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# Development Of Risk-Based Policy Strategies to Improve Sustainable Investment Performance in Geothermal Working Areas in Indonesia

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**ABSTRACT:**
This study analyzes the influence of stakeholder decision-making strategies and policies on PT's investment performance. PLN (Persero), is Indonesia's state-owned electricity company. Indonesia has a geothermal potential of 28 GWe and aims to add 3.3 GW of installed capacity by 2030. Our analysis reveals that effective stakeholder decision-making and well-formulated policies significantly enhance investment performance. This is supported by statistical evidence, with both the t-test and F-test results showing significance (calculated t-value and F-value exceed their respective critical values, with p-values < 0.05). Enhancing these strategies and policies is crucial for meeting Indonesia's new renewable energy (NRE) targets as outlined in the 2021-2030 RUPTL.

**Keywords**: Development, Risk-Based Policy Strategies, Sustainable, Investment Performance, Geothermal Working Areas.

## INTRODUCTION

In order to achieve the New and Renewable Energy ("NRE") development target and consider the potential of geothermal as one of the abundant NRE resources in Indonesia and spread from the islands of Sumatra, Java, Nusa Tenggara, Sulawesi, and Maluku, the Government of Indonesia targets an additional installed capacity of 3.3 GW of PLTP until 2030 in the mix or covering 16% of the total additional installed capacity of the NRE mix of 20.9 GW based on the Power Supply Business Plan Electricity ("RUPTL") 2021 – 2030. Referring to data released in the 2020 National Energy Council Energy Mix Book Report, Indonesia has a potential of 28 GWe of geothermal resources (ASHARI, 2021).

One of the business holders of energy geothermal development is PT. PLN (Persero). According to the website of the Director General (EBTKE, 2022), the geothermal projects at PT PLN cannot be separated from the optimization of the investments made and the investment policies carried out. In this case, investment performance analysis is the last phase of the portfolio management process. This provides a general evaluation of the success of investment management in achieving its overall goals. Measurement can be measured by simple performance measurement or through attribution. This study will analyse the influence of stakeholder decision-making and policy strategies on investment performance in PLN's geothermal projects using a simple investment performance assessment.

Geothermal comes from the word geo, which means earth, and thermal, which means heat (Basid et al., 2014; Farras et al., 2017; Gunawan et al., 2021). Geothermal can be defined as an energy source that comes from natural heat in the earth. Geothermal is the process of transferring heat from a certain place in the earth's crust from a heat source to the surface (Bagher et al., 2014; Dickson & Fanelli, 2018). Law No. 21 of 2014 on geothermal energy defines geothermal energy as a thermal energy source found in hot water, water vapor, and rocks, along with associated minerals and other gases that are genetically inseparable within a geothermal system (Undang-Undang Nomor 21 Tahun 2014, 2014).

The geothermal energy development process is generally divided into 2 stages: the Exploration and Exploitation (Ayuningtyas et al., 2019; Putriyana, 2018; Salsabila & Adharani, 2021). Exploration work is carried out to confirm geothermal energy resources in certain areas. The exploration process consists of several stages, namely: 1) Preliminary exploration, 2) Advanced exploration, 3) Exploration drilling, and 4) Feasibility study.

If the results of the study are declared feasible, the development process will continue to the Exploitation Stage. In this phase, the risks related to resources are relatively lower than in the exploration stage because geothermal resources at the exploitation stage are considered confirmed. Based on these considerations, new production and injection wells will begin to be drilled in the Exploitation Stage. The construction of electricity production facilities and other supporting facilities can also begin construction. When these activities and construction are completed, PLTP can be declared to have reached COD.

The research aims to identify and analyze the roles and responsibilities of key actors involved in the development of renewable energy-based power plants, including the President, National Energy Council (DEN), relevant ministries, PT PLN (Persero), regional governments, fund providers, and developers. It seeks to understand the interactions and collaborations among these actors, assess the impact of their policies and actions on renewable energy projects, and provide insights into the challenges and opportunities they face in promoting renewable energy initiatives. Additionally, the research aims to offer recommendations for enhancing the effectiveness of these actors in accelerating the transition to renewable energy sources.

