International Journal Of Humanities Education And Social Sciences ***(IJHESS)*** *E-ISSN:* **2808-1765**
Volume 3, Number 5, April 2024, *Page. 2613 – 2622*
Email : editorijhess@gmail.com

Optimization of Micro Hydro Power Plants to Support Community Energy and Indonesian National Army Training in Gunung Halu, West Bandung Regency

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Abstract

Gunung Halu Village, Tangsi Jaya hamlet to reach 250 people in 2023, is faced with significant challenges related to the need for sustainable energy. The energy crisis and environmental issues have encouraged research into alternative energy sources, including Micro Hydro Power Plants (PLTMH), especially in areas with abundant water potential such as Gunung Halu, namely the Ciputri River. The main problem currently being faced is that the PLTMH, which was built in 2007 with a capacity of 18 kW has experienced overload due to population growth and increasing household electronic needs. The aim of the research is to determine the potential of PLTMH in Gunung Halu, develop ways to optimize PLTMH to provide the community's electricity needs and optimize PLTMH as an alternative option for TNI training areas. The method used in this research is a descriptive qualitative method which is carried out in depth so that it is supported by literature studies and then combined with field observation data, interviews and documentation. The research results show that the PLTMH that can be optimized on Gunung Halu is 30 kW by optimizing turbine efficiency and considering changes in height differences according to the characteristics of the area. In conclusion, it was found that optimizing the PLTMH is important to provide adequate electrical energy and support TNI training so that it hopes to become sustainable energy and a practical solution to increase local energy independence and support national defense.

Keywords: Renewable energy, Energy independence, Optimization PLTMH, TNI.

INTRODUCTION

Indonesia, with a population reaching 276 million people, faces significant challenges in meeting sustainable energy needs by 2023 (BPS, 2023). Urgent energy crises and environmental issues have spurred further research into sustainable and eco-friendly alternative energy sources. One intriguing and explored solution is the utilization of Micro Hydro Power Plants (PLTMH), especially in regions abundant in water resources, such as mountainous areas. Gunung Halu is one such region with abundant water resources, and geographically, it could provide benefits to the surrounding community in terms of providing clean and stable energy. Additionally, harnessing PLTMH in Gunung Halu can also support the pre-deployment training activities of the Indonesian National Army (TNI) before executing tasks in Papua. Therefore, the development of PLTMH in Gunung Halu is a strategic step in addressing energy and environmental challenges, as well as national defense.

Micro Hydro Power Plants (PLTMH) utilize existing river streams or artificial water flows to generate electricity. This potential is measured based on the available water discharge and the height of the water fall. In Gunung Halu, the hilly terrain and abundant river flows, such as the Ciputri River, offer significant opportunities to harness PLTMH as a source of electrical energy. The energy potential derived from PLTMH has several advantages, such as being sustainable and environmentally friendly. The construction of PLTMH in the Tangsi Jaya Village, Cipayung Hamlet, Gunung Halu Village, Gunung Halu District, West Bandung Regency, West Java Province is a crucial step in improving access to electricity in an area that previously faced limitations in meeting its electricity needs. Before the presence of PLTMH, some areas in Gunung Halu experienced darkness as they were not covered by the PLN electricity network. Reliance on oil lamps and torch lights restricted community activities at night, hindering access to information and education.

According to a study by Nurlina et al., (2021) on the utilization of PLTMH in Bungin, Enrekang Regency, the construction of PLTMH has social, economic, and environmental impacts. Social impacts include changes in health, safety, lifestyle, religious activities, and social activities. Economic impacts for the community include socio-economic progress in rural areas, increased production results, support for small industries, and the adoption of more advanced technology. Economic impacts for PLTMH include profits from selling electricity to PLN. Furthermore, from an environmental perspective, PLTMH is considered environmentally friendly as it primarily uses water as its energy source.

Furthermore, PLTMH has a positive impact on the environment as it does not produce carbon emissions. This means that PLTMH helps reduce the carbon footprint and negative impacts of climate change. The air pollution level measured by the Air Quality Index (AQI) at 139 in West Bandung Regency on September 5, 2023, indicates that the air quality in the area is "Unhealthy for Sensitive Groups." The main pollutant contributing to high air pollution levels is particulate matter less than 2.5 micrometers, PM2.5 (IQ AIR, 2023).

