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Valuation Analysis of Mini Hydro Power Plant Using Value at Risk Method

Satria Mulia Purnomo, Armand Omar Moeis
Universitas Indonesia
Email: satriamulia28@gmail.com, armand.omar@ui.ac.id

KEYWORDS

Valuation; Mini-hydro; Value at Risk; Monte Carlo

ABSTRACT

The Paris agreement made Indonesia committed to the renewable energy transition. This commitment encourages Indonesia and PLN to make RUPTL which increases the potential for hydropower in Indonesia. This increased potential has attracted investors to invest in the MHP business. However, the MHP business still has risks that make costs fluctuate, disrupting prospects and causing doubts in investment. To overcome this problem, the authors created a financial projection model using a discounted cash flow model with a risk approach using the value at risk monte carlo method so that it can measure MHP valuations more accurately and can provide investment feasibility considerations. This study examines the financial viability of Mini Hydro Power Plant (PLTM) investments in Indonesia, where renewable energy development faces risks from fluctuating costs and uncertain returns. The research aims to evaluate PLTM project risks using the Value at Risk (VaR) method combined with Monte Carlo simulation, focusing on three key variables: loss factor (7%), operational costs, and water retribution fees. Financial data from a West Sumatran PLTM company was analyzed through discounted cash flow (DCF) modeling with a 3% discount rate, supplemented by 10,000-iteration Monte Carlo simulations at 95% confidence levels. Results indicate positive NPV values under normal conditions (Rp161.6 billion), demonstrating investment feasibility, while sensitivity analysis shows potential 8-22% valuation improvements with reduced loss factors. The study provides investors with a risk-assessment framework and suggests infrastructure optimization could enhance PLTM profitability.

INTRODUCTION

The problems in this research began when there was the Paris Agreement, namely the global agreement to deal with climate change through the COP21 conference in Paris in 2015 (Bernardo et al., 2021; Mousavi et al., 2020; Nhamo & Nhamo, 2016). With the signing of the Paris Agreement, countries promised to reduce CO2 and other greenhouse gas emissions (UNFCCC, 2015; Rogelj et al., 2016). Accelerating the global transition to low carbon can be achieved through policies such as the development of new and renewable energy (IEA, 2021; Jacobson et al., 2017). In response to this, Indonesia and PLN prepared a 2021–2030 *Rencana Usaha Penyediaan Tenaga Listrik* (RUPTL) concerning the determination of Indonesia's electricity capacity (Ministry of Energy and Mineral Resources, 2021). As one of the world's largest CO_2 emitters, Indonesia has promised to achieve carbon neutrality by 2060 (Setyawan et al., 2022). The Indonesian government and PLN released the 2021–2030 RUPTL regarding the determination of Indonesia's electricity capacity. Where this RUPTL contains plans for the development of Indonesia's electric power which in the future will focus on renewable energy, of which around 50% will come from hydropower (Utama & Malik, 2022; Kementerian ESDM, 2021).

The prospect of hydropower in Indonesia itself is quite promising. Indonesia has a hydropower potential of 75 GW, most of which are spread over Sumatra, Sulawesi, Kalimantan, and Papua (Handayani et al., 2020). Based on data from BPS for 2021, hydropower growth has increased by 2.7% from 2020 to 2021, with the type experiencing the greatest increase being PLTM with an increase of 134% (Hutapea & Kurniawan, 2022). This increase is the second largest after solar power in EBT-based generators (Sari et al., 2021). Among the regions in Indonesia, Sumatra is one of the areas that has the greatest water potential (Rakhmadi et al., 2019). And among the provinces in Sumatra, West Sumatra is one that has optimized its water potential (1100 MW), where around 93% has been utilized (Widayanti & Lestari, 2021). This success is supported by local community participation and regional government policy (Putra & Wahyuni, 2020). The use of hydropower on a mini and micro scale in West Sumatra is considered to have great potential, especially for electrifying remote areas, with local technology mastery and low operational costs being key enablers (Nasution et al., 2019).

Apart from the increased prospects and support, renewable energy faces various uncertainties and challenges in implementation, namely there are problems in the form of risks that can affect the financial condition of a PLTM. At the operation and maintenance stage, there are several factors that determine the sustainability of the PLTM, such as the availability of funds, the availability of water discharge throughout the year, and the ability of the managing institution to manage the PLTM as well as support from the government/local residents (H Didik et al 2018). This can result in fluctuating financial conditions. Not only that, the PPA contract policy which is always extended and the decrease in the value of the feed-in tariff reduces investor interest in PLTM (Maulana & Dalimi, 2022). This raises doubts in investing in the PLTM business. Therefore, a feasibility study and good technical design are also needed at the planning stage to avoid greater losses in order to measure the MHP valuation more accurately.