## RESEARCH METHODS

To answer the RQ, the research strategy chosen is a literature study and survey method. Literature studies are carried out to identify indicators that exist in variables. The survey was used to obtain data from respondents regarding stakeholder decision-making strategies. Furthermore, this data will be processed statistically.

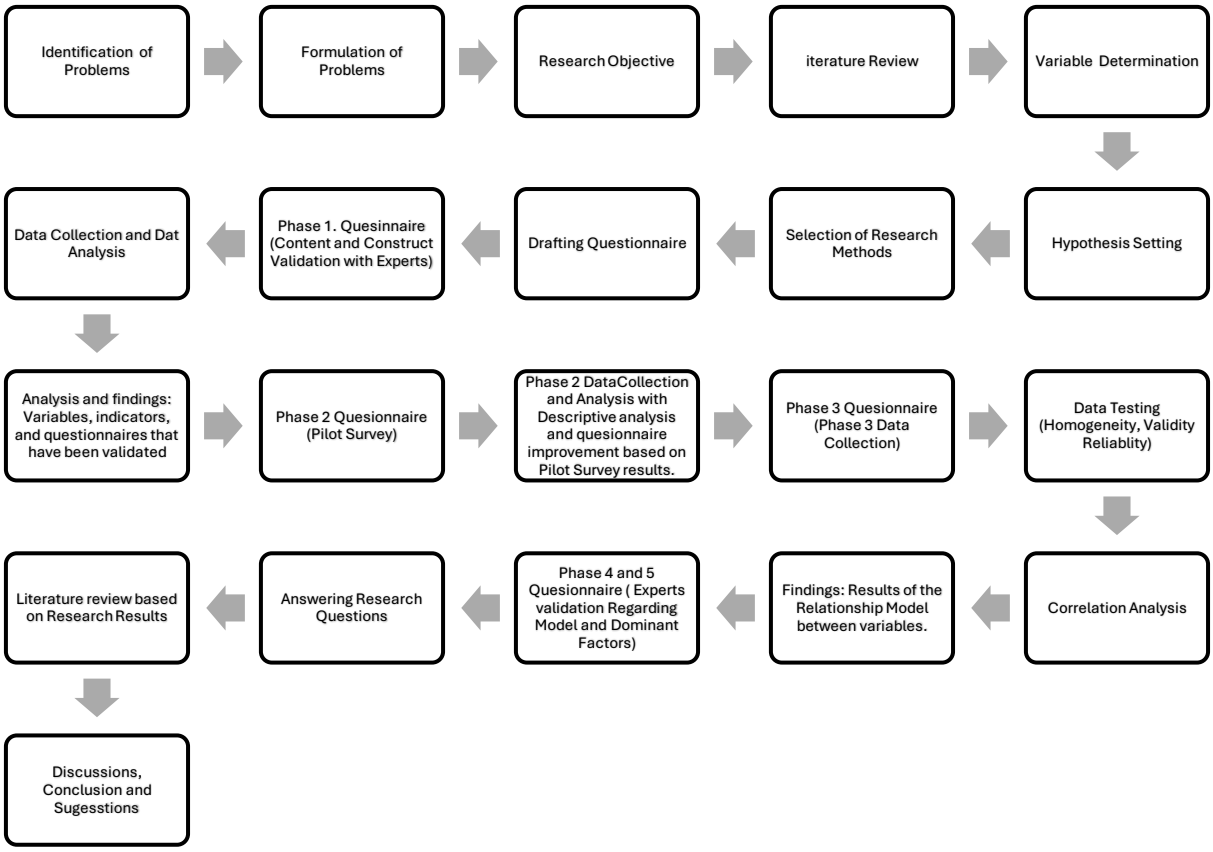


**Figure 1. Research flow**

In the research question, indicators are needed so that we can make a questionnaire. To answer RQ1, a secondary source, namely previous research, will be used to provide an overview/input for the author regarding indicators for decision-making strategies. Furthermore, with questionnaire research instruments, these indicators will be validated by experts, to obtain measurement indicators. The theoretical basis used belongs to Ahmed & Omotunde (2012). A questionnaire is a data collection method that presents a series of questions or written statements for respondents to answer (Rea & Parker, 2014). (Rea & Parker, 2014) stated that questionnaires are an effective data collection method when the researcher has a clear

understanding of the variables being measured and knows what responses are expected from participants. Moreover, questionnaires are particularly suitable when there is a large number of respondents who are not located in the same city as the researcher. As in this study, the researcher was in Jakarta while the respondents were in East Java.

