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ANALYSIS OF INVESTMENT FEASIBILITY AND SENSITIVITY ANALYSIS FOR THE XYZ GEOTHERMAL POWER PLANT (GPP) DEVELOPMENT PROJECT

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Abstract

Currently, the electricity system of North Sulawesi Province is supplied by power plants including Geothermal Power Plant (GPP), Coal-fired Power Plant (CFPP), Hydroelectric Power Plant (HPP), Solar Power Plant (SPP), Diesel Power Plant (DPP), and Gas Turbine Power Plant (GTPP) with a total installed capacity of 589 MW. The Net Capacity (NC) of this system is approximately 492 MW and the Net Supply Capacity (SC) is around 462 MW, resulting in a gap between installed capacity, NC, and SC Over the past few years, the electricity sales growth in North Sulawesi Province has been quite high, around 7.8% based on sales data from 2011-2020, and is projected to continue growing. Additionally, it is expected that the Energy Mix from New and Renewable Energy sources should reach 23% by 2025, thus the development of new power plants from New and Renewable Energy sources can contribute to achieving this Energy Mix. This research is conducted as a further study regarding the feasibility of investing in the development of XYZ Geothermal Power Plant to provide added value for the company. The research method employed is quantitative descriptive method, which involves calculating the Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), Discounted Payback Period (PP), and Sensitivity Analysis (SA). The results show that the investment will be feasible if the capital source for the investment comes from corporate loans for the upstream sector and soft loans for the downstream sector of development, resulting in an NPV of 2,241 thousand USD, an IRR of 11.11%, a PI of 1.01, and a PP of 24 years. Furthermore, the analysis shows that the decision on the capital source is important, as it affects feasibility, and loan variables such as the interest rate in corporate loans and repayment years in soft loans are important factors to consider in increasing economic feasibility. On the other hand, if the best scenario is chosen—decreasing cost variables and increasing both the electricity tariff and capacity factor by 10% from the base scenario—it can result in higher economic feasibility. Moreover, the electricity tariff, capacity factor, production well cost, and power plant cost have the greatest impact on feasibility. Therefore, it is important to strive for the maximum value of the electricity tariff and capacity factor, while minimizing production well and power plant costs as efficiently as possible.

Keywords: ***Investment Feasibility, Net Present Value (NPV), Internal Rate of Return (IRR), Sensitivity Analysis (SA), Geothermal Power Plant (GPP).***

I. INTRODUCTION

Currently, the electricity system in North Sulawesi Province is supplied by power plants including Geothermal Power Plant (GPP), Coal-fired Power Plant (CFPP), Hydroelectric Power Plant (HPP), Solar Power Plant (SPP), Diesel Power Plant (DPP), and Gas Turbine Power Plant (GTPP). In North Sulawesi province, the total installed capacity is 589 MW, with a Net Available Capacity of around 492 MW and a Supply Capacity of approximately 462 MW [1], indicating a gap between the installed capacity, NC, and SC. Furthermore, focusing on the geothermal power plant (GPP) data, with an installed capacity of 120 MW, there is a discrepancy between the installed capacity and the SC, where the SC generated is only 105.6 MW. This gap can be attributed to operational conditions, where the power plant does not operate at maximum or ideal conditions due to damage and maintenance activities, and also to inefficiencies in the power system, where some of the electricity generated is lost during transmission and distribution processes. The impact of this ongoing gap can lead to several issues, including power outages due to insufficient electricity supply to meet demand. This results in rolling blackouts to maintain grid stability. Additionally, it has the potential to hinder economic growth in a region, as electricity is crucial for sectors reliant on it, such as manufacturing and industry. If electricity availability is insufficient, economic activities could be disrupted. Therefore, the need for additional power generation becomes essential to ensure stable electricity availability. In recent years, electricity sales growth in North Sulawesi province has been quite high, at around 7.8%, based on sales data from 2011 to 2020 [1], as shown in Table 1. This table shows the percentage growth of electricity sales realization from 2011 to 2020, where the growth of each year is compared to the previous year.