This study introduces the Value at Risk (VaR) method, which is still rarely applied in the context of Mini Hydro Power Plant (PLTM) valuation. By employing the VaR Monte Carlo approach, this research provides a more accurate and risk-adjusted assessment of PLTM investments, addressing gaps in existing methodologies that often overlook the dynamic financial risks associated with hydropower projects.

With this, the authors designed a study entitled " Valuation Analysis of Mini Hydro Power Plant Using Value at Risk Method ". This research aims to evaluate the financial feasibility of Mini Hydro Power Plant (PLTM) investments by integrating key risk factors—such as loss factor, operational and maintenance costs, and water retribution costs—into a comprehensive valuation model. By employing the Value at Risk (VaR) Monte Carlo method, the research seeks to provide a more accurate and risk-adjusted assessment of PLTM projects, which are often subject to financial uncertainties. The benefits of this research include offering investors a robust tool to assess project viability under varying risk scenarios, enabling policymakers to identify strategies for optimizing infrastructure and contractual terms (e.g., reducing loss factors), and supporting PLTM operators in making data-driven decisions to enhance sustainability and profitability.

From a scientific perspective, this research contributes to the field of renewable energy finance by demonstrating the applicability of the VaR method in hydropower project evaluations, particularly in emerging markets like Indonesia. It bridges the gap between financial risk theory and practical application, providing a methodological framework for future studies. Practically, the findings offer actionable insights for stakeholders: investors can use the model to mitigate risks, policymakers can refine regulations to attract more renewable energy investments, and PLTM operators can improve financial planning. Ultimately, this study supports the broader goal of sustainable energy development by aligning economic viability with environmental objectives.

METHOD

This study employs a quantitative approach using descriptive and simulation methods to analyze the financial risks of Mini Hydro Power Plant (PLTM) investments. The research utilizes secondary data from a PLTM company in West Sumatra, including financial reports (2019-2021), feasibility studies, and projection models submitted to PLN. The data used in this study came from a PLTM company in West Sumatra. The company is engaged in the business of power generation, services, industry, trading, workshops, land transportation, construction and mining. Companies can also carry out business activities in the field of providing electricity for public purposes, building power plants, selling electricity to PT Perusahaan Listrik Negara (Persero), and carrying out operation and maintenance of power plants. The initial investment value issued by this company is worth 60 billion rupiah. This company has an electric power capacity of 8000 kWH assuming a capacity factor of around 85% annually.

In general, distributed electricity will experience resistance from the cable material used in distribution. This resistance makes the amount of electricity received by the public or consumers will decrease. This makes the income or income received by the PLTM company decreases. This reduction in revenue has also been stated in the power purchase agreement, where PLN West Sumatra stated that there was a reduction of around 7% in the energy distribution process. This reduction is often referred to as the loss factor.

A high loss factor can reduce the value of the electricity capacity that can be generated by the company. When the loss factor reaches 7%, it means that about 7% of the energy produced by a power plant cannot be used effectively and is lost in the process of shipping and distribution. This means that of the capacity that should be available, only a small portion can be utilized efficiently. In this case, the company will face a potential loss of revenue because the energy that should be sold cannot be fully utilized.

The data used in this research is data that comes from public documents and company documents such as the 2021 company financial statements, 2020 company financial reports, 2019 company financial reports, Financial Feasibility Study Report, PT X Financial Update 2021, PT X Financial Update 2020, PT X's projected model to PLN, 2019 PT X Share Valuation Document, and Bank Mandiri ROI & INDOIS Bonds Price Indication on May 5, 2023. In the 2021 position, the company submits a projection model that will be given to PLN which contains the financial model for the PLTM company from 2021 to 2050.

To calculate the VaR of these variables, time series data for each variable is required which is based on several assumptions from secondary data and expert opinion. The output of this study is the NPV value of the company related to the assumption of a discount rate based on the 2021 BI Rate with no significant macro events or policies. The use of the BI rate as a discount factor can also be used as a generally accepted industry standard. In many industries, the BI rate is often used as a reference for calculating NPV and making investment decisions because it has taken into account the growth of inflation that occurs.

