JURNAL PENELITIAN GEOGRAFI
Volume (12), Nomor (2), (2024), pp. 185-198
Doi: http://dx.doi.org/10.23960/jpg

Original Article

Potential of Micro Hydro for Electricity Supply in Remote Areas of Singajaya, South Garut

Dede Rohmat[1*], Iwan Setiawan[1], Suhendro[1], Raksa Salat Kamila[1], Edwin Slamet[1]

[1] Department of Geography Education, Faculty of Social Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

*coresponding e-mail: dede_rohmat@upi.edu

ABSTRACT
The issue of electricity needs in remote areas is the focus of this study. One proposed alternative solution is to provide electricity by utilizing natural resources, such as harnessing hydropower through micro-hydro systems. This research aims to (1) analyze electricity supply, (2) assess the conditions of remote areas based on the non-electrification ratio of villages, (3) evaluate the potential of Micro Hydro Power Plants (MHPP), and (4) analyze the distribution of this potential in the region. The study employs a spatial approach based on Geographic Information Systems (GIS) to map potential locations for MHPP development, along with field data such as rainfall, water flow rates, and topography. The findings indicate that (1) the electricity supply in Singajaya District is still limited, particularly in remote areas where only 450 W is available, while central areas of the district can exceed 450 W, (2) the conditions in remote areas of Singajaya District are characterized by a high non-electrification ratio, with Sukamulya at 34.32%, Pancasura at 32.23%, and Sukawangi at 31.28%, making these three villages priorities for electrification, (3) six main locations were identified with significant capacity for electricity development, resulting in a total potential output of 170.18 kW, and (4) the distribution of MHPP potential, with high water flow rates and adequate head height, could address electricity access for 19.22% of households that currently lack electricity.

KEYWORDS
Electricity Supply
Mircro Hydro;
Remote Area;
Renewable Energy Potential.

Received: August, 1th 2024 Accepted: September, 23th 2024 Published: September, 30th 2024

Citation:
Rohmat, D., Iwan, S., Suhendro., Raksa, S. K., Edwin, S. (2024). *Potential of Micro Hydro for Electricity Supply in Remote Areas of Singajaya, South Garut*. Jurnal Penelitian Geografi (JPG), 12 (2), 185-198. http://dx.doi.org/10.23960/jpg.v12.i2.31270

INTRODUCTION

Currently, the world faces the challenge of dependency on non-renewable energy resources such as coal, oil, and natural gas, which pose risks of environmental pollution and potential energy crises in the future. Countries with large coal industries, such as China, India, and the United States, experience high levels of air pollution due to coal combustion in Coal-Fired Power Plants (CFPP), emitting pollutants like nitrogen oxides (NOx) and sulfur oxides (SOx), which negatively impact both the environment and human health (Dmitrienko & Strizhak, 2018; Faruk & Altarans, 2020).

Indonesia, still reliant on fossil fuels, faces similar challenges. With coal reserves reaching 42.19 billion tons (Yudhistira & Rofli, 2023), reliance on this energy source poses a risk of future energy crises. Amid these conditions, the push towards renewable energy sources like micro-hydro becomes increasingly urgent. Renewable energy is seen as a long-term solution to reduce dependence on fossil fuels and lower carbon emissions (Purwanto et al., 2017).

Garut Regency, while known for its significant electricity generation through the Darajat Geothermal Power Plant, still faces challenges in providing electricity access to all its residents. It is reported that 27,128 households in Garut lack electricity access, with Singajaya District having the highest non-electrification ratio at 14.34% (Dinas Pemberdayaan Masyarakat dan Desa, 2023). This highlights the urgent need for infrastructure development, particularly in remote villages like Sukamulya, Pancasura, and Sukawangi, each of which has over 30% of households without electricity access.

Micro Hydro Power Plants (MHPP) present a potential solution for supplying electricity to these remote areas. By harnessing the abundant natural resources in mountainous and water-rich regions, the development of MHPP can enhance the quality of life for local communities, support the local economy, and bolster education and social activities. According to Maruf Al Bawani (2022), MHPP has shown positive impacts on the economy, social fabric, and education of communities, despite challenges related to consumer behavior in renewable energy usage.

The deployment of MHPP in remote areas not only improves energy access but also supports Sustainable Development Goals (SDGs) such as clean and affordable energy (SDG 7) and climate action (SDG 13). Singajaya District possesses significant potential for MHPP development due to its hilly and mountainous topography, along with numerous rivers that can be utilized as renewable energy sources.

Recognizing the critical role of renewable energy in enhancing electricity access in remote areas, this research aims to (1) analyze electricity supply in Singajaya District, (2) assess the conditions of remote areas based on the non-electrification ratio of villages, (3) evaluate the potential of Micro Hydro Power Plants, and (4) analyze the distribution of MHPP potential in the region. The findings of this study are expected to provide a clear overview of the potential for MHPP in Singajaya District and offer recommendations for further development.

METHOD

Research Location

This study is conducted in Singajaya District, Garut Regency, West Java, focusing on three remote villages: Sukamulya, Pancasura, and Sukawangi. This location was chosen due to its suitable topography for the development of Micro Hydro Power Plants (MHPP), characterized by stable river flows and waterfalls throughout the year. Additionally, the non-electrification ratio in this area is the highest in Garut Regency, indicating a critical need for sustainable energy solutions.

Research Design

The research employs a mixed methods approach that integrates both qualitative and quantitative methodologies. The qualitative approach is utilized to understand the social and economic factors associated with electricity access, while the quantitative approach analyzes technical data such as water flow rates and head height for MHPP. Geographic Information Systems (GIS) are employed for spatial analysis to identify potential sites for MHPP development.

Population and Sample

The research population comprises all household heads in Singajaya District, with samples drawn using stratified random sampling from the three priority villages that exhibit the highest non-electrification ratios.