PM2.5 consists of small particles carried by the wind and spread across regions, including areas far from their initial pollution sources. In the context of global warming, PM2.5 can have a significant negative impact. Negative health impacts associated with PM2.5 exposure include respiratory problems, heart diseases, and even premature death. These particles can easily enter the human respiratory system, causing various health issues (Xing et al., 2016).Moreover, PM2.5 also has negative impacts on the environment. When these particles settle on the ground or water surface, PM2.5 can damage ecosystems and affect water and soil quality. Additionally, PM2.5 can interact with greenhouse gases and influence atmospheric composition, which can further strengthen the effects of global warming (Zhang & Jiang, 2018). By using PLTMH as the primary energy source, the community in Gunung Halu can reduce dependence on fossil fuel combustion, which often produces PM2.5 particles and greenhouse gases.

As an alternative solution to limited electricity needs and the negative impacts of power plants relying on fossil fuels on the environment, the optimization of PLTMH in Gunung Halu is necessary. The PLTMH has a capacity of 18 kW, capable of providing electricity access to 67 households (HH), 3 mosques, 1 school, and a coffee processing facility in the village (ESDM, 2010). However, based on field observations conducted on August 12, 2023, the latest information reveals that the PLTMH in Gunung Halu is overloaded due to population growth. In 2007, there were only 67 HH using electricity from PLTMH with a capacity of 225 Watts or 1 Ampere per household. Currently, the total has increased to 80 HH with a capacity of 450 Watts or 2 Ampere. The total population in Tangsi Jaya Village, Cipayung Hamlet, Gunung Halu Village, Gunung Halu District, West Bandung Regency, West Java Province, is approximately 250 people or 103 HH. Additionally, the PLTMH often experiences power outages, mainly due to factors such as maintenance for approximately ± 2 hours. Moreover, the electricity from PLTMH is also used to support TNI training. This TNI exercise aims to provide pre-deployment training to TNI personnel before being deployed to Papua. The Papua Task Force (Satgas) is one of the areas facing threats from Armed Criminal Groups (KKB).

This phenomenon has become a current issue, making the addition of power from PLTMH a priority to provide electricity to the village. Additionally, factors that need attention include how the use of PLTMH for TNI training purposes affects the availability of electricity in the village, especially in the current context where power addition is a priority. The use of electricity for TNI training activities undoubtedly requires significant power, and if not managed properly, it can disrupt the electricity supply for the local community. Moreover, concerning the threat of KKB in Papua, it is evident that these training activities are crucial in preparing TNI personnel stationed in the conflict area. The presence of KKB in Papua poses a serious challenge to national security, and effective training is key to addressing it properly. Therefore, a deeper analysis regarding the use of PLTMH in supporting TNI training is essential to ensure the readiness of reliable and well-trained TNI personnel in national defense, while still considering the electricity needs of the local community.

Research on optimizing the potential of PLTMH to support the energy needs of the community and TNI training in the Gunung Halu area is highly relevant and important. This research is expected to help formulate appropriate solutions to support the development of renewable energy infrastructure in remote areas, especially in mountainous regions like the Gunung Halu area. Furthermore, the presence of PLTMH can have a positive impact on community welfare and support national defense through the sustainability of environmentally friendly and independent energy supply.

RESEARCH METHODS

This research employs a qualitative approach with a descriptive qualitative research design. Descriptive qualitative research is an in-depth qualitative study supported by literature reviews. Qualitative research is often referred to as naturalistic research because it is conducted in natural conditions. The results of qualitative research are verbal descriptions or words conveyed orally by informants, and the analysis is conducted comprehensively, in detail, and in-depth, without making generalizations. In qualitative research, the researcher acts as the primary research instrument. The qualitative research method emphasizes the importance of data reduction, especially in quality management research with a case study approach. As we know, qualitative research steps involve data reduction, categorization, and ultimately drawing conclusions

RESULT AND DISCUSSION

Micro Hydro Power Plants (PLTMH) Energy Potential in Gunung Halu

Based on the results of measuring the instantaneous discharge at the Ciputri River location using a flow meter, data was obtained that the instantaneous discharge of the river water was around 0.4 m³/second. The local community provided information that this discharge could be considered as an estimate of the average discharge during the long dry season. River water discharge is a crucial component in the planning and operation of Micro Hydro Power Plants (PLTMH).