In the income calculation, there are four variables, namely the beginning balance, feed-in tariff, income, and inflow which will affect the final result of the model. Beginning balance is the final value of cash flow in the previous period. Income is the income per year that the company gets from multiplying water capacity, capacity factor, and feed-in tariff. The value of the feed in tariff is based on the PPA agreed by the company and PLN in 2010, the feed-in tariff for electricity will be 921 Rupiah/Kwh after tax until 2025 and the agreement will be extended until 2050 with a feed-in tariff of 50%. from before or 460.5 Rupiah/Kwh after tax. Meanwhile, the inflow value is the value obtained from the sum of income per year with the feed-in tariff for that year. The feed-in tariff value in inflow aims to provide an indication of how much the feed- in tariff price will be in that period. Income calculation is assumed to be stable every year until 2050 except for the feed-in tariff, because the PLTM capacity is constant every year.

In the expenditure calculation, there are eight variables that affect the value of expenditure, these variables are outflow, operation and maintenance, water retribution, general and administrative, cash flow surplus, interest, and after interest surplus. Outflow is the value obtained from the sum of the variable costs of operation and maintenance, water retribution, and general and administrative. Operation and maintenance are costs incurred related to the operation and maintenance of machines with the assumption that these costs have an increase of 2% annually until 2050 which is obtained from changes in values in the financial update. Water retribution is a cost incurred for regional water managers assuming this fee has a reduction of 2% annually until 2050 which is obtained from changes in value in the financial update. General and administrative are overhead costs incurred related to administrative and other costs assuming these costs have an increase of 1% annually until 2050 which is obtained from changes in values in financial updates. Surplus cash flow is the value obtained from reducing inflow and outflow. Surplus cash flow from operational after interest is the value obtained from reducing the cash flow surplus with interest. Meanwhile, the value of interest experiences a different scheme. Interest in this model is a representation of the interest that needs to be paid from developments carried out by related companies. However, the ownership of the related company is divided into two which are symbolized by PT. A and PT. B. The value of the interest paid each year is obtained from the plans and roadmaps of each company to pay their respective debts.

RESULT AND DISCUSSION

Analysis using the Discounted Cash Flow (DCF) model provides an overview of the company's financial projections from 2021 to 2050 using a discount rate of 3%. The results of this projection show a Net Present Value (NPV) of Rp. 206,600,749,401. The DCF model is used to calculate the present value of the cash flows expected to be received by the company in the future.

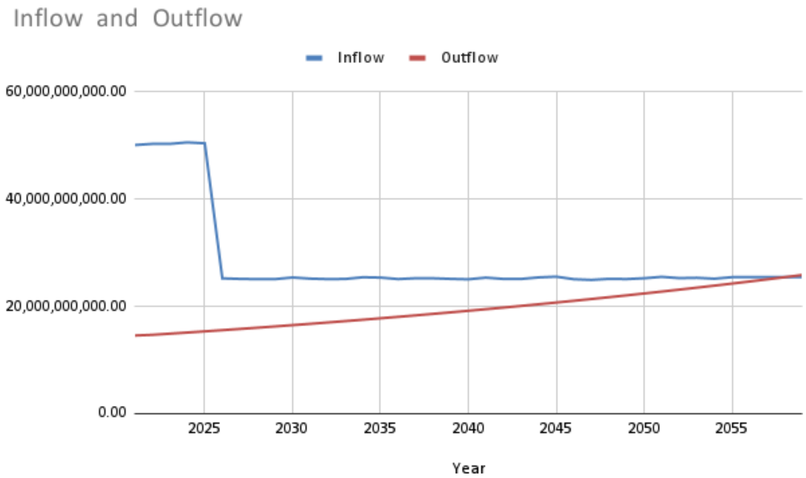

Figure 1. Comparison of Outflow and Inflow

Source: Analysis of PT X's financial projections (2021-2050)

After considering the risk of loss factor of 7% in the analysis, it is found that the NPV of the project is Rp. 161,636,613,842 with an NPVAR of Rp. 138,670,000,000 with BEP cash flow in 2058. In this condition, the PBV value is 2.69 with a risk-adjusted value of 2.31. The rate of return is still at 15.40% and risk-adjusted at a value of 11.95%, which is still higher than the 30-year SBN value.