Research Instruments

Data are collected through observation sheets at survey sites and interviews with local residents to understand the conditions of electricity provision and the potential for

MHPP. An identification sheet for remote areas is used to document regions that are difficult to access via conventional electricity networks.

Data Collection Techniques

Data are gathered through field surveys, direct observations, and geospatial analysis utilizing ArcGIS. A literature review is also conducted to support the secondary data necessary for spatial analysis and MHPP planning.

Data Analysis Techniques

Data are analyzed using GIS-based spatial analysis techniques to map potential locations for MHPP development. Descriptive analysis techniques are employed to interpret both the technical and social data obtained from field surveys.

Research Flow

This study is conducted in four stages: literature review, geospatial analysis using ArcGIS, field observation, and dissemination of results through scientific publications, along with the formulation of recommendations for local government.

RESULTS AND DISCUSSION

Singajaya District is one of the districts located in Garut Regency, West Java Province, Indonesia. This area is strategically situated approximately 57 kilometers from the capital of Garut Regency, accessible via the southern route through Cikajang. The administrative center of Singajaya District is in Singajaya Village. Geographically, Singajaya is positioned in the eastern part of Southern Garut, bordered by Tasikmalaya Regency and neighboring districts, including Banjarwangi and Cihurip to the west, and Peundeuy to the south. Singajaya District covers an area of approximately 4,684.6 hectares.

Electricity Provision in Singajaya, Garut Regency

The electrification ratio (RE) measures the level of electricity accessibility in a region (Yusuf & Rahayan, 2018). Consequently, the non-electrification ratio is the inverse of the electrification ratio. The concept of the non-electrification ratio serves as an important indicator for measuring electricity access in an area. Regions with high non-electrification ratios demonstrate limited electricity access due to inadequate infrastructure and geographic challenges.

Electricity provision in Singajaya District by PLN (Perusahaan Listrik Negara) has become a primary concern, especially for remote areas. Although PLN has expanded its electricity network to remote corners, geographic challenges and low population density have constrained electrification coverage. A survey by the Department of Community Empowerment and Village Affairs in 2023 revealed that Singajaya District has the highest non-electrification ratio in Garut Regency, primarily influenced by three villages: Sukamulya, Pancasura, and Sukawangi, each with ratios exceeding 30%. In contrast, other villages in Singajaya generally exhibit non-electrification ratios below 9%. Thus, these three villages are the focus of this study, aiming to map energy needs and explore the potential development of Micro Hydro Power Plants (MHPP) as a sustainable renewable energy solution.

The challenges of electricity access in the northern and central regions of Singajaya District are related to topography and difficult accessibility. While the majority of electricity supply in these villages comes from PLN, with a capacity of 450 watts, the difficulty of accessing electrical substations poses a significant issue. Approximately 67% of the population reports challenges in accessing electricity, largely due to their residences being far from electrical infrastructure and transportation access.

Meanwhile, the use of MHPP remains very limited; only a few residents have implemented MHPP systems, typically through individual initiatives for personal needs. The substantial potential for MHPP in this area has yet to be optimally utilized for broader community needs. The majority of electricity demand in this region is for household lighting, while household facilities primarily reflect a focus on domestic needs.

The power supplied to remote areas is still limited to about 450 watts per household, contrasting with areas near the district center that have greater electricity capacities. This discrepancy indicates an imbalance in electricity distribution that needs to be addressed to improve quality of life, particularly in areas distant from growth centers.

Conditions of Remote Areas in Singajaya District, Garut Regency Based on Non-Electrification Ratios

A high non-electrification ratio often indicates that a region has limited access to basic infrastructure, including electricity, which serves as a key indicator that the area can be categorized as remote. In Singajaya

District, Garut Regency, the villages of Sukamulya, Pancasura, and Sukawangi are prioritized in efforts to enhance electricity provision due to their notably high non-electrification ratios. The non-electrification ratio in Sukamulya Village reaches 34.32%, in Pancasura Village it is 31.28%, and in Sukawangi Village it is 32.23%.

1) Priority Village I: Sukamulya Village

Sukamulya Village exhibits the worst electricity access in Singajaya District, primarily due to challenging geographical conditions and dispersed settlements. These geographic challenges result in uneven electricity distribution, leaving many households without adequate access to electricity. The lack of reliable electricity supply adversely affects the quality of life for residents, particularly in terms of access to public facilities such as schools and hospitals. The distribution of settlements is illustrated in Figure 1.