To answer RQ2, secondary sources, namely previous research, will be used to provide an overview/input for authors regarding indicators for decision-making strategies. Furthermore, with questionnaire research instruments, these indicators will be validated by experts, to obtain measurement indicators (Retnawati, 2016). The study results are considered valid if there is a consistency between the collected data and the actual data from the object being studied (Djollong, 2014; Herawati & Mulyani, 2016; Usman & Gustalika, 2022). For instance, if the object is red but the collected data indicates it is white, the research results are invalid. Additionally, for research to be reliable, the data should be consistent over different times. A valid instrument ensures the measurement tool is accurate for obtaining valid data. Validity means that the instrument accurately measures what it is intended to measure (Clark & Watson, 2019; Rahardja et al., 2019).

The questionnaire results will be processed through a series of tests, including validity test, reliability test, normality test, homogeneity test, linearity test, and hypothesis test. The validity test measures the extent to which an instrument accurately reflects the variable being studied. An instrument is considered valid if it correctly captures the data for the variable in question. The level of validity indicates how closely the collected data aligns with the true characteristics of the variable. Validity is assessed through calculations, and in this study, it is done using Pearson correlation. This test examines the correlation score for each question item. An item is deemed valid if the calculation exceeds the table value, with a 95% confidence interval. Respondents or indicators that fail the homogeneity test will not be included in the validity test. These tests are conducted using the SPSS 23.0 for Windows software.

Reliability is an index indicating how dependable a measuring device is (Ursachi et al., 2015). If a measuring instrument consistently yields similar results when used repeatedly to measure the same phenomenon, it is considered to have high reliability. A research instrument is deemed highly reliable if it consistently measures what it is intended to measure. This means that the more reliable a test, the more confidence we can have that it will produce the same results upon retesting. An unreliable test is essentially useless because it will yield different results if retested. The reliability of a test is generally expressed numerically as a coefficient. A high coefficient signifies high reliability, while a low coefficient indicates low reliability. A test with perfect reliability has a coefficient of +1 or -1.

Reliability tests can use Cronbach's Alpha method. Indicators that have previously been declared invalid in the validity test will not be included in this reliability test. For this study, the

instrument is said to be reliable if it has an alpha value above 0.9 (very high). Testing will be carried out using SPSS 23 for windows.

The data normality test is a prerequisite to determine if the data is suitable for analysis using parametric or nonparametric statistics. This test reveals whether the research data is normally or abnormally distributed. In this study, the normality test is conducted using the Kolmogorov-Smirnov Test. The researcher utilizes the SPSS 23 for Windows software for this analysis.

The data homogeneity test is a prerequisite analysis to determine if the data is suitable for certain statistical tests. This test is crucial for parametric statistical analyses, such as ANOVA and independent t-tests (Marwan et al., 2023). The researcher used the IBM SPSS 23 Statistics for Windows application for this test. In making decisions based on the homogeneity test, if the significance value is less than 0.05, the variances of two or more data population groups are not the same. If the significance value is greater than 0.05, the variances of two or more data population groups are the same.

The linearity test is a procedure used to determine whether the distribution of research data is linear. The results from the linearity test will identify the appropriate analysis technique. If the linearity test concludes that the data distribution is linear, then the research data must be analyzed using linear techniques (Matondang & Nasution, 2022)

The hypothesis test will be carried out by multiple regression analysis. The multiple linear regression statistical test is used to test the significance or not of the relationship between more than two variables through the regression coefficient. For multiple linear regression, the statistical test uses Test F. According to (Konasani et al., 2015), if there is only one dependent variable (Y) and one independent variable (X), then in multiple regression, there is one dependent variable and two or more independent variables.