Table 1. Result with 7% Loss Factor

Comparison	Value	Initial Investment	PBV	Rate of Return	SBN 30 years
NPV	**161,636,613,842**	**60,000,000,000.00**	**2.69**	**15.40%**	**6.875%**
NPVAR	**138,670,000,000**	**60,000,000,000.00**	**2.31**	**11.95%**	**6.875%**

Source: Monte Carlo simulation (10,000 iterations, α=95%)

However, if we consider a loss factor of 5% and 0%, then the NPV and NPVAR values become IDR 174,375,775,304 and IDR 150,740,000,000 for a loss factor of 5%, with PBV and PBVAR values of 2.91 and 2.51, and return rates of 17.33% and 13 .75%. For zero loss factor, the NPV NPVAR value is Rp. 225,770,060,472 and Rp. 217,950,000,000, with PBV and PBVAR values of 3.44 and 3.20, and return rates of 22.21% and 20.03%.

Table 2. Comparison of 5% loss factor

Comparison	Value	Initial Investment	PBV	Rate of Return	SBN 30 Years
NPV	Rp174,375,775,304	60,000,000,000.00	2.91	17.33%	6.875%
NPVAR	Rp150,740,000,000	60,000,000,000.00	2.51	13.75%	6.875%

Source: Sensitivity analysis based on infrastructure improvement scenarios

Table 3. Comparison with *zero loss factor*

Perbandingan	Nilai	Initial Investment	PBV	Tingkat Return	SBN 30 tahun

NPV	225,770,060,472	60,000,000,000.00	3.44	22.21%	6.875%
NPVAR	217,950,000,000	60,000,000,000.00	3.20	20.03%	6.875%

Source: DCF simulation (3% discount rate) under ideal conditions

To see the correlation, the researchers used the Spearman's correlation, where the results obtained were that the variables that had the most significant effect were operational and maintenance costs.

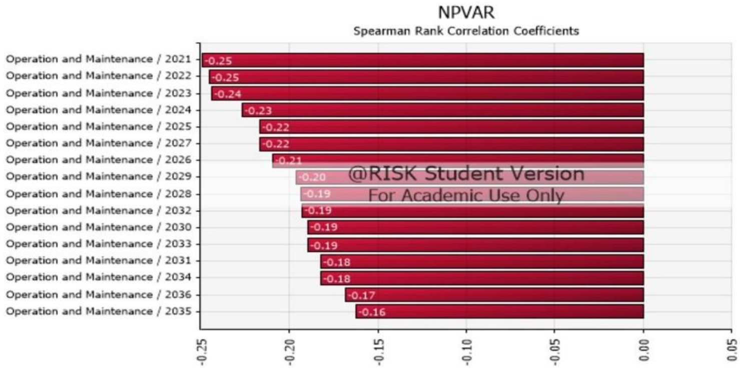

Figure 2. Result of Spearman's Correlation

Source: Operational cost data processing (2019-2021) using @Risk 8.0

Table 4. Comparison of Zero Loss Factor, 5% Loss Factor, and 7% Loss Factor

Comparison	*Zero Loss Factor*	*Loss Factor 7%*	*Loss Factor 5%*
NPV	Rp206,600,749,401	Rp161,636,613,842	Rp174,375,775,304
NPVAR	Rp192,230,000,000	Rp138,890,000,000	Rp150,740,000,000
BEP (Cashflow)	2062	2058	2059
PBV	3.44	2.69	2.91
PBV at Risk	3.20	2.31	2.51
Rate of Return	22.21%	15.40%	17.33%
Rate of Return at Risk	20.03%	11.95%	13.75%

Source: Synthesis of results from Tables 4-6 with 30-year government bonds as benchmark

Based on the analysis that has been done, changes to the loss factor in a Mini Hydro Power Plant (PLTM) can have a significant impact on the financial and investment parameters associated with the project. With a zero loss factor, the company can have an NPV of IDR 206,600,749,401. When compared to normal conditions which have a loss factor of 7% following the PPA scheme, the company's NPV is IDR 161,636,613,842. This indicates that there is a difference of around 28% which can be increased again. Meanwhile, if we assume PLN West Sumatra can improve the existing infrastructure so that the loss factor is reduced to 5%, then the NPV value can be increased to IDR 174,375,775,304. Where this is an increase of 8% from the NPV when the loss factor is 7% based on the current PPA.

Based on the business analysis that has been made, PLTM companies experience cash flow break evens in certain years. Meanwhile, in business, an entrepreneur must apply the principle of "going concern". Where the ownership of a company can and may change, but the company must be eternal. With the BEP in cash flow, investors can reduce investor interest in investing in PLTM. In this case, the loss factor has quite a big influence in increasing the life of the BEP. During normal circumstances with a loss factor of 7%, the PLTM company concerned will experience BEP cash flow in 2058. Meanwhile, if we can reduce the loss factor to 5% or even 0%, then we can extend the BEP year to 2059 or 2062. This shows every decrease in loss factor by 2%, the company can extend the life of the BEP for 1 year.