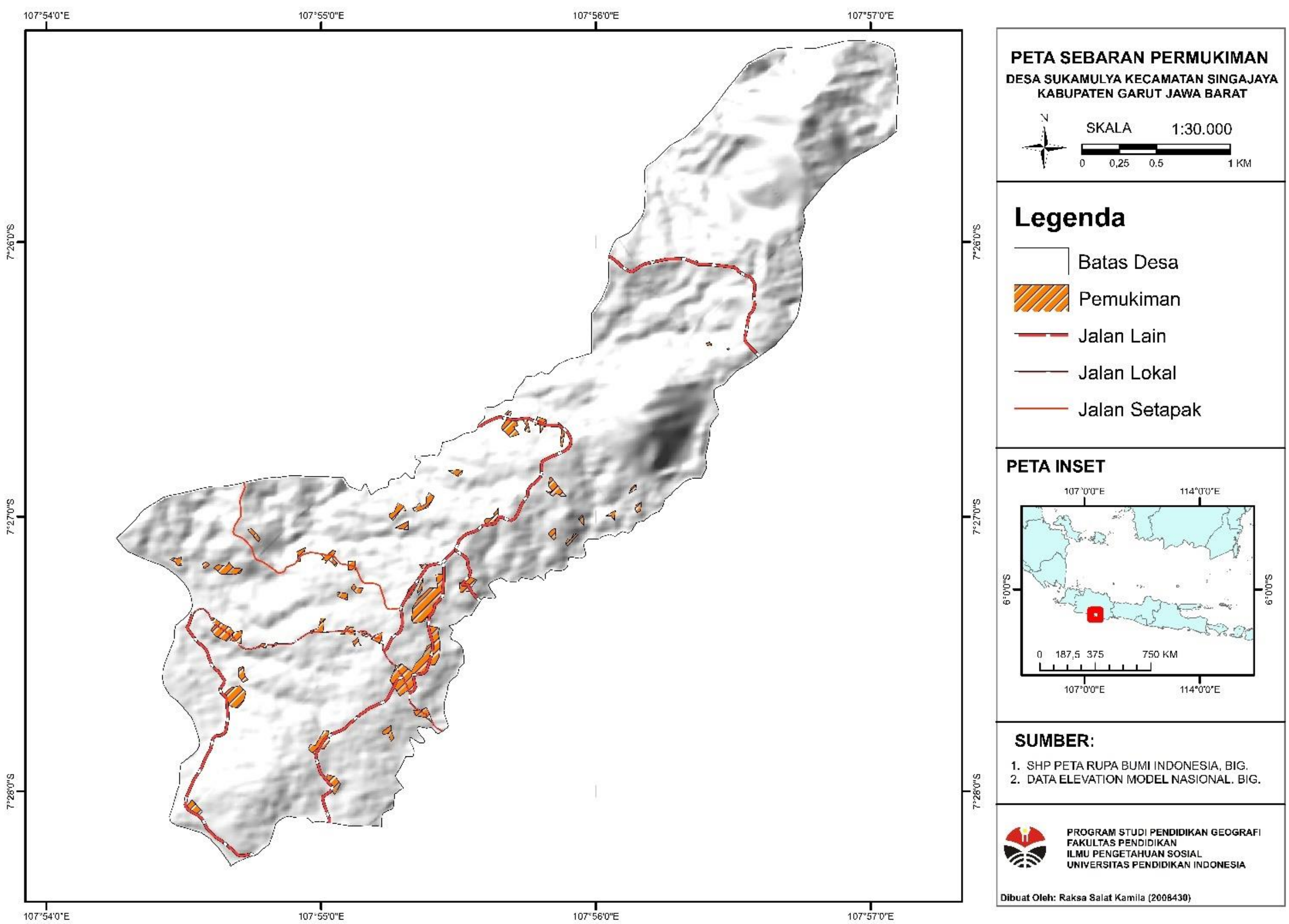

Figure 1. Map of Settlement Distribution of Sukamulya Village
Source: Research Results (2024)

The settlement distribution in Sukamulya Village reveals an uneven pattern. The southern part of the village is densely populated, while the northern area tends to be more dispersed. The geographical conditions, characterized by mountains and forests, divide the village into two distinct areas with different characteristics. Settlements in the southern part are closer to growth centers, whereas those in the northern part are situated far from these centers and are more reliant on agricultural activities. This disparity affects the income levels and quality of life for residents in each settlement area.

2) Priority Village II: Pancasura Village

The electricity provision situation in Pancasura Village is not significantly different from that in Sukamulya, although some households in the northern region of the village still rely on electricity from their neighbors. This indicates that electricity access is not yet optimal in this village. Pancasura Village has relatively flatter terrain and is closer to major roads, which results in better electricity access compared to Sukamulya Village. However, the uneven electricity availability continues to impact residents' quality of life, particularly concerning access to public facilities such as schools and hospitals.

The distribution of settlements in Pancasura Village can be seen in Figure 2. This distribution is more balanced than that of Sukamulya Village. Nevertheless, the socioeconomic progress in this village does not markedly differ from that of Sukamulya. Pancasura's flatter terrain and proximity to main roads facilitate easier access to public facilities for residents. In contrast, Sukamulya's hilly terrain and greater distance from main roads make access to public facilities more challenging. These conditions significantly influence the income levels and quality of life for the communities in each village.