## RESULTS AND DISCUSSION

### Results

**Table 1. Validity test**

| Variable | Items | r calculate | r table | Decision |
|---|---|---|---|---|
| Stakeholder Decision Making (X1) | Item1 | 0,265 | 0,157 | Valid |
| | Item2 | 0,484 | 0,157 | Valid |
| | Item3 | 0,638 | 0,157 | Valid |
| | Item4 | 0,656 | 0,157 | Valid |
| | Item5 | 0,677 | 0,157 | Valid |
| | Item6 | 0,592 | 0,157 | Valid |
| | Item7 | 0,504 | 0,157 | Valid |

| | | | | |
|---|---|---|---|---|
| | Item8 | 0,681 | 0,157 | Valid |
| | Item9 | 0,593 | 0,157 | Valid |
| | Item10 | 0,586 | 0,157 | Valid |
| | Item11 | 0,582 | 0,157 | Valid |
| | Item12 | 0,585 | 0,157 | Valid |
| | Item13 | 0,496 | 0,157 | Valid |
| Policy Strategy (X2) | Item1 | 0,451 | 0,157 | Valid |
| | Item2 | 0,747 | 0,157 | Valid |
| | Item3 | 0,636 | 0,157 | Valid |
| | Item4 | 0,655 | 0,157 | Valid |
| | Item5 | 0,640 | 0,157 | Valid |
| | Item6 | 0,736 | 0,157 | Valid |
| | Item7 | 0,517 | 0,157 | Valid |
| Investment | Item1 | 0,633 | 0,157 | Valid |
| Performance (Y) | Item2 | 0,815 | 0,157 | Valid |
| | Item3 | 0,814 | 0,157 | Valid |

Based on the table provided, it is evident that all items exhibit correlation values exceeding the critical value of 0.157 (r table). This indicates that the questionnaire items are valid. Upon calculation using the SPSS program, the reliability value (Cronbach's alpha) is determined as follows:

**Table 2. Cronbach alpha**

| Variable | Alpha | Limit r | Decision |
|---|---|---|---|
| Stakeholder Decision Making (X1) | 0,826 | 0,600 | Reliable |
| Policy Strategy (X2) | 0,749 | 0,600 | Reliable |
| Investment Performance (Y) | 0,629 | 0,600 | Reliable |

Based on the table above, it is apparent that the Cronbach's alpha value for all three variables exceeds 0.600. This indicates that the questionnaire measurement tool is reliable and meets the required reliability standards.

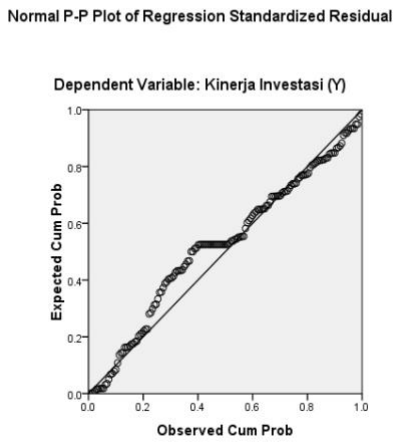


**Figure 2. Normality Test**

Based on the graph above, it is evident that the points are scattered around and closely follow the diagonal line, indicating that the regression model is normal and suitable for predicting independent variables.

Another way to test normality is by the One-Sample Kolmogorov Smirnov statistical test. The test criteria are as follows (Priyatno, 2014):

1. The residual data is normally distributed if the Significance value (Asym Sig 2 tailed) > 0.05.
2. If the Significance value (Asym Sig 2 tailed) ≤ 0.05, then the residual data is not normally distributed.

**Table 3. One-Sample Kolmogorov-Smirnov Test**

| | | **Unstandardized Residual** |
|---|---|---|
| N | | 156 |
| Normal Parameters[a] | Mean | .1089744 |
| | Std. Deviation | 1.71318961 |
| Most Extreme Differences | Absolute | .106 |
| | Positive | .041 |
| | Negative | -.106 |
| Kolmogorov-Smirnov Z | | 1.326 |
| Asymp. Sig. (2-tailed) | | .060 |
| a. Test distribution is Normal. | | |

Based on the table above, the significance value (Asym.sig 2 tailed) is 0.060. Since this value is greater than 0.05, it indicates that the residuals are normally distributed. Here are the results of the multicollinearity test:

**Table 4. Multicollinearity Test Results**

| Coefficientsa | | | |
|---|---|---|---|
| Type | | Collinearity Statistics | |
| | | Tolerance | VIF |
| 1 | (Constant) | | |
| | Stakeholder Decision Making (X1) | .723 | 1.382 |
| | Policy Strategy (X2) | .723 | 1.382 |
| a. Dependent Variable: Investment Performance (Y) | | | |