In the Spearman correlation analysis, there is a significant relationship between the variables measured using a rating scale. In this case, the results of the analysis show that the variable with the most significant influence is operation and maintenance cost, which has the highest Spearman correlation value. In addition, this variable also has the highest volatility, which indicates that operating and maintenance costs have significant fluctuations in relation to other observed variables.

The importance of the variable operating and maintenance costs can be explained by several factors. First, operating and maintenance costs are important factors in determining the sustainability of a project or business. The higher the operating and maintenance costs, the more difficult it is for the project or business to remain profitable. In addition, high volatility in operating and maintenance costs may indicate that there are factors contributing to these fluctuations. For example, fluctuations in raw material prices, changes in regulatory policies, or increases in labor costs. These factors can cause operation and maintenance costs to rise or fall suddenly, which in turn can have a significant impact on the performance and profitability of a project or business.

In the PLTM business, there are three main risks involved in determining the valuation of a PLTM, namely loss factor, operational and maintenance costs, and water retribution costs. Based on the PPA, the said PLTM company has a risk factor in the form of a loss factor which is worth 7% under normal circumstances. The loss factor is assumed to be normally distributed with a mean value of 7% and a standard deviation of 0.5%. This risk will then affect the value of income per year from the projection model made. Meanwhile, based on literature studies and consultations with experts, PLTM also has other risks, namely operational and maintenance costs and water retribution costs. After conducting a literature study and analysis of fit distribution based on the company's financial update data, it was found that the distribution of the variable operational and maintenance costs is triangular, while the cost of water charges has a uniform distribution.

Based on the business analysis conducted, the PLTM company faces a break even cash flow (BEP) in a certain year. In a business context, the principle of "going concern" is applied, which means that a company must remain sustainable even though its ownership may change. Under normal conditions with a loss factor of 7%, the PLTM company experiences BEP in 2058. However, if we succeed in reducing the loss factor to 5% or even 0%, then the BEP year can be extended to 2059 or even 2062. This shows that every decrease in loss factor by 2%, the company can extend the life of the BEP for 1 year.

After using the value at risk approach with the Monte Carlo method with 10,000 iterations and a confidence level of 95%, the NPV value of the PLTM is obtained along with the NPVAR value or valuation value that has taken into account the existing risk factors. Under normal circumstances, with a loss factor of 7% following the PPA scheme, the company's NPV is IDR 161,636,613,842 with a potential loss value of -IDR 22,746,613,842, making the NPVAR value IDR 138,890,000,000. When compared to the zero loss factor situation, the company can have an NPV of IDR 206,600,749,401. This indicates that there is a difference of around 22% which can be increased again. If PLN West Sumatra can improve the existing infrastructure so as to reduce the loss factor to 5%, then the NPV value can increase to IDR 174,375,775,304. This increase reflects an increase of 8% from the NPV at a loss factor of 7% based on the current PPA. By reducing the loss factor risk, West Sumatra PLN can increase the value of its projects and optimize the expected investment returns.

In making investment feasibility considerations, one of the parameters used is price book value (PBV). Under normal circumstances with a loss factor of 7%, a PBV value of 2.69 is obtained, whereas after risk adjustment is carried out, the PBV value will decrease to 2.31. However, this value is still said to be a good indicator because it is worth more than 1. So, in 2021, a PLTM company is still worth investing in or selling. However, if the loss factor can be reduced to 5%, then the PBV value will increase to 2.91 and the PBV at risk will increase to 2.51. Meanwhile, if we do not calculate the loss factor risk, then the PBV value becomes 3.76 and the PBV at risk becomes 3.63.

Another parameter in making investment considerations is the rate of return on capital which is also compared to the value of SBN. Under normal circumstances, with a loss factor of 7%, a capital return rate of 15.40% is obtained, whereas after risk adjustment is carried out, the value of the capital return rate will decrease to 11.95%. However, if the loss factor can be reduced to 5%, then the rate of return on capital will increase to 17.33% and the rate of return on capital at risk will increase to 13.75%. Meanwhile, if we do not calculate the risk loss factor, then the rate of return on capital becomes 22.21% and the rate of return on capital at risk becomes 20.03%. However, all of these values are still considered good indicators because they still exceed the value of SBN. This shows that investing in companies has a higher profit potential compared to investing in SBN (risk free).