Table 1.
Electricity Sales Realization

Year	***2011***	***2012***	***2013***	***2014***	***2015***
Growth%	*12.3*	*10.2*	*9.7*	*4.0*	*5.0*
Year	***2016***	***2017***	***2018***	***2019***	***2020***
Growth%	*7.5*	*10.3*	*8.5*	*3.9*	*6.9*

Based on the data, it can be concluded that the growth in electricity sales shows a positive trend, indicating the need for support in the development of power generation that aligns with the growth in electricity sales. Due to the increasing economic growth in North Sulawesi, it is estimated that the electricity demand will also rise, as projected in Table 2. This table shows the average projected growth for the period 2021-2030 across several factors [1], including economic growth, electricity sales, electricity production, peak electricity load, and electricity customers.

Table 2.
Electricity Demand Projection

Descrip tion	***Economic growth***	***Sales***	***Production***	***Peak load***	***Customer***
Average Growth% (2021-2030)	*5.0*	*6.5*	*7.0*	*6.9*	*3.7*

The projection of economic growth, electricity sales, electricity production, peak load, and the number of customers in North Sulawesi (2021-2030) continues to increase, providing opportunities for the development of new power plants to meet the growing electricity demand. This could signal power plant developers to invest in the region. The development of economies must be supported by energy, which plays a key role and also impacts human lives [2]. The increasing demand for electricity requires the government to enhance power generation capacity by implementing programs for the construction of new power plants [3].

Additionally, geothermal power plants are a form of New and Renewable Energy (NRE) that can reduce dependence on fossil fuels and contribute to environmental preservation by not producing carbon emissions. Geothermal energy is a renewable, non-carbon source of sustainable energy with significant untapped potential to help address the challenges of climate change, compares the emissions from various power plants, including geothermal plants, revealing that CO_2 emissions from geothermal energy are significantly lower—approximately 10 times less than those from gas-fired plants and up to 20 times less than oil- and coal-fired power generation [4]. Compared to other renewable resources, geothermal energy still produces fewer emissions than solar and biomass. Additionally, emissions of SO_2, particulate matter, and NO_x, which contribute to acidification and eutrophication, are substantially lower in geothermal energy than in fossil fuels [4].

Renewable energy technologies are essential for developing energy resources that are significantly more sustainable than the current fossil fuel-based energy systems [5]. Therefore, based on the National Energy Policy, it is expected that the Energy Mix from NRE should reach 23% by 2025 [6], making the development of new power plants from New and Renewable Energy a contribution toward achieving this Energy Mix. Aligned with the Paris Agreement, sustainable energy production is highlighted as a crucial approach to limiting the global temperature increase to below 2°C above pre-industrial levels [7]. Expanding the share of renewable energy sources (RES) will play a central role in achieving sustainable electricity generationGeothermal energy is regarded as a sustainable and renewable energy source that can offer the nation a carbon-free environment through safe and reliable energy utilization [8]. Geothermal energy has successfully attracted foreign direct investments among renewable energy sources due to its initial cost-effectiveness, reliability, versatile applications, and environmentally friendly nature, as it does not contribute to increased emissions [9]. Based on the aforementioned phenomena, the development of Geothermal Power Plant XYZ can be a promising business prospect for developers. However, further analysis is needed to assess the investment feasibility of the development of Geothermal Power Plant XYZ. One essential step in developing power plants is to evaluate them from both technological and economic perspectives based on several criteria. From an economic standpoint, it is important to consider capital costs, fuel costs, external costs, and operational and maintenance costs, as the economic aspect is closely linked to investment decisions [3]. The investment cost of a geothermal power plant is a key factor influencing its economic feasibility. These costs are generally divided into surface costs and subsurface costs. Surface costs include expenses for preliminary and surface exploration, infrastructure design and construction, as well as site operation and maintenance. On the other hand, subsurface costs primarily consist of well drilling expenses [4]. In this study, the costs are divided into upstream and downstream costs. Upstream costs include all expenses related to steam gathering, while downstream costs pertain to geothermal power plant expenditures.

The purpose of this research is to conduct further research related to the investment in the development of the XYZ geothermal power plant (GPP). Specifically, the objectives of this research are as follows:

1. To evaluate the results and feasibility analysis of the investment based on NPV, IRR, PI, and PP.
2. To determine the sensitivity of variable values that influence the feasibility of the GPP development investment.
3. To identify proposed parameter scenarios for the GPP development plan.

