Theoretical Review. Uluslararası Sosyal Araştırmalar Dergisi The Journal of International Social Research. https://doi.org/10.17719/jisr.2017.1832
Kementrian Energi Sumber Daya Mineral. (2024, May). JETP Inisiasi Kajian Captive Power Sebagai Bagian dari Pemutakhiran CIPP 2024.
Lazell, F., Lang, D., Silbert, E., Feldman, D., & Stainer. Peter. (2024). EU Regulations Restricting Imports of Renewable Natural Gas and Green Hydrogen Derivative Products.
Lüdeke-Freund, F., Carroux, S., Joyce, A., Massa, L., & Breuer, H. (2018). The sustainable business model pattern taxonomy—45 patterns to support sustainability-oriented business model innovation. Sustainable Production and Consumption, 15, 145–162. https://doi.org/10.1016/j.spc.2018.06.004
Mukoro, V., Sharmina, M., & Gallego-Schmid, A. (2022). A review of business models for access to affordable and clean energy in Africa: Do they deliver social, economic, and environmental value? In Energy Research and Social Science (Vol. 88). Elsevier Ltd. https://doi.org/10.1016/j.erss.2022.102530
Namugenyi, C., Nimmagadda, S. L., & Reiners, T. (2019). Design of a SWOT analysis model and its evaluation in diverse digital business ecosystem contexts. Procedia Computer Science, 159, 1145–1154. https://doi.org/10.1016/j.procs.2019.09.283
Osterwalder, Alexander., & Pigneur, Yves. (2013). Business model generation : a handbook for visionaries, game changers, and challengers. https://www.wiley.com/en-sg/Business+Model+Generation%3A+A+Handbook+for+Visionaries%2C+Game+Changers%2C+and+Challengers-p-9781118656402
Setiawan, A., & Effendi, P. L. (2023). Strategy for Optimizing Electricity Oversupply in Indonesia Through Captive Power Acquisition: Using Sustainable Business Model. ICT-PEP 2023 - 2023 International Conference on Technology and Policy in Energy and Electric Power: Decarbonizing the Power Sector: Opportunities and Challenges for Renewable Energy Integration, Proceedings, 93–98. https://doi.org/10.1109/ICT-PEP60152.2023.10351166
Shadman, S., Chin, C. M. M., Yap, E. H., Sakundarini, N., & Velautham, S. (2021). Progress in Energy and Environment The role of current and future renewable energy policies in fortifying Malaysia's energy security: PESTLE and SWOT analysis through stakeholder engagement (Vol. 16).
Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2015). Engineering economy. Engineering Economy Sixteenth Edition, 16th edition. https://thuvienso.hoasen.edu.vn/handle/123456789/9028

Uhunamure, S. E., & Shale, K. (2021). A SWOT analysis approach for a sustainable transition to renewable energy in South Africa. Sustainability (Switzerland), 13(7). https://doi.org/10.3390/su13073933