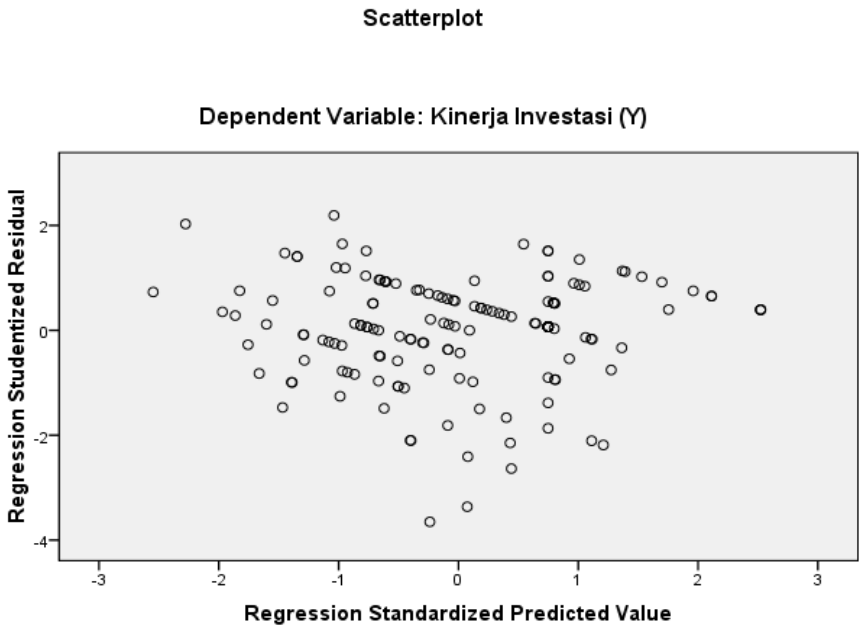


**Figure 3. Heteroscedasticity Test Results of Scatterplot Chart Method**

From the table above, it is observed that the VIF (Variance Inflation Factor) values are below 10.00 and the Tolerance values are above 0.100 for both independent variables. Therefore, it can be concluded that the regression model does not exhibit multicollinearity issues. The scatterplot shows points scattered in an indistinct pattern both above and below the zero line on the Y-axis.

Note: Visual inspection of graph-based heteroscedasticity tests can lead to different conclusions due to reliance on pattern observation alone. Therefore, conducting statistical tests such as the Glejser Test is essential for more reliable results.

Another method to test for heteroscedasticity is the Glejser test, where the absolute residuals from the regression model are regressed against the independent variables. If the regression coefficients of these independent variables are not statistically significant, it suggests that heteroscedasticity is not present (Setyawan et al., 2019).

**Table 5. Glejser Test**

| Coefficientsa | | | | | | |
|---|---|---|---|---|---|---|
| Type | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 1.266 | .618 | | 2.046 | .042 |
| | Stakeholder Decision Making (X1) | .010 | .015 | .067 | .707 | .480 |
| | Policy Strategy (X2) | -.018 | .023 | -.076 | -.799 | .425 |
| a. Dependent Variable: ABS_RES | | | | | | |

Based on the table above, it is evident that both variables have significance values greater than 0.05 (not significant). Therefore, it can be concluded that there is no heteroscedasticity issue in the regression model.

**Table 6. Results of linear regression analysis**

| Coefficientsa | | | | | | |
|---|---|---|---|---|---|---|
| Type | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 2.507 | 1.137 | | 2.205 | .029 |

| | | | | | |
|---|---|---|---|---|---|
| | Stakeholder Decision Making (X1) | .068 | .027 | .203 | 2.531 | .012 |
| | Policy Strategy (X2) | .209 | .042 | .403 | 5.024 | .000 |
| a. Dependent Variable: Investment Performance (Y) | | | | | | |

The regression equation is as follows:

$$Y = 2.507 + 0.068X1 + 0.209X2$$

The meaning of these numbers is as follows:

1. Constant of 2.507; This means that if the stakeholder decision-making and policy strategy value is 0, then the amount of investment performance (Y) is 2,507.
2. The regression coefficient of the Stakeholder Decision-Making variable (X1) is 0.068, meaning that every increase in Stakeholder Decision-Making by 1 unit will increase the Policy Strategy by 0.068 units, assuming the other independent variables have a fixed value.
3. The regression coefficient of the policy strategy variable (X2) is 0.209. This means that every increase in the policy strategy by 1 unit will increase the policy strategy by 0.209 units, assuming that the value of other independent variables is fixed.