Figure 1. River Water Depth Measurement
Source: Processed by Researchers, 2023

When researchers validated by directly measuring in the field, the water discharge on September 6, 2023, around 13:11 WIB, was obtained from the Ciputri River by calculating the flow velocity multiplied by the river's cross-sectional area.

$$Q = A \times v$$

Where:
Q = Water discharge (m^3/second)
A = River cross-sectional area (m^2)
v = Water flow velocity (m/s)

The water flow velocity was measured using a flow meter with 5 readings, and the cross-sectional area was measured by calculating the area from the depth measurements divided into 5 segments. The following are detailed images of the measurements for the river's cross-sectional area and water flow velocity.

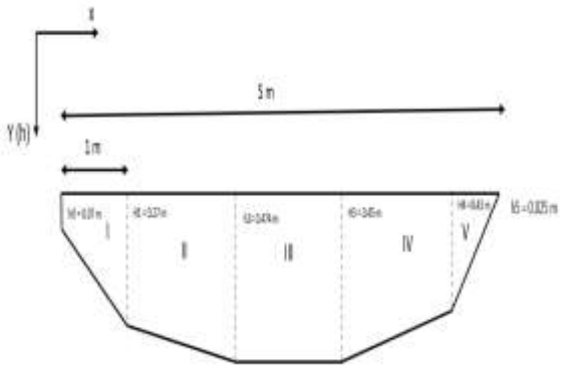

Figure 2. Detailed image of measuring flow speed and river area
Source: Processed by Researchers, 2023

After 5 literacy measurements were carried out, the data was tabulated to produce detailed data as follows:

Tablel 1. Discharge Calculation

Segmen	V_{avg}	**A**	**Q**
1	0.16	0.17	0.0272
2	0.29	0.372	0.1078
3	0.25	0.463	0.1155
4	0.276	0.44	0.1214
5	0.185	0.222	0.041
Qtotal (m^3/s)			**0.413**
Qtotal (L/s)			413

Source: Processed by Researchers, 2023

It can be seen that the total discharge produced by the Ciputri River in the period 6 September 2023 is 0.413 m³/second. This discharge has a deviation or difference from the discharge calculated by PT WPU, namely 0.013 m³/second. Water discharge, which reflects the volume of water flowing per second in a river, is a key element in estimating the potential power that can be generated by MHP. This discharge is the basis for calculating the kinetic energy of water which can be converted into electrical energy. Apart from that, another parameter that cannot be ignored is head, which indicates the difference in height between the water surface at the intake and outflow of the PLTMH. This head has a significant influence on the potential water energy that can be utilized. PLTMH efficiency is an important focus in evaluating plant performance. The efficiency level reflects the extent to which water potential energy can be converted into electrical energy. The higher the level of efficiency, the more optimal the use of existing natural resources. The following are detailed estimated calculations related to discharge, head and efficiency that affect PLTMH:

Tablel 2. Estimation of Potential Power Generated

No	Description	Value
1	*Gross Head*	12 m
2	Probability Discharge 70%	0,8 m^3/detik
3	Design Discharge	0,5 m^3/detik
4	Estimated Net Head	10 m
5	Estimated Turbine Efficiency	0,74
6	Estimated Generator Efficiency	0,85
7	Estimated Mechanical Transmission Efficiency	0,98
8	Estimated Generated Power	30 kW

Source : PT. WPU, 2023

The precise measurement and calculation related to discharge, head, and efficiency are crucial foundations in planning the optimal design and operation of Micro Hydro Power Plants (PLTMH). In-depth analysis of river discharge variations, with a comparison to calculations done by PT WPU, is an important initial step to identify deviations' causes and optimize the performance of PLTMH. By understanding these key elements, we can ensure the sustainability and efficiency of PLTMH as a provider of sustainable electricity for the local community. The potential power generation of 30 kW can be calculated using available data and calculation formulas.