II. METHODOLOGY

This research is descriptive quantitative in nature. The aim of this research is descriptive, utilizing data collection and presentation methods that summarize quantitative data systematically, making it easier to interpret for decision-making based on existing data [10]. Furthermore, the research employs a quantitative approach, systematically organized through data collection that can be measured using mathematical, statistical, or computational methods [11]. Methodology of this study is a business feasibility analysis for the development of a power plant, calculated using the capital budgeting method with operational variables including NPV, IRR, PI, and Payback Period. This study also tests the sensitivity of the parameters that affect business feasibility, such as differences in funding sources and variations in funding parameter values. The characteristics of this research can be summarized in Table 3. The research characteristics table displays the determination of the study based on its characteristic categories.

Table 3.
Research Characteristics

Research Characteristics	***Type of Research***
Based on Purpose	*Descriptive*
Based on Research Method	*Quantitative*
Based on Research Strategy	*Case Study*
Based on Unit of Analysis	*Individual*
Based on Researcher Involvement	*Participatory*
Based on Research Setting	*Non-Contrived*
Based on Data Collection Method	*Secondary Data Observation*
Based on Sampling Technique	*Non-Probability Sampling*
Based on Implementation Time	*Cross-Sectional*

A. Data Collection and Data Sources

In this research, data collection is obtained through gathering data from documentation that includes existing company data, government regulations or relevant ministries, and previous research studies.

B. Data Analysis Techniques

The data analysis for this research is conducted using descriptive statistical analysis techniques. This involves processing data from the research parameters and then summarizing the results according to the applicable economic feasibility criteria. An investment is deemed feasible based on the feasibility criteria of each economic parameter, including NPV, IRR, PI, and PP. Analyzing the results from this sensitivity analysis. The sensitivity analysis will be performed by assessing the funding types in both upstream and downstream aspects of the geothermal power plant (GPP) project. The economic feasibility results, based on the funding types, will be subjected to sensitivity analysis by considering a 10% increase and decrease in each cost variable (such as production testing costs, infrastructure costs, piping or SAGS costs, make-up well costs, injection well costs, G&A costs, cost escalation, downstream O&M, upstream O&M, exploration well costs, power plant costs, and production well costs). Additionally, the analysis will include a 10% decrease and 10% increase in the capacity factor and electricity tariff from the base scenario, which will be treated as the worst-case and best-case scenarios, calculated from the base scenario, respectively. The treatment of these scenario differences is used to determine the volatility of the projects and the uncertainties that impact their valuation [12].

C. Investment Theory

Investment is the activity of placing funds to obtain additional profits in the future [13]. Referring to investment in a company, investment is the activity of capital investment in the company's business to generate profits and ensure the company's future sustainability, where this capital investment can be in the form of fixed or non-fixed capital.

D. Business Feasibility Study

Related to the investments made in a company's business, a fundamental step that needs to be undertaken is a business feasibility study. A business feasibility study is a comprehensive process for assessing and evaluating the viability of an investment project before the investment is made [14]. Several key aspects that need to be examined include the description and background of the business project, the required technology, and financial details. The economic feasibility analysis evaluates the viability of the design by considering the total costs, from the design phase to installation. This analysis was carried out using the Net Present Value (NPV), Payback Period (PP), and Internal Rate of Return (IRR) methods [15].

The feasibility of a project relies heavily on the investments and costs incurred, as financial considerations are among the most critical factors in assessing a project's viability [16]. In this study, the business feasibility analysis is specifically focused on Financial Feasibility, which includes an analysis of the costs and revenues of the business project. It also encompasses budget planning, cash flow projections, and return on investment calculations. The financial feasibility projects cash inflows (such as revenue from electricity sales) and cash outflows (including capital expenditures, operating costs, and taxes) over a specified timeframe [17].

E. Capital Budgeting

Capital Budgeting is the process of planning expenditures or outlays for an asset or capital with the goal of generating cash flows that exceed one year [18]. Capital budgeting is the process of evaluating and choosing investment opportunities in long-term assets whose benefits extend beyond one year [19]. The capital budgeting also relate with the engineering economics that consists of at least seven key steps: (1) identifying and defining the problem, (2) formulating alternative solutions, (3) preparing realistic cash flow projections, (4) establishing economic evaluation criteria to aid decision-making, (5) evaluating each option while considering non-financial factors and applying sensitivity analysis if needed, (6) selecting the optimal solution based on the analysis, and (7) implementing the chosen solution and monitoring its results [20]. Common techniques used in capital budgeting include Net Present Value (NPV), Internal Rate of Return (IRR), Profitability Index (PI), and Discounted Payback Period (PP).

a. Net Present Value (NPV) is the difference in net income, which is the result of subtracting costs from revenues and has been multiplied by the discount factor [14], as shown in the following formula.

$$\text{NPV} = \sum_{t=1}^{n} \frac{CF_t}{(1+i)^n} - \text{IO} \qquad (1)$$

Where:

NPV is net present value or present value.
Σ is symbol for summation.
t is time period or year t.
n is economic life of the proposed project/investment.
CFt is cash flow in year t.
I is interest rate or cost of capital.
IO is initial investment capital.