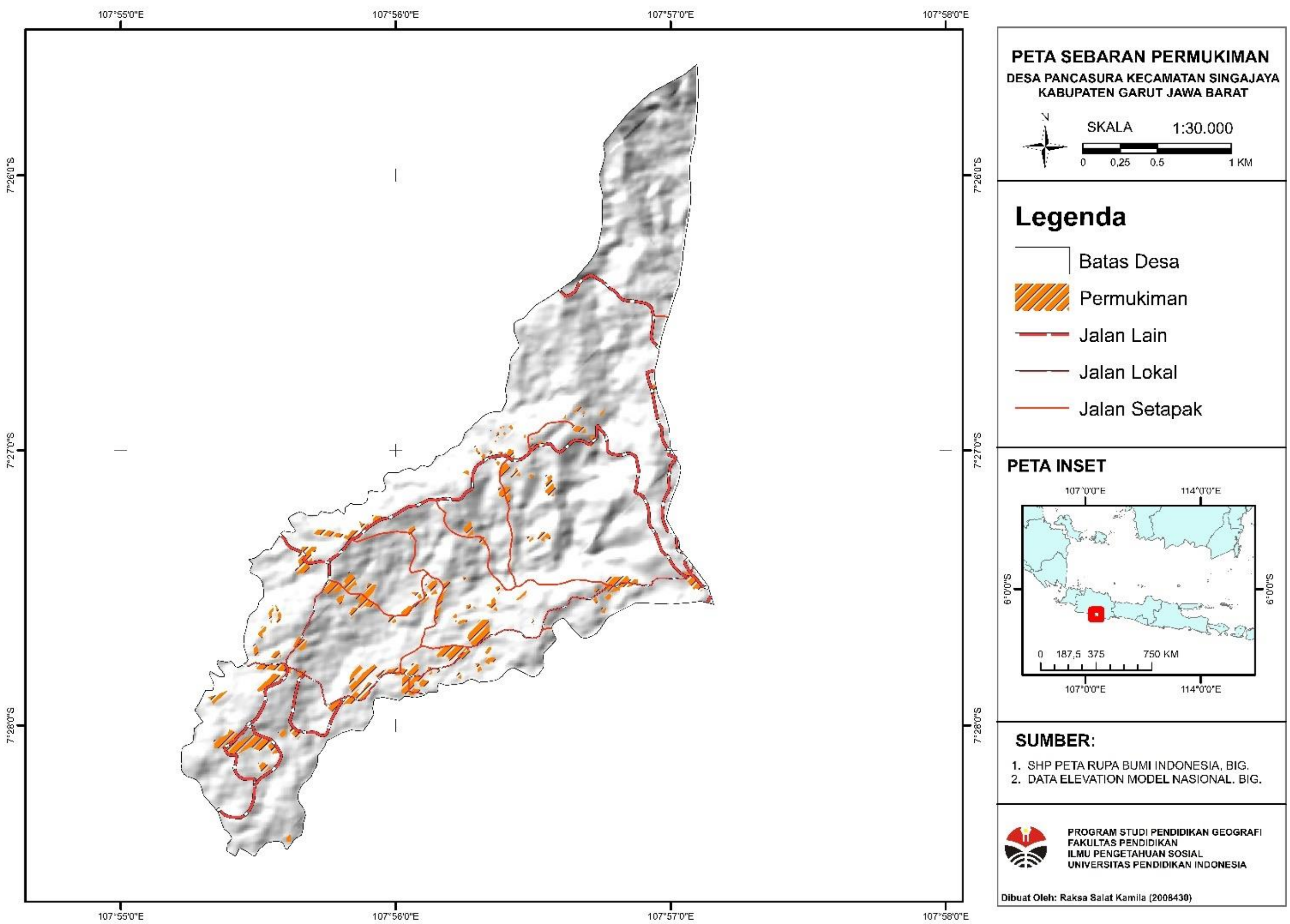

Figure 2. Map of settlement distribution in Pancasura Village
Source: Research Results (2024)

3) Priority Village III: Sukawangi Village

The district authorities indicate that electricity access is relatively equitable in Sukawangi Village, although some households still rely on connecting electricity from neighbor to neighbor. This suggests ongoing efforts to enhance electricity access in the village. Sukawangi features a flatter geographical terrain and is closer to major roads, resulting in better electricity access compared to Sukamulya Village.

Sukawangi Village exhibits the most favorable socioeconomic conditions among the three villages; however, the overall level of socioeconomic advancement remains low compared to other villages in Singajaya District. The village's flatter terrain and proximity to main roads facilitate easier access to public facilities for residents. Figure 3 illustrates the settlement distribution map for Sukawangi Village.

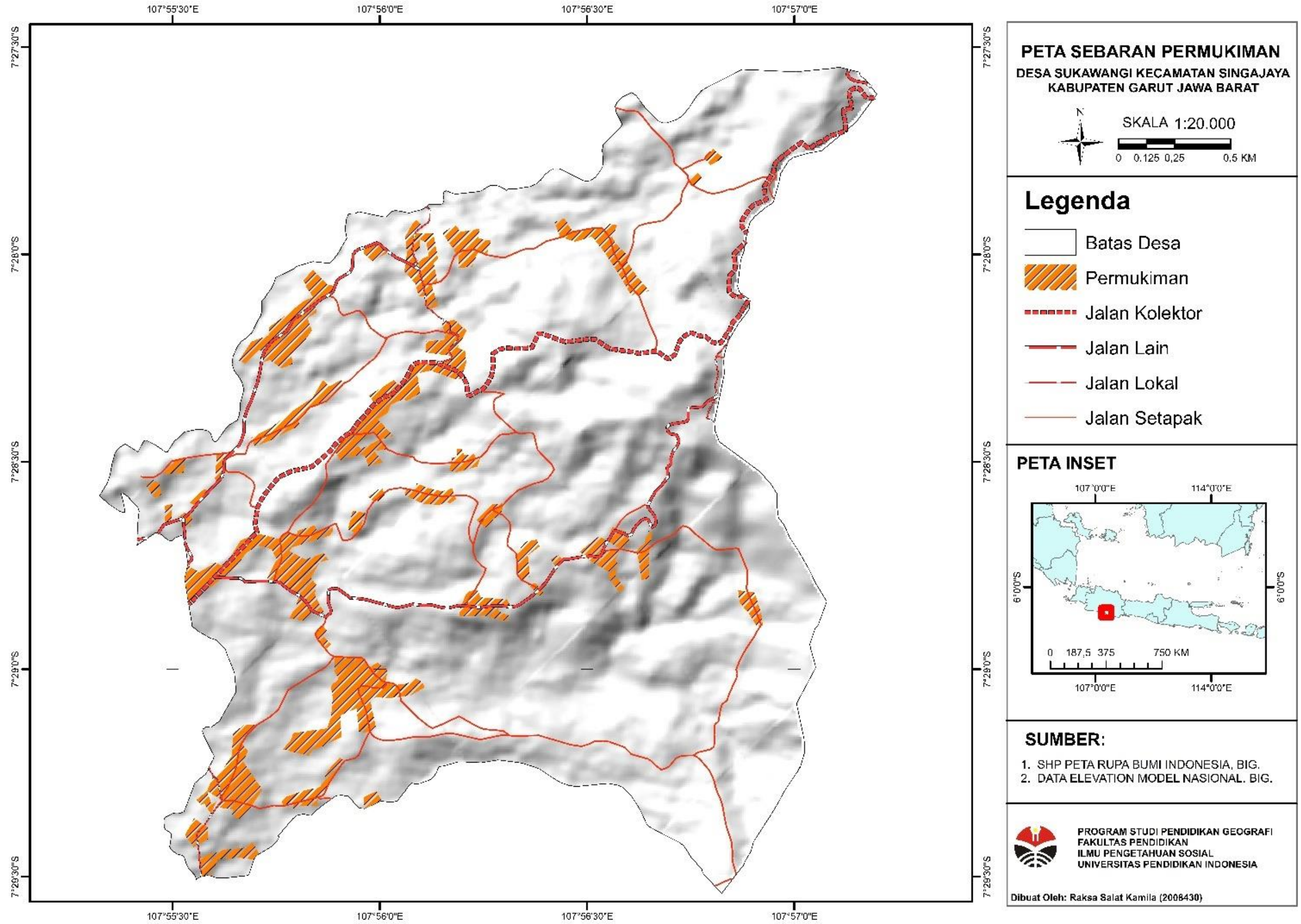

Figure 3. Settlement Distribution Map of Sukawangi Village
Source: Research Results (2024)