CONCLUSION

This study successfully evaluated the financial feasibility of Mini Hydro Power Plant (PLTM) investments using the Value at Risk (VaR) method, achieving its objectives by quantifying key risks—loss factor, operational costs, and water retribution—and demonstrating their impact on project valuation. The findings confirm that PLTM remains a viable investment under normal conditions (7% loss factor), with improvements in infrastructure (reducing loss factors) further enhancing returns. Future research should expand this framework by incorporating additional risk variables, such as regulatory changes or climate variability, and test the model in diverse geographical contexts to strengthen its applicability for renewable energy investment decisions globally.

REFERENCES

Bernardo, C., Wang, L., Vasca, F., Hong, Y., Shi, G., & Altafini, C. (2021). Achieving consensus in multilateral international negotiations: The case study of the 2015 Paris Agreement on climate change. *Science Advances*, *7*(51), eabg8068.

Handayani, K., Krozer, Y., & Filatova, T. (2020). From fossil-fuel to renewable energy: Constraints and opportunities in Indonesia. *Energy Policy, 132*, 111–119. https://doi.org/10.1016/j.enpol.2019.110189

Hutapea, R., & Kurniawan, A. (2022). Renewable energy development in Indonesia: The role of micro hydropower in national energy policy. *International Journal of Renewable Energy Development, 11*(2), 245–254.

International Energy Agency. (2021). *Net zero by 2050: A roadmap for the global energy sector*. https://www.iea.org/reports/net-zero-by-2050

Jacobson, M. Z., Delucchi, M. A., Bazouin, G., Bauer, Z. A., Heavey, C. C., Fisher, E., ... & Morris, S. B. (2017). 100% clean and renewable wind, water, and sunlight all-sector energy roadmaps for 139 countries of the world. *Joule, 1*(1), 108–121. https://doi.org/10.1016/j.joule.2017.07.005

Kementerian Energi dan Sumber Daya Mineral Republik Indonesia. (2021). *Rencana Umum Penyediaan Tenaga Listrik (RUPTL) 2021–2030*.

Ministry of Energy and Mineral Resources. (2021). *Indonesia's Power Supply Business Plan 2021–2030 (RUPTL)*.

Mousavi, A., Ardalan, A., Takian, A., Ostadtaghizadeh, A., Naddafi, K., & Bavani, A. M. (2020). Health system plan for implementation of Paris agreement on climate change (COP 21): a qualitative study in Iran. *BMC Public Health*, *20*(1), 1388.

Nasution, A., Alfitri, A., & Roslina, R. (2019). Empowering remote areas through micro hydropower: Case study in West Sumatra. *Energy Procedia, 160*, 511–517. https://doi.org/10.1016/j.egypro.2019.02.186

Nhamo, G., & Nhamo, S. (2016). Paris (COP21) Agreement: Loss and damage, adaptation and climate finance issues. *International Journal of African Renaissance Studies-Multi-, Inter-and Transdisciplinarity*, *11*(2), 118–138.

Putra, Y. F., & Wahyuni, S. (2020). Community-based hydropower implementation: Success factors from West Sumatra. *Journal of Sustainable Energy & Environment, 11*(1), 33–40.

Rakhmadi, R., Santosa, M. H., & Nugroho, A. B. (2019). Water resource mapping and hydropower potential in Sumatra. *IOP Conference Series: Earth and Environmental Science, 306*(1), 012065. https://doi.org/10.1088/1755-1315/306/1/012065

Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., ... & Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2 °C. *Nature, 534*(7609), 631–639. https://doi.org/10.1038/nature18307

Sari, A. P., Hidayat, N. R., & Priyadi, A. (2021). The acceleration of renewable energy deployment in Indonesia: Assessment and policy recommendations. *Renewable and Sustainable Energy Reviews, 148*, 111263. https://doi.org/10.1016/j.rser.2021.111263

Setyawan, W., Indriani, N. L. P., & Damayanti, A. R. (2022). The challenges of achieving Indonesia's net-zero emissions target by 2060: A policy review. *Journal of Environmental Management & Energy, 12*(2), 47–56.

Utama, N. A., & Malik, A. (2022). Renewable energy transition and the role of PLN in Indonesia's low-carbon pathway. *Energy Reports, 8*, 1804–1814. https://doi.org/10.1016/j.egyr.2022.01.027

Widayanti, R., & Lestari, D. (2021). Optimizing renewable energy utilization: A case study of hydropower in West Sumatra. *Journal of Energy and Power Engineering, 15*(3), 156–162.