River discharge, as the volume of water flowing per second in the river, is an essential element as an energy resource for PLTMH. The discharge of the Ciputri River forms the basis for calculating the power that can be generated by PLTMH. Equally important is the head, which reflects the height difference between the water surface at the intake and outflow of PLTMH, influencing the potential kinetic energy of water that can be converted into electrical energy. PLTMH efficiency is the main focus in evaluating the generator's performance. Efficiency, which measures the extent to which the potential energy of water can be converted into electrical energy, is a key indicator of the success of PLTMH in maximizing the utilization of available natural resources. With parameters such as discharge, head, and efficiency as the focus of optimal planning in the design and operation of PLTMH, optimization can be achieved. Through accurate measurement and calculation, PLTMH can be optimized to make a maximum contribution to sustainable electricity provision. A profound understanding of discharge, head, and efficiency forms a critical basis in maintaining the sustainability and efficiency of PLTMH in meeting the electricity needs of the local community continuously.

Optimization of Micro Hydro Power Plants Gunung Halu

The optimization of components in the civil structure of the Micro Hydro Power Plant (PLTMH), including the raising of the dam crest, directly impacts key factors in power generation: head and water flow rate (debit). Raising the dam crest increases the head, the height difference between the water surface at the intake and outflow. A higher head generates higher hydraulic energy potential, improving the efficiency of converting water energy into electricity.The increased dam crest height allows better control of water flow, contributing to an enhanced water flow rate available for the turbine. This increased water flow rate directly contributes to the potential power output of the PLTMH. Improvements in carrier channels, replacement of landslide-prone channels with sturdy iron pipes, and enhancements to the penstock pipe also play a role in supporting the optimization of flow rate and head. These improvements collectively create an environment conducive to high efficiency in converting hydraulic energy into electricity.

Efficiency becomes the primary focus in evaluating the PLTMH's performance, measuring how effectively potential water energy is converted into electrical energy. Debit, head, and efficiency serve as the focal points for optimal planning in the design and operation of PLTMH to achieve maximum contribution to sustainable electricity supply.Optimizing the civil components of PLTMH, especially the dam crest, is a critical step to enhance structural performance and durability. The dam plays a vital role as a reservoir and flow regulator, influencing the source of water that drives the turbine according to PLTMH needs. In the context of PLTMH Gunung Halu, raising the dam crest height is a proposed solution to optimize water flow regulation.

In-depth analysis of PLTMH Gunung Halu with the provided data indicates that dam improvements are a strategic step. Raising the dam crest enhances water storage capacity, allows better flow control, and ultimately optimizes the availability of hydraulic energy needed for the turbine. Additionally, additions such as higher carrier channels, replacement of landslide-prone channels with robust iron pipes, and the creation of sedimentation and calming basins are crucial improvements in achieving optimal PLTMH efficiency. Increasing the diameter of the penstock pipe to 57 cm supports larger water flow, enhancing the hydraulic power produced by the turbine.

The turbine house and discharge channel are also focal points for improvement to ensure the overall performance of PLTMH Gunung Halu. Enhancements to these components will positively impact the overall performance of PLTMH Gunung Halu, creating a strong foundation for sustainable electricity provision in the local community. This optimization approach encompasses structural aspects while pursuing operational efficiency and sustainability. In connection to the electrical grid, the optimization of PLTMH Gunung Halu can include better integration with existing electrical infrastructure. By increasing PLTMH capacity and efficiency, larger electrical power can be generated and fed into the grid. Thus, this optimization not only benefits the local community by providing electricity but also contributes to the resilience and sustainability of the electrical system on a broader scale.