**Table 7. Test results t**

| **Coefficientsa** | | | |
|---|---|---|---|
| Type | | t | Sig. |
| 1 | (Constant) | 2.205 | .029 |
| | Stakeholder Decision Making (X1) | 2.531 | .012 |
| | Policy Strategy (X2) | 5.024 | .000 |
| a. Dependent Variable: Investment Performance (Y) | | | |

Based on the study findings, it is established that stakeholder decision-making partially influences investment performance in PT PLN's geothermal projects. This conclusion stems from the t-test results, where the calculated t-value (2.531) exceeds the critical t-table value (1.976), and the significance level is less than 0.05 (0.012 < 0.05). Thus, the null hypothesis (Ho) is rejected, and the alternative hypothesis (Ha) is accepted. The positive t-value indicates a positive effect: increased stakeholder decision-making enhances investment performance. Thus, the first

hypothesis that states, "Stakeholder decision-making affects investment performance in PT PLN's geothermal project", is proven and can be declared accepted.

Based on the results of the study, it is known that the policy strategy partially affects the investment performance in PT PLN's geothermal projects. This is based on the results of the t-test obtained by the t-value calculated > t table (5.024 > 1.976) and the significance of < 0.05 (0.000 < 0.05) so that Ho was rejected and Ha was accepted. The value of the t calculation is positive, which means that it has a positive effect, namely, the increasing policy strategy will improve investment performance. Thus, the second hypothesis, which states that "Policy strategy affects investment performance in PT PLN's geothermal project," is proven and can be declared acceptable.

Based on the results of the study, it is known that stakeholder decision-making and policy strategies affect investment performance in PT PLN's geothermal projects. This is based on the results of the F test obtained by the F value $_{calculated}$ > F $_{table}$ (31.122 > 3.055) or the significance < 0.05 (0.000 < 0.05), so Ho was rejected and Ha was accepted. Thus, the third hypothesis, "Stakeholder decision-making and policy strategy jointly affect investment performance in PT PLN's geothermal project" is proven and accepted.

**Discussion**

**The Influence Of Stakeholder Decision-Making On Investment Performance In PT PLN's Geothermal Projects**

Stakeholder decision-making plays a pivotal role in influencing investment performance in geothermal projects undertaken by PT PLN in Indonesia. This finding is in line with (Edwaren et al., 2019) which suggests that stake holder involvement provides quite positive results that are ready to support the NPP programme in the NTB region. Stakeholders involved in these projects, ranging from government regulators to local communities and environmental groups, contribute significantly to the strategic direction and operational outcomes. Their decisions on licensing, environmental approvals, and community engagement policies can either facilitate or hinder project progress and operational efficiency. For instance, favorable decisions by regulatory bodies and community support can streamline project timelines and reduce operational risks, thereby enhancing investment returns and overall project sustainability.

Furthermore, stakeholder decisions directly impact project financing and investor confidence. Investor perceptions of regulatory stability, environmental compliance, and community relations heavily influence their willingness to commit capital to geothermal ventures. Positive stakeholder decisions that prioritize transparent governance, sustainable development practices, and proactive risk management strategies can attract investment, lower financing costs, and mitigate project risks. Conversely, delays in decision-making, regulatory uncertainty, or community opposition can deter investors and increase project costs, thereby affecting long-term investment viability and sustainability goals.

In navigating these complexities, PT PLN must adopt strategic engagement approaches that foster collaborative decision-making among stakeholders. This includes promoting inclusive dialogue, addressing stakeholder concerns through effective communication channels, and integrating stakeholder feedback into project planning and implementation phases. By aligning stakeholder interests with project objectives and adopting transparent decision-making processes, PT PLN can enhance stakeholder confidence, optimize investment performance, and sustainably develop Indonesia's geothermal resources for long-term energy security and environmental stewardship.