The criteria for approving or rejecting an investment plan using the NPV method are as follows:

- If NPV > 0, the investment proposal is approved.
- If NPV < 0, the investment proposal is rejected.
- If NPV = 0, it indicates that the investment project does not affect the company's value, regardless of whether the proposal is approved or rejected, as the project is essentially at its Break Even Point (BEP).

b. Internal Rate of Return (IRR) is The interest rate that equates the present value of revenues with the present value of total costs incurred during the project's lifespan [14], as shown in the following formula.

$$IRR = i_1 + \frac{NPV_1}{NPV_1 . NPV_2} X \, (i_2 - i_1) \qquad (2)$$

Where:

i_1 is the interest rate that results in a positive NPV

i_2 is the interest rate that results in a negative NPV

NPV_1 is the NPV that is positive

NPV_2 is the NPV that is negative

On the other hand, the Internal Rate of Return (IRR) can be calculated through extrapolation to determine the exact discount rate at which the Net Present Value (NPV) becomes zero [21]. A project or business venture is approved if its Internal Rate of Return (IRR) is greater than or equal to the cost of capital, interest rate, required rate of return, or the specified interest rate. Conversely, an investment proposal is rejected if its IRR is lower than the cost of capital, interest rate, required rate of return, or the specified interest rate. In this study, the designated interest rate within the company is referred to as the Project Required rate of return, which is the minimum required return on investment set by the relevant function in the company Pertamina [22].

c. The Profitability Index (PI) represents the value obtained for every unit of currency invested. The Profitability Index (PI) is calculated by dividing the present value of a project's future cash flows by the initial capital investment [23].
A project can be evaluated using the Profitability Index (PI) based on the following guidelines:

- If PI > 1, the project proposal is accepted.
- If PI < 1, the project proposal is rejected.

d. Discounted Payback Period (PP) is A payback period for expenditures related to investments that can serve as a source of analysis concerning business performance in terms of the returns on investments made [14], as shown in the following formula.

$$Payback\ Period = \frac{Investment\ Value}{Net\ cash\ inflow}\ x\ 1\ year \qquad (4)$$

The payback period is calculated by dividing the initial investment by the annual profit expressed in present value terms [21]. A business/project is approved if the payback period is shorter or faster than the required timeframe. Conversely, if the payback period is longer or slower than required, the business/project is rejected. If there are multiple business/projects, the one with the shortest or fastest payback period is selected.

e. Sensitivity Analysis (SA) is an analysis used to examine the impact of changes on the feasibility calculation by varying parameter values as risk variables deemed important in an investment business. Sensitivity analysis determines the outcomes of an investment activity if there are changes in the underlying calculations of costs and benefits affecting the investment [14]. The parameters as variables in this study include electricity tariff, capacity factor, capital expenditure, operational expenditure, and sources of funding. The sensitivity analysis examines the impact of various parameters, which may include economic factors [24]. Conducting a sensitivity analysis made it possible to identify not only the parameters affecting economic performance but also those significantly influencing installed capacity and lifetime, which in turn impact the derived sustainability criteria [25].

F. Conceptual Framework

A conceptual framework is the thought process or flow followed in this study, starting from a literature review to recommendations, as shown in Figure 1.

a. Literature Study
Understanding the concept of investment theory and the key considerations in business feasibility studies, followed by selecting the research method to be used.
b. Determination of Research Variable Parameters
Inventorying the parameters of variables to be used in the research.
c. Determination of Investment Feasibility Parameters
Inventorying the parameters to be used as benchmarks in the research
d. Investment Feasibility Calculation
Conducting investment feasibility calculations using the predetermined method on the research variables, then evaluating the results based on the investment feasibility parameters.
e. Sensitivity Analysis
Performing sensitivity analysis calculations on the research variables.
f. Recommendations
Analyzing the results of the sensitivity analysis and providing recommendations for investment scenarios.