This comprehensive approach to PLTMH optimization involves a holistic integration of factors such as head, water flow rate, and grid connectivity, resulting in a more reliable and efficient small-scale power generation system. Increasing the capacity of the carrier channel by raising the channel walls to accommodate the design flow rate of 800 L/s positively impacts the efficiency and reliability of the power generation system. Raising the channel walls allows the carrier channel's capacity to be adjusted to the desired level, helping to maintain an adequate water supply for the turbine, especially when river water flow varies. This adjustment directly relates to water flow rate considerations. With increased channel capacity, PLTMH can utilize a larger water flow rate, enhancing the potential power output. Therefore, this step not only improves operational efficiency but also ensures the optimal utilization of available water resources.

The use of rapid pipes in the revitalization planning of PLTMH Gunung Halu is a crucial aspect related closely to the sedimentation and calming basin (Head tank). Rapid pipes installed along the ground surface, according to local geographic conditions, serve as the water transport path from the carrier channel to the sedimentation and calming basin. Several planning factors for rapid pipe installation become key considerations to ensure the smooth operation of the power generation system and impact the function and efficiency of the head tank. Pressure in the rapid pipes is a critical parameter affecting the water flow towards the sedimentation and calming basin. Alongside the increased capacity of the carrier channel, rapid pipes must be designed to withstand appropriate water pressure, ensuring stable and sufficient water distribution into the head tank. Additionally, considerations such as the connection method of rapid pipes, pipe diameter, and friction loss calculations are crucial to achieving optimal and efficient water flow.

In this context, the head tank acts as a water storage before it is directed to the turbine. Raising the walls of the carrier channel and installing rapid pipes are efforts to increase the water storage capacity before entering the head tank. The success of rapid pipe planning will ensure a sufficient and stable water supply in the head tank, supporting efficient PLTMH operations. Other factors, such as weight, ease of installation, accessibility, geographic and geological conditions, as well as cost, are holistic considerations in designing rapid pipes. The use of mild steel ST.37 for rapid pipe material with increased thickness, as part of the corrosion protection and maintenance strategy, reflects seriousness in addressing environmental challenges.

Furthermore, the PLTMH generator building, measuring 4 m² x 4 m², or commonly known as the turbine house, is designed with special considerations to maximize the river's fall height and remain protected from floods. Placing the generator building as low as possible aims to utilize the river's fall height, a crucial factor in increasing the kinetic energy potential of water to be converted into electricity by the turbine. However, the design also considers caution against potential floods, especially in the area where water is discharged from the generator building.

Within the generator building, there are installations of turbines and generators constantly experiencing dynamic loads and vibrations. To address this, the turbine-generator foundation is separated from the building foundation to minimize the transmission of vibrations and dynamic loads to the building structure, ensuring overall stability and safety. Furthermore, the generator building design also considers flexibility in the periodic disassembly and reassembly of the turbine generator for routine annual inspections. The generator used is a synchronous/IMAG type with a voltage of 230/400 volts, a frequency of 50 Hz, a rotation speed of 1500 rpm, 3 phases, and an optimum efficiency of 84%.

The Social and Economic Impacts of Optimizing the Micro Hydro Power Plant (PLTMH)

The optimization of the Micro Hydro Power Plant (PLTMH) in Tangsi Jaya village, Gunung Halu, has brought about substantial social and economic impacts on the local community. The provision of electricity by PLTMH extends beyond households, encompassing critical infrastructure such as early childhood education (PAUD), primary schools (SD), mosques, and community meeting places, contributing significantly to improved living conditions and community development. However, the surge in population from 67 to 96 households since 2007 has strained the PLTMH capacity, necessitating efforts by the government through PT WPU to address overload issues. The community actively participates in sustaining PLTMH by contributing a monthly fee of 25 thousand rupiahs per household. While this aids in covering operational costs, the limited funds pose challenges, particularly when major repairs or component replacements are required. Moreover, the reliable electricity supply facilitates educational activities and supports local businesses, fostering economic growth and employment opportunities.

On the economic front, PLTMH enables income generation for the community, especially through small-scale industries like coffee production. However, economic activities face challenges due to increased electricity usage at night. The monthly contribution of 25 thousand rupiahs per household results in a total operational budget of 2.4 million rupiahs, covering salaries for local operators and minor maintenance. Yet, it may fall short for major repairs or component replacements, posing a threat to the overall performance of PLTMH. The mechanical components, such as turbines and bearings, face challenges as they have not been replaced since the initial construction, and financial constraints hinder optimal maintenance.