**The Effect Of Policy Strategy On Investment Performance In Geothermal Projects Of PT PLN**

Policy strategies play a crucial role in influencing investment performance in geothermal projects managed by PT PLN in Indonesia. This finding is in line with (Sabiq et al., 2020), The results showed that there is uncertainty in the price of geothermal electricity caused by the existence of two conflicting policies, namely regulations regarding the WKP auction mechanism and the electricity generation BPP policy. The short-term impact of the geothermal electricity price policy is the non-completion of PLTP projects that have produced electricity because they are waiting for a power purchase agreement between the developer and PLN while the long-term impact of this problem is the low investment interest in geothermal development. Recommendations from the results of the analysis of geothermal electricity price policies in this study are the provision of fiscal incentives by the government to developers, the government that conducts drilling during exploration, involves independent auditors to decide on price agreements between PT PLN and developers, and includes a mix of power plants in the national energy mix target. If the recommendations from the results of this study are used as input in making geothermal electricity pricing policies, it will encourage the development of geothermal electricity in Indonesia.

Well-designed policies can create a stable and supportive regulatory environment that encourages long-term commitment from investors in these projects. For example, policies supporting transparency, regulatory predictability, and proactive risk management can reduce uncertainty and enhance investor confidence in the investment prospects within the geothermal energy sector.

Additionally, policy strategies also impact access to funding sources and project capital costs. Policies that consider environmental and social sustainability aspects, such as stringent environmental compliance requirements or inclusive community participation policies, can strengthen PT PLN's position in securing financial support from financial institutions and private investors. Therefore, risk-oriented and sustainable policy strategies not only bolster the economic fundamentals of projects but also mitigate environmental and social risks that could hinder project development.

Amidst global energy market dynamics and climate change challenges, PT PLN also needs to adapt policies to meet the demands of sustainable energy transformation. Government support in designing policies that promote clean and environmentally friendly energy use can provide additional incentives for PT PLN in developing sustainable geothermal energy projects. By combining progressive policy strategies with technological innovation and careful risk management, PT PLN can strengthen its position as a leader in the renewable energy industry in Indonesia and enhance long-term investment performance.

**The Influence of Stakeholder Decision-Making and Policy Strategy Simultaneously Affects Investment Performance In PT PLN's Geothermal Projects**

Stakeholder decision-making and the implementation of policy strategies proceed simultaneously and mutually influence the investment performance of PT PLN's geothermal projects in Indonesia. Stakeholders, including government entities, local communities, financial institutions, and investors, play crucial roles in shaping the direction and operational outcomes of these projects. Their decisions regarding permits, environmental approvals, and social and political support can either create a conducive investment climate or hinder it (Oktiarifadah et al., 2024; Yasah et al., 2024).

The policy strategies employed by PT PLN must be responsive to the dynamics and needs of these diverse stakeholders. For example, policies that prioritize environmental sustainability and support for local communities can enhance PT PLN's reputation as a socially and environmentally responsible operator. This not only builds trust within the community and supports project sustainability but also enables PT PLN to access funding sources at lower costs and attract long-term investors (Rofiah, 2021; Siahaan & Pardede, 2022).

Furthermore, stakeholder decisions based on strategic policy considerations can influence resource allocation and investment priorities for PT PLN. Policy strategies oriented towards risk management and effective governance can reduce project uncertainty, improve operational efficiency, and accelerate financial and environmental targets. Thus, the synergy between stakeholder decision-making and the implementation of appropriate policy strategies can create a stable and sustainable operational environment for PT PLN in developing geothermal projects in Indonesia.

## CONCLUSION

Based on the results of the discussion, it is known that stakeholder decision-making and policy strategies partially and simultaneously affect investment performance in PT PLN's geothermal projects. It can be concluded that the development of risk-based policy strategies is a crucial step to improve sustainable investment performance in geothermal projects in Indonesia, especially those run by PT PLN. A policy strategy that proactively manages risk, supports environmental sustainability, and effectively integrates stakeholder interests, can form

a solid foundation for long-term investment. Thus, PT PLN can strengthen its position as a leader in the renewable energy industry, provide clean energy, and contribute positively to sustainable development in Indonesia.

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