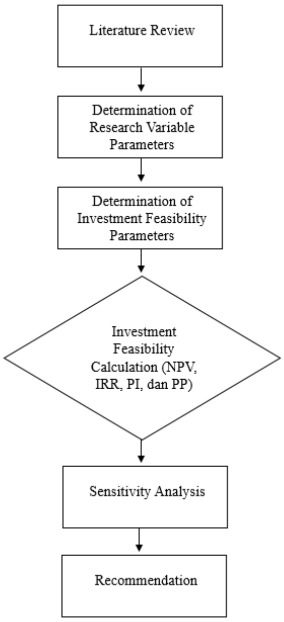

Figure 1. Conceptual Framework

III. RESULTS AND DISCUSSION

A. Capital Budgeting Calculation for Initial Base or Moderate Scenario

In the initial calculation, the investment feasibility is assessed based on the base or moderate scenario, with the funding sources for both the upstream and downstream sectors of the project coming from equity, as shown in the table below. The development project of GPP XYZ is planned to begin in 2025 and is targeted to commence commercial operations by 2028, with a lifetime of 30 years from the commercial date, extending until 2058. Table 4 shows the results of the capital budgeting calculation with the base or moderate scenario where the funding source, in general, obtained from the company's own capital.

Table 4. Results of Capital Budgeting Calculation for Initial Base or Moderate Scenario

Research Characteristics	*Value*
NPV (US$ Thousand)	*(32.023)*
IRR (%)	*6,19*
PP (Years)	*>30*
PI	*0,80*

As the results, based on the initial capital budgeting calculations under the base or moderate scenario, it was found that the NPV is below 0, the IRR is lower than the project required rate of return or the cost of capital/interest rate/required rate of return, the payback period exceeds the contract or project lifetime, and the profitability index is below 1. Therefore, the development plan of GPP XYZ under the base or moderate scenario, with funding for both upstream and downstream coming from equity, can be declared economically unfeasible. Another study also found that there was a geothermal project that failed to provide adequate compensation to equity, as evidenced by a negative NPV and an IRR below the discount rate [17].

B. Capital Budgeting Calculation for the Base Scenario Based on Funding Sources

Based on the economically unfeasible results, further calculations were conducted using alternative funding scenarios. From three funding sources (equity, corporate loan from Pertamina Holding, and soft loan from foreign lenders), three different scenarios were created for upstream and downstream funding, with the feasibility results as follows:

- The 2nd base or moderate scenario: upstream is funded by equity and downstream by a soft loan.
- The 3rd base scenario: both upstream and downstream are funded by corporate loans.
- The 4th base scenario: upstream is funded by a corporate loan and downstream by a soft loan.

In funding sources that come from loans, there are several parameters to consider, including:

- Interest rate: the percentage of interest charged on the loan,
- Grace period: the time allowed before the borrower must start repaying the principal and interest within a specified period, and
- Repayment years: the time frame within which the borrower or company must repay the loan provided by the lender or investor.

Table 5 shows the results of the capital budgeting calculation for 3 funding source scenarios, where the funding can come from a mix of equity, corporate loans, and soft loans.

Table 5. Results of Capital Budgeting Calculation for the Base Scenario Based on Funding Sources

Parameter	***2nd Base Scenario***	***3rd Base Scenario***	***4th Base Scenario***
Upstream Funding Sources	*Equity*	*Corporate Loan* *IR[a]: 6%* *GP[b]: 6 Years* *RY[c]: 11 Years*	*Corporate Loan* *IR[a]: 6%* *GP[b]: 6 Years* *RY[c]: 11 Years*
Downstream Funding Sources	*Soft Loan* *IR[a]: 2%* *GP[b]: 8 Years* *RY[c]: 20 Years*	*Equity*	*Soft Loan* *IR[a]: 2%* *GP[b]: 8 Years* *RY[c]: 20 Years*
NPV (US$ Thousand)	*(9.811)*	*(14.818)*	*2.241*
IRR (%)	*8,27*	*6,30*	*11,11*
PP (Years)	*>30*	*>30*	*24*
PI	*0,94*	*0,94*	*1,01*

[a]Interest Rate (IR) [b]Grace Period (GP) [c]Repayment Years (RY)

Based on the capital budgeting results for different funding sources, the fourth base scenario is the only one that yields a viable outcome, with a positive NPV, IRR above the project required rate of return (cost of capital/interest rate/required rate of return), a payback period of 24 years, which is still within the contract duration, and a PI greater than 1.