Local businesses, particularly in the coffee industry, depend on electricity from PLTMH. Disruptions or inefficiencies in the PLTMH operation can directly impact these businesses and, subsequently, the livelihoods of the residents. To address these challenges, recommendations include optimizing PLTMH for increased capacity and efficiency, exploring financial solutions, and aligning with the principles of Renewable Energy Based Economic Development (REBED). This holistic approach is crucial for ensuring the sustainability of PLTMH operations and fostering the socio-economic development of Gunung Halu village.

The Impact of PLTMH Optimization to Support TNI Pre-Training before Departing for the Papua Task Force

Optimizing the Gunung Halu Micro Hydro Power Plant (PLTMH) as a critical source of electrical energy supply is crucial for supporting the smooth execution of pre-duty exercises by Brigif 13/Kostrad Galuh, specifically Yonif 303 and Yonif 323, preparing for assignments in Papua. The reliability of the energy supply from PLTMH is crucial for military personnel's preparedness before facing challenging environmental conditions in Papua. Careful planning, routine maintenance, and efficient PLTMH management are essential for ensuring a reliable energy supply. Additionally, backup power and emergency plans are implemented to anticipate possible disruptions or failures in the electrical system.

Yonif 303 and Yonif 323 conduct periodic exercises in the Gunung Halu area, providing valuable experience in facing environmental and topographical challenges similar to those in Papua. The varying duration of exercises, ranging from 1 week to 1 month, highlights the importance of military personnel's preparation for various extreme conditions. The TNI exercise command post, located approximately 100-200 meters from the Gunung Halu PLTMH, requires around 400 watts of power during the day and approximately 1 kW during the night for lighting the command post and using other electronic devices. Efforts to support the use of renewable energy in pre-duty exercises in Papua have been considered, including alternatives such as Solar Power (PLTS) or microgrid systems.

The operational concept during these exercises mirrors actual operations in the Ilaga regency, covering combat operations, territorial operations, and intelligence operations. Combat operations involve perimeter patrols, securing territorial activities, intelligence support, and ambushing/enemy interception. Territorial operations include positive interaction with the local community, emphasizing the positive relationship between the military and the community. Intelligence operations focus on establishing security systems, securing personnel and materials, limited outreach, and observations. The outlined operational concept demonstrates a comprehensive and integrated approach in executing operational tasks in the Ilaga regency. The personnel placement in various military positions considers the quantity and requirements at each location. The coordinate points of positions and daily temperature information provide an overview of the environmental conditions. The importance of grouping personnel based on rank and location demonstrates a well-planned organization and structure, enhancing effectiveness and efficiency in tasks.

TNI personnel undergoing pre-duty training for assignments in Papua, such as Yonif 303 and Yonif 323, need to master various individual training aspects involving specific skills and expertise. Health training prioritizes ensuring personnel have a good understanding of medical conditions and first aid actions in emergency situations. Combat Communication training ensures effective interaction in combat conditions. Basic Battle Techniques provide exercises on urban and mountain forest warfare. Training materials like Field Science, Drone Operations, and Reaction Box emphasize the enhancement of tactical and technological capabilities. Sniper Rifle Box, Mini Grenade Launcher Box, and Altitude Crossing Box indicate improved abilities in weapon usage and combat tactics. Steep Slope Box, Steep Box, and Road Box reflect physical training and cross-country skills necessary for operations in difficult terrains. Combat Instinct and Contact Drill focus on quick and accurate responses to emergency situations or sudden battles.In addition to the provided pre-duty training materials, mechanisms for territorial security activities, perimeter patrols, and ambushes, as well as the logistics drop, mechanism in Kotis Wuloni, are given to all TNI personnel preparing for assignments in Papua, such as Yonif 303 and Yonif 323.