Potential of Micro Hydro Power Generation in Singajaya District, Garut Regency

The sampling considerations were based on the non-electrification ratios of the villages, selecting those with the best potential. The prioritized villages chosen are Sukamulya, Pancasura, and Sukawangi. Figure 4.15 displays the survey locations for potential micro hydro power generation in Singajaya District, Garut Regency, with 13 survey points distributed across various villages within the district.

The selection of these six points is also based on the significant water head, which greatly influences water flow rates. A substantial head height allows for greater water flow, an essential factor in the efficiency of micro hydro power generation. Examples of locations with high head heights include Cibedil Waterfall at point 7, Uju Waterfall at point 6, and Citiis Waterfall at point 13, as well as other points like 3, 4, and 5, which have slopes ranging from 15 to 55 degrees. This optimal water head not only enhances energy production efficiency but also ensures that micro hydro power plants can operate effectively throughout the year, even during the dry season.

Table 1. Potential Generated Power

No	Potential Point Code	Potential Location				Q l/d	H	G	Eff	Potential	
		Coordinat		River	Village					watt	Kilo watt
		X	Y								
1	Location 3	107,935743	-7,460528	Kudu waterfall	Pancasura	10609,0	2	0,98	0,6	12476,20	12,4762
2	Location 4	107,934506	-7,460793	Ereng waterfall	Pancasura	10392,7	3	0,98	0,6	18332,76	18,33276
3	Location 5	107,945526	-7,450438	Cikaengan upstream	Pancasura	4002,5	12	0,98	0,6	28241,63	28,24163
4	Location 6	107,927777	-7,471843	Uju waterfall	Pancasura-Sukawangi	26739,6	5	0,98	0,6	78614,52	78,61452
5	Location 7	107,944664	-7,484174	Cibedil waterfall	Sukawangi	1466,1	15	0,98	0,6	12931,38	12,93138
6	Location 13	107,939037	-7,447721	Citiis waterfall	Sukamulya	1565,0	7	0,98	0,6	19587,69	19,58769

Describe:
Q l/d :
H : *Head*
G :
Eff :
P :

Table 1 above considers the available water flow rates at each location, taking into account the size of the catchment area. A larger catchment area provides a stable and substantial water flow, which is critical for the sustainability of micro hydro power plants (PLTMH). A significant catchment area also indicates the region's potential to effectively collect and store rainwater, thereby ensuring a consistent water supply for the operation of PLTMH. This factor is crucial in guaranteeing the sustainability and efficiency of micro hydro power generation, especially in the face of climate change and weather variability.

Another important consideration is land use around the proposed PLTMH locations. This analysis takes into account the distance of PLTMH sites from residential areas and forested regions upstream. Selecting locations near settlements facilitates electricity distribution to the community, while upstream forested areas act as natural buffers that maintain water availability and prevent erosion. This prudent land use ensures that PLTMH development is not only technically efficient but also environmentally friendly and sustainable.

This map also provides a comprehensive guide for PLTMH development in Singajaya District. By identifying potential sites based on various factors such as non-electrification ratios, head height, water flow rates, and land use, the map offers practical solutions to electricity access issues while supporting environmental conservation efforts. Implementing PLTMH at these identified sites is expected to enhance electricity access for local communities and promote sustainable development in the region. This development is also anticipated to reduce reliance on fossil fuel energy sources and decrease greenhouse gas emissions, contributing to climate change mitigation.

Distribution of Micro Hydro Power Generation Potential in Remote Areas of Singajaya District, Garut Regency

The map showing the potential for Micro Hydro Power Generation (PLTMH) in Singajaya District, Garut Regency, West Java, serves as a comprehensive output of this research, identifying strategic locations for PLTMH development. This map focuses on a small section of the Cikaengan Sub-Watershed, where the river flow possesses significant potential to be harnessed as an energy source. Out of the 13 survey locations assessed, six sites exhibit the highest potential for PLTMH development: points 3, 4, 5, 6, 7, and 13.