C. Sensitivity Analysis Calculation with Worst and Best Scenarios

From the previous calculations, the results indicated that fourth scenario base is the best scenario compared to others based on funding. Therefore, a sensitivity analysis was conducted, considering a 10% increase in each cost variable (production test costs, infrastructure costs, piping or SAGS costs, makeup well costs, injection well costs, G&A expenses, cost escalation, upstream and downstream O&M costs, exploration well costs, power plant costs, and production well costs) and a 10% decrease in the capacity factor and electricity tariff variables from the base scenario as the worst-case scenario. Conversely, for the best-case scenario, a 10% decrease in each cost variable and a 10% increase in the capacity factor and electricity tariffs were considered from the base scenario, as shown in Table 6 which shows the NPV (in US$ .000) results from the best and worst scenarios, as well as the percentage compared to the base scenario. In this sensitivity analysis, only the NPV value is used because NPV takes into account variations in cash flow and discount rates [19].

Table 6. Results of Sensitivity Analysis Calculation with Worst and Best Scenarios

Parameter	*NPV Worst Scenario*	*NPV Best Scenario*	*% NPV Worst versus Base Scenario*	*% NPV Best versus Base Scenario*
Production Testing Costs	2,221	2,261	-0.89	0.89
Infrastructure Costs	2,154	2,328	-3.88	3.88
SAGS Costs	2,128	2,354	-5.04	5.04
Makeup Well Costs	1,718	2,764	-23.34	23.34
Injection Well Costs	1,718	2,710	-23.34	20.93
G&A Costs	1,724	2,758	-23.34	23.34
Cost Escalation	1,488	2,976	-33.60	32.80
OPEX Downstream	1,327	3,155	-40.79	40.79
OPEX Upstream	1,327	3,155	-40.79	40.79
Exploration Well Costs	1,091	3,391	-51.32	40.79
Power Plant Costs	974	3,508	-56.54	56.54
Production Well Costs	247	4,235	-88.98	88.93
Capacity Factor	-4,394	8,877	-296.07	296.12
Electricity Tariff	-6,258	10,704	-379.25	377.64

Based on the results above, it is found that a decrease and increase in cost variables by 10% will impact the NPV values in the range of 379.25% to 0.89%. From the calculations above, it can be analyzed which variables influence the feasibility of the investment in the development of the XYZ Geothermal Power Plant, as illustrated in Figure 2 (tornado diagram) where the tornado diagram can show the cost variables that are most sensitive and have the greatest impact on business feasibility:

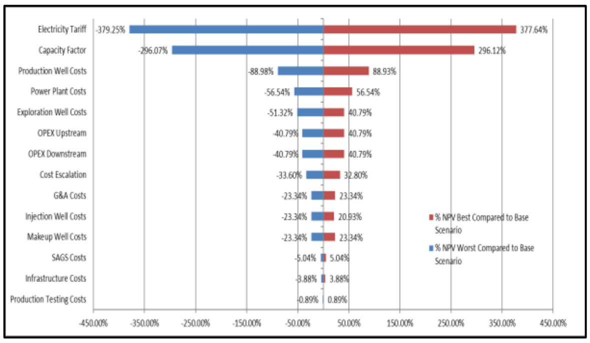

Figure 2. Tornado Diagram

From the tornado diagram of the sensitivity analysis results regarding the economic feasibility based on NPV, several key parameters influencing NPV can be identified. These parameters include electricity tariffs, capacity factor, production well costs, and power plant costs. A 10% increase in electricity tariffs leads to an NPV increase of up to 377.64%, while a 10% decrease results in an NPV drop of 379.25%. Changes in electricity tariffs will significantly impact the economic feasibility of investment in geothermal power plant development projects. This aligns with government policies implemented in several countries worldwide, such as the United States, Germany, and others, where the tariff is one of the important factors in development, achieved through the adoption of the Feed-in-Tariff (FiT) scheme. One of the key components of this scheme is Cost-Based Purchase Price [2], where the electricity tariff purchased from producers is determined based on the production cost of electricity from renewable energy sources. This price is usually higher than the tariff for conventional energy to encourage investment and cover the higher costs of the technology. A 10% increase in the capacity factor leads to an NPV increase of up to 296.12%, while a 10% decrease results in an NPV drop of 296.07%. A 10% increase in production well costs leads to an NPV decrease of 88.98%, while a 10% decrease results in an NPV increase of 88.93%. Lastly, a 10% increase in power plant costs leads to an NPV decrease of 56.54%, and similarly, a 10% increase in power plant costs results in an NPV decrease of 56.54%. The results of this tornado diagram are consistent with other studies on geothermal development, indicating that the most sensitive variables from a financial perspective are electricity selling price, production well costs, and power plant construction costs. From a technical perspective, one of the most sensitive factors is the capacity factor [26]. An increase in the geothermal electricity selling price leads to a significant rise in the overall NPV, and conversely, a decrease results in a decline. Additionally, the capacity factor is the most impactful parameter [27]. The electricity selling price and capacity factor are the most critical factors in determining the economic feasibility of development. Therefore, they need to be supported by a power purchase agreement that ensures the continuity of sales [28].

D. Capital Budgeting Calculation for the Scenario Based on Loan Variables

References are recommended to be based on the 4th base scenario (Upstream: Corporate loan and Downstream: Soft loan), which yields the most viable economic results. Sensitivity calculations are conducted for the variables Interest Rate (IR), Grace Period (GP), and Repayment Years (RY) in relation to operational variables, without considering the best- or worst-case scenarios. The soft loan variables are as follows: IR min: 0,5%, IR max: 3%, IR base or average: 1,75%; GP min: 4 years, GP max: 12 years, GP base or average: 8 years; RY min: 10 years, RY max: 30 years, RY base or average: 20 years. The corporate loan variables are as follows: IR min: 4%, IR max: 8%, IR base or average: 6%; GP min: 4 years, GP max: 12 years, GP base or average: 8 years; RY min: 7 years, RY max: 15 years, RY base or average: 11 years. Table 7 shows the results of the capital budgeting calculation to illustrate the differences in the loan parameter values and their impact on business feasibility.

Table 7. Results of Capital Budgeting for the Scenario Based on Loan Variables

Code	*Scenario*	*NPV (US$ .000)*	*IRR (%)*	*PP (Years)*	*PI*
a	*4th base scenario with Soft Loan IR min GP base RY base*	*4,867*	*12,53*	*21*	*1,02*
b	*4th base scenario with Soft Loan IR max GP base RY base*	*-385*	*9,91*	*>30*	*1,00*
c	*4th base scenario with Soft Loan IR base GP min RY base*	*-1,259*	*9,60*	*>30*	*0,99*
d	*4th base scenario with Soft Loan IR base GP max RY base*	*4,890*	*12,72*	*21*	*1,02*
e	*4th base scenario with Soft Loan IR base GP base RY min*	*-4,836*	*8,49*	*>30*	*0,98*
f	*4th base scenario with Soft Loan IR base GP base RY max*	*6,217*	*13,35*	*18*	*1,03*
g	*4th base scenario with Corporate Loan IR min GP base RY base*	*8,965*	*16,17*	*20*	*1,04*
h	*4th base scenario with Corporate Loan IR max GP base RY base*	*-4,483*	*8,43*	*>30*	*0,98*
i	*4th base scenario with*	*2,765*	*11,24*	*24*	*1,01*

Code	*Scenario*	*NPV (US$ .000)*	*IRR (%)*	*PP (Years)*	*PI*
	Corporate Loan IR base GP min RY base				
j	*4th base scenario with Corporate Loan IR base GP max RY base*	*4,040*	*12,38*	*26*	*1,07*
k	*4th base scenario with Corporate Loan IR base GP base RY min*	*-2,006*	*9,40*	*>30*	*0,99*
l	*4th base scenario with Corporate Loan IR base GP base RY max*	*5,542*	*13,69*	*20*	*1,02*

From the table above, here is the sensitivity analysis graph of loan parameters, specifically the interest rate, grace period, and repayment years, in relation to NPV, where Figure 3 shows the NPV values for each scenario based on the differences in loan parameter value:

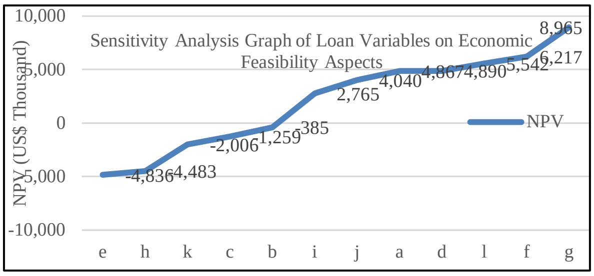

Figure 3. Sensitivity Analysis Graph of Loan Variables on Economic Feasibility Aspects

From the sensitivity analysis of loan variables, it was found that the interest rate on corporate loans has a significant impact on the economic feasibility results, followed by the repayment years on soft loans. Therefore, it is crucial to determine the optimal parameters for these variables when financing through loans.