CONCLUSION

The Micro Hydro Power Plant (PLTMH) in Gunung Halu, boasting an 18 kW capacity since its inception in 2007, stands out as a pivotal contributor to the local community. Functioning not only as a reliable electricity source but also as an educational and training hub, the PLTMH has been meticulously maintained and strategically planned. The research underscores the plant's adaptability, with the abundant water discharge from the Ciputri River optimizing electricity generation to an impressive 30 kW, significantly benefiting the local residents. This dual-purpose role showcases the PLTMH's positive impact on both sustainable energy utilization and community development.

In optimizing PLTMH operations to meet the electricity needs of the Gunung Halu community, the management has implemented effective measures. These include meticulous scheduling of operations aligned with peak energy demands, continuous load monitoring, and the integration of energy-efficient equipment. These strategies ensure not only the reliability of electricity supply but also contribute to the plant's efficiency and sustainability.Moreover, PLTMH in Gunung Halu plays a crucial role in supporting the training activities of Brigif 13/Kostrad Galuh, specifically involving personnel from Yonif 303 and Yonif 323 designated for duty in Papua. The plant's reliable energy supply is a critical factor, managed through careful planning, routine maintenance, and a diversified energy source approach. Initiatives to incorporate renewable energy options, such as solar power or microgrid systems, underscore a commitment to environmentally friendly and sustainable practices. Overall, the successful optimization of PLTMH in Gunung Halu serves as a commendable model for alternative energy solutions, supporting the sustainability of both operational activities and TNI training endeavors in remote regions like Papua.

REFERENCES

BPS. (2023). Total Population of Indonesia 2022 (Vol. 4, Issue 1).

Creswell, J. W., & Creswell, J. D. (2018). Research Design Qualitative, Quantitative, and Mixed Methods Approaches. In Research Defign: Qualitative, Quantitative, and Mixed Methods Approaches.

Dolores, M., & Tongco, C. (2007). Definition of Purposive Sampling. A Journal of Plants, People and Applied Research, 5, 1–12. https://ethnobotanyjournal.org/index.php/era/article/view/126.

ESDM. (2023). Draft RUKN 2023-2060. Maret. https://gatrik.esdm.go.id/assets/uploads/download_index/files/eed9c-draft-rukn-cover.pdf.

Hanggara and Harvi Irvani's pledge. (2017). Potential of PLTMH (Micro Hydro Power Plant) in Ngantang District, Malang Regency, East Java. Journal of Design, 2(2), 149–155.

Heriyanto & Muttaqien, A. (2017). Optimizing the Energy Potential of Geulis Cisuru Waterfall as a Source of Electrical Energy. CIVIL ENGINEERING MATRIX E-Journal, 476.

IQ AIR. (2023). IQ Air. Air Quality in Lucknow:Air Quality Index (AQI) and PM2.5 Air Pollution in Lucknow.

Nurlina, N., Jumadi, J., & Bahri, B. (2021). Micro Hydro Power Plant in Bungin, Enrekang Regency 2008-2019. Attoriologist Journal of Historical Thought and History Education, 19(1), 68–80. https://scholar.google.com/citations?view_op=view_citation&hl=en&user=mtybYXYAAAAJ&pagesize=100&citation_for_view=mtybYXYAAAAJ:fPk4N6BV_jEC.

PT WPU. (2023). Hydrological Conditions of Gunung Halu PLTMH.

Rianto, D. J. (2021). Determination of Rainfall Intensity in Determining Runoff Discharge for Recommendations for Making Water Channels for Different Types of Water Channel Walls. Journal of Research Innovation, 1(9), 1795–1804.

Xing, Y. F., Xu, Y. H., Shi, M. H., & Lian, Y. X. (2016). The impact of PM2.5 on the human respiratory system. Journal of Thoracic Disease, 8(1), E69–E74. https://doi.org/10.3978/j.issn.2072-1439.2016.01.19.

Zhang, & Jiang, Y. (2018). Pollution characteristics and influencing factors of atmospheric particulate matter (PM2 . 5) in Chang- Zhu-Tan area Pollution characteristics and influencing factors of atmospheric particulate matter (PM2 . 5) in Chang-Zhu-Tan area. IOP Conference Series: Earth and Environmental Science PAPER.