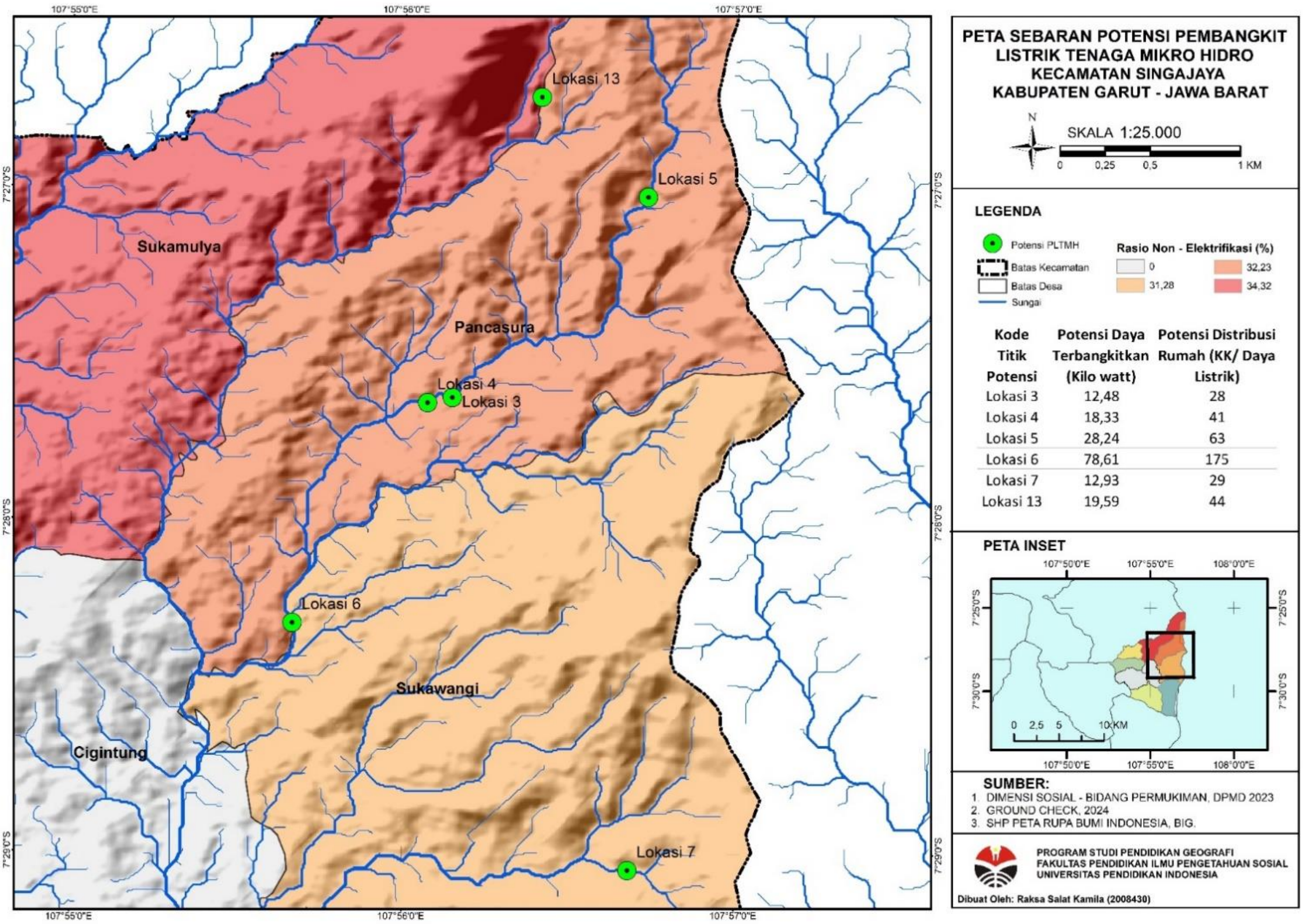

Figure 4. Map of MHP Potential Distribution
Source: Research Results (2024)

Table 2. Percentage of Electricity Supply to Non-Electrification Ratio

Potential Point Code	Village	Number of households (not yet electrified)	Total households	Ratio non electrification (%)	Electricity Supply Potential/Head of household	Availability Percentage (%)
13	Sukamulya-Pancasura	1328	3995	33,2	43,52	4,10
3	Pancasura	664	2060	32,2	27,72	5,22
4	Pancasura	664	2060	32,2	40,73	7,67
5	Pancasura	664	2060	32,2	62,76	11,81
6	Sukawangi-Pancasura	1304	4106	31,8	174,69	16,75
7	Sukawangi	640	2046	31,3	28,73	5,61
	Total	**1968**	**6041**	**32,6**	**378,19**	**19,22**

The map depicting the potential for Micro Hydro Power Generation (PLTMH) in Singajaya District, Garut Regency, represents the primary outcome of this research, identifying strategic locations for PLTMH development. The focus of the study is on the Cikaengan Sub-Watershed, with six out of thirteen surveyed sites demonstrating the greatest potential: points 3, 4, 5, 6, 7, and 13. These locations were selected based on the non-electrification ratios of three priority villages—Sukamulya (34.32%), Pancasura (31.28%), and Sukawangi (32.23%)—which highlight a significant demand for electricity. The main objective is to provide energy access to remote villages that are challenging to reach with conventional power grids.

Additionally, site selection was influenced by significant head height, contributing to the efficiency of power generation. For instance, sites with high head include Cibedil Waterfall (point 7), Uju Waterfall (point 6), and Citiis Waterfall (point 13), which have slopes ranging from 15 to 55 degrees. Stable water flow rates were also considered, along with large catchment areas to ensure the operational sustainability of PLTMH.

Land use around the PLTMH sites is another important factor, with locations close to settlements facilitating electricity distribution, while upstream forested areas serve as natural buffers. This map not only aids in technical planning but also supports environmental sustainability. Overall, the map serves as a guide for PLTMH development, offering practical solutions to electricity access issues, supporting sustainable development, and reducing reliance on fossil fuels. It can serve as a model for renewable energy development in other regions facing similar challenges.

Based on Table 2, the data presents the percentage of electrification issues resolved in several villages, namely Sukamulya, Sukawangi, and Pancasura, while illustrating the potential for enhancing electricity availability through Micro Hydro Power Generation (PLTMH). In Sukamulya Village, there are 664 households (HH) without electricity access out of a total of 1,935 HH, resulting in a non-electrification ratio of 34.32%. The overall percentage of electricity availability is 24.22%, indicating significant potential for PLTMH development to improve electricity access in this village.

In Sukawangi Village, 640 HH lack electricity access from a total of 2,046 HH, leading to a non-electrification ratio of 31.28%. This also suggests opportunities to harness PLTMH potential to provide electricity for the community. Meanwhile, in Pancasura Village, there are 664 HH without electricity out of a total of 2,060 HH, with a non-electrification ratio of 32.23%. Developing PLTMH in this village could serve as a solution for more equitable electricity availability. Table 2 illustrates that PLTMH development could address non-electrification issues in these villages, with an overall electricity availability percentage of 19.22% across the three priority villages.