IV. CONCLUSION

In the base or moderate scenario, the GPP XYZ development project is not economically feasible if funded entirely through equity for both the upstream and downstream sectors. The results show an NPV of -US$32,023,000, an IRR of 6.19%, a PI of 0.80, and a PP of over 30 years. From the sensitivity analysis conducted under the worst-case and best-case scenarios of the 4th scenario, the best-case scenario—characterized by a 10% reduction in each cost variable and a 10% increase in both capacity factor and electricity tariffs—yields the highest NPV. Specifically, with a 10% increase in electricity tariffs, the highest NPV is US$ 10,704,000. Based on the sensitivity analysis results shown in the tornado diagram, electricity tariffs are the most influential parameter affecting the economic feasibility of the GPP XYZ development project. Based on the sensitivity analysis of loan parameters reveals that the corporate loan interest rate and the repayment period for soft loans are the most significant factors influencing the economic viability of the GPP XYZ development project. Under a specific funding scheme, represented by the 4th scenario ("Corporate Loan IR min, GP base, RY base"), the highest NPV achieved is US$ 8,965,000. Therefore, this study recommends adopting the proposed parameters to ensure the feasibility of the Geothermal Power Plant (GPP) XYZ development project. These include utilizing more cost-effective project financing. The findings indicate that the investment will be feasible if the capital source consists of corporate loans for the upstream sector and soft loans for the downstream sector. This financing structure results in an NPV of 2,241 thousand USD, an IRR of 11.11%, a PI of 1.01, and a PP of 24 years. Based on the simulation, the source of funding is a critical factor in determining the project's economic feasibility. One of the key obstacles to the widespread adoption of geothermal energy is securing financing. The significant investment required for exploration, drilling production and injection wells, establishing field infrastructure, geothermal fluid collection and disposal systems, constructing the energy plant, grid connection, and other project development expenses poses a challenge. A substantial portion of this capital must be committed upfront, prior to confirming the resource's viability and the project's profitability [29]. The key measure of success in developing and utilizing renewable energy lies in its ability to compete with other energy sources in terms of price and cost.

This is particularly crucial for developing countries, where financial resources are more constrained compared to developed nations, making the efficient allocation of funds vital [30], because the significant investment risks remain the foremost challenge in progressing geothermal development in Indonesia [31]. Additionally, adopting the best-case scenario-by reducing cost variables such as minimizing production well and power plant costs as efficiently as possible, increasing the electricity tariff, and improving the production factor—further enhances the project's viability. Optimizing project funding by combining corporate loans for upstream financing and soft loans for downstream financing, while minimizing the corporate loan's interest rate and extending the soft loan's repayment period, will significantly improve the project's economic feasibility. Regarding another concern, the development of geothermal energy as one of renewable energy, requires appropriate government policies, as demonstrated by Iceland's approach. Iceland has implemented the Law on the National Energy Company and the Act on Electricity Produced Using Renewable Sources, leading to 85% of its electricity being generated from renewable energy sources [32]. Renewable energy plays a crucial role in fostering sustainable economic growth in developing countries [33].

The renewable energy sector significantly contributes to the overall growth of a country. In Indonesia, the adoption of renewable energy systems plays a crucial role in driving economic growth. While utilizing clean energy may not yield immediate benefits during the early stages of production in developing countries, it proves advantageous in later stages, not only for increasing production efficiency but also for preserving the environment. Therefore, policymakers are encouraged to leverage globalization to reduce the costs of renewable energy technologies [34]. Renewable energy plays a vital role in ensuring energy security, enhancing environmental protection, and creating job opportunities in many countries. Recognizing its importance, numerous nations view renewable energy as a strategic priority in the advancement of next-generation energy technologies and have set ambitious targets for its development as part of their policy frameworks [35].

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