The distribution of energy potential discussed highlights the importance of spatial analysis in determining ideal locations for renewable energy development. Renewable energy development must consider local geographic and socio-economic conditions (Panche, 2004). The map of PLTMH potential generated in this study indicates that areas with high non-electrification ratios also possess significant potential for PLTMH development. These findings align with literature that emphasizes spatial analysis as a key factor in renewable energy development (Sukmadinata, 2006). Thus, this research provides a strong foundation for recommending PLTMH development in Singajaya District.

The distribution and supply of electricity are based on the ideal provision of 450 watts per household (Lastina et al., 2019). Consequently, the potential distribution in this study indicates that the electricity generation capacity from PLTMH, divided by 450 watts, could provide access to 378.19 households, each receiving 450 watts of power.

Additionally, the research indicates that using a spatial approach, combined with spatial analysis and field surveys, can yield electricity generation capacities ranging from a minimum of 12.4762 kW to a maximum of 78.61452 kW, with six surveyed locations across the three villages. These include three sites in Pancasura Village, one site in Sukawangi Village, one site at the border of Sukamulya and Pancasura Villages, and one site at the border between Sukawangi and Pancasura Villages. Each of these priority sites has the potential to provide for 27.72 HH (location 3), 40.73 HH (location 4), 62.76 HH (location 5), 174.69 HH (location 6), 28.73 HH (location 7), and 43.52 HH (location 13).

CONCLUSION

The provision of electrical energy in Singajaya District, Garut Regency, continues to face significant challenges. According to the collected data, the majority of residents in this area still rely on electricity supply from PLN. However, the availability of electricity from PLN is not evenly distributed across the region, particularly in remote villages. Field interviews reveal that communities often struggle to access electrical substations, mainly due to the proximity of residential areas to rivers and their distance from major roads or transportation access points. This indicates that the existing electrical infrastructure is insufficient to meet the electricity needs of the entire community, highlighting an urgent need for alternative solutions that can provide a more reliable and affordable electricity supply.

The condition of remote areas in Singajaya District still exhibits a relatively high non-electrification rate. The priority villages of Sukamulya, Pancasura, and Sukawangi have non-electrification ratios of 34.32%, 31.28%, and

32.23%, respectively. These high ratios indicate that many households remain unconnected to the PLN electricity grid. This situation adversely impacts the quality of life for residents, hinders economic activities, and reduces access to essential services such as education and healthcare. Therefore, there is a pressing demand for alternative energy solutions that can reach these remote areas and enhance electricity access for the entire population.

Singajaya District possesses significant potential for the development of Micro Hydro Power Generation (PLTMH) due to favorable geographical conditions, such as rivers with adequate water flow and optimal head height. Research indicates that locations like Cibedil Waterfall, Uju Waterfall, and Citiis Waterfall have high head and sufficient water flow, making them ideal candidates for PLTMH. Analytical data show that these sites, including Hulu Cikaengan and Ereng Waterfall, can produce significant power output, ranging from 12.93 kilowatts to 78.61 kilowatts. This potential suggests that with appropriate planning and investment, PLTMH in Singajaya District can not only efficiently meet local electricity needs but also contribute to sustainable energy solutions in remote areas.

The distribution of potential Micro Hydro Power Generation (PLTMH) in the remote areas of Singajaya demonstrates several identified sites with substantial development potential. The distribution map indicates that potential sites for PLTMH are concentrated around priority villages with high non-electrification ratios. Six of the most promising sites—Ereng Waterfall, Kudu, Hulu Cikaengan, Uju, Cibedil, and Citiis—were selected based on various factors including head height, water flow, and land use around the locations.

Acknowledgments: The author would like to express gratitude for the grant funding provided by the Research and Community Service Institution of Universitas Pendidikan Indonesia under the excellence research scheme. Special thanks are also extended to the local community, particularly the residents of Singajaya District, Garut Regency, for their assistance in data collection for this research.

Conflict of interest: The author has no competing interests to declare that are relevant to the content of this article.

REFERENCES

Akella, A. K., Sharma, M. P., & Saini, R. P. (2007). *Optimum utilization of renewable energy sources in a remote area*. Dalam *Renewable and Sustainable Energy Reviews* (Vol. 11, Nomor 5, hlm. 894–908). https://doi.org/10.1016/j.rser.2005.06.006

Aji, P., & Roza, I. (2023). Unit Pengendali Sistem Hibrida Panel Surya Dengan PLN Pada Penggunaan Rumah Tinggal. *JET (Journal of Electrical Technology)*, *8*(2), 74-77.

Al Hakim, R. R. (2020). Model energi Indonesia, tinjauan potensi energi terbarukan untuk ketahanan energi di Indonesia: Sebuah ulasan. *ANDASIH Jurnal Pengabdian Kepada Masyarakat*, *1*(1). https://doi.org/10.57084/andasih.v1i1.374

Almanda, D & Lubis, Y. (2018). Peningkatan Kelayakan Operasi Pembangkit Listrik Tenaga Mikro Hidro di Desa Cinta Mekar Kabupaten Subang. Jurnal Elektum Vol. 15 No. 2, https://jurnal.umj.ac.id/index.php/elektum/article/download/3189/2548

Ariyani, S., Wicaksono, D. A., Fitriana, F., Taufik, R., & Germenio, G. (2021). Studi Perencanaan dan Monitoring System Pembangkit Listrik Tenaga Surya di *Remote Area*. *Techné: Jurnal Ilmiah Elektroteknika*, *20*(2), 113-124.

Badan Pusat Statistik Kabupaten Garut (*Statistics of* Garut). (2024). Kabupaten Garut Dalam Angka 2024. Nomor Publikasi : 32050.24001. ISSN / ISBN : 0215-420X

Badrun, Kartowagiran. (2009). Pengembangan Instrumen Kinerja SMK SBI. Makalah. P4TK Matematika Yogyakarta.

Balai Besar Survei dan Pengujian Ketenagalistrikan, Energi Baru, Terbarukan, dan Konservasi Energi. (n.d.). Pada Agustus 14, 2024, dari https://p3tkebt.esdm.go.id/pilot-plan-project/energi_hidro/mikrohidro

Cahyadi, D., & Sutanhaji, A. T. (2013). Operator Morpho-Hidrologi pada DEM (*Digital Elevation Model*) dan Peta Digital untuk Pemetaan Awal Potensi PLTA dan PLTMH (Studi Kasus DAS Mamberamo). Jurnal Sumberdaya Alam dan Lingkungan, 1(1), 1-6.

Cavalcanti, E. J., Ribeiro, T. J., & Carvalho, M. (2021). *Exergoenvironmental analysis of a combined cycle power plant fueled by natural gas from an offshore platform*. *Sustainable Energy Technologies and Assessments*, *46*, 101245. https://doi.org/10.1016/j.seta.2021.101245

Darmadi, Hamid. 2011. "Metode Penelitian Pendidikan". Bandung: Alfabeta

Das, B. K., Hoque, N., Mandal, S., Pal, T. K., & Raihan, M. A. (2017). *A techno-economic feasibility of a stand-alone hybrid power generation for Remote area application in Bangladesh*. *Energy*, *134*, 775-788. https://doi.org/10.1016/j.energy.2017.06.024

Di, E., Literatur Review, I. :, Ridlo, R., Hakim, A., Tengah, P. J., Sekretaris, T. W., Riset, J., Dem, K., Sekretariat, I., Bina, K., Jl, W. H., Soebrantas, K. 12, & Riau, P. (2020). *ANDASIH Jurnal Pengabdian kepada Masyarakat Model Energi Indonesia, Tinjauan Potensi Energy Terbarukan Untuk Ketahanan*.

Djuwendah, E., Hapsari, H., Renaldy, E., & Saidah, Z. (2013). Strategi pengembangan daerah tertinggal di Kabupaten Garut. *Sosiohumaniora*, *15*(2), 167-177.

Dmitrienko, M. A., & Strizhak, P. A. (2018). *Coal-water slurries containing petrochemicals to solve problems of air pollution by coal thermal power stations and boiler plants: An introductory review. Science of the total environment,* 613, 1117-1129. https://doi.org/10.1016/j.scitotenv.2017.09.189

Dwipayana, I. K. D., Mareta, J., & Reksa, A. F. A. (2024). Membangun Kesejahteraan melalui Pembangkit Listrik Tenaga Mikro Hidro Berbasis Masyarakat di Desa Baturotok, Kabupaten Sumbawa. Masyarakat Indonesia, 49(2), 215-226.

Dwiyoko, G., Sukisno, T., & Damarwan, E. S. (2020). Proyeksi Kebutuhan Energi Listrik Kabupaten Purbalingga Tahun 2030 Menggunakan *Software Leap*. *Jurnal Edukasi Elektro*, *4*(1), 29-40.http://dx.doi.org/10.21831/jee.v4i1.32043

Erinofiardi, Gokhale, P., Date, A., Akbarzadeh, A., Bismantolo, P., Suryono, A. F., Mainil, A. K., & Nuramal, A. (2017). *A Review on Micro Hydropower in* Indonesia. *Energy Procedia*, *110*, 316–321. https://doi.org/10.1016/j.egypro.2017.03.146

Erivianto, D., Dani, A., & Gunawan, H. (2021, March). Sistem Konversi Energi Listrik Sebagai Energi Alternatif Untuk Kebutuhan Rumah Tangga. In Scenario *(Seminar of Social Sciences Engineering and Humaniora)* (pp. 323-334).

Faruk, F., & Altarans, I. (2020). Dampak PLTU Tidore Terhadap Lingkungan Udara, Kesejahteraan Dan Kesehatan Masyarakat Di Kelurahan Rum Balibunga Kecamatan Tidore Utara. *DINTEK*, *13*(02), 38-49.

Gunawan, A., Oktafeni, A., & Khabzli, W. (2013). Pemantauan pembangkit listrik tenaga mikrohidro (PLTMH). *Jurnal rekayasa elektrika*, *10*(4), 201-206. https://doi.org/10.17529/jre.v10i4.1113

Hanggara, I., & Irvani, H. (2017). Potensi PLTMH (Pembangkit Listrik Tenaga Mikro Hidro) di kecamatan ngantang kabupaten malang jawa timur. Reka Buana: Jurnal Ilmiah Teknik Sipil dan Teknik Kimia, 2(2), 149-155.https://doi.org/10.33366/rekabuana.v2i2.731

Hariyanto, T., & Robawa, F. N. (2016). Identifikasi potensi panas bumi menggunakan landsat 8 serta penentuan lokasi pembangkit listrik tenaga panas bumi (Studi Kasus: Kawasan Gunung Lawu). *Geoid*, *12*(1), 36-42.

Hasan, M. H., Mahlia, T. M. I., & Nur, H. (2012). A review on energy scenario and sustainable energy in Indonesia. Dalam *Renewable and Sustainable Energy Reviews* (Vol. 16, Nomor 4, hlm. 2316–2328). https://doi.org/10.1016/j.rser.2011.12.007

Hiendro, A., Kurnianto, R., Rajagukguk, M., & Simanjuntak, Y. M. (2013). *Techno-economic analysis of photovoltaic/wind hybrid system for onshore/Remote area in Indonesia. Energy,* 59, 652-657.https://doi.org/10.1016/j.energy.2013.06.005

Hutabarat, P. H., Zambak, M. F., & Suwarno, S. (2022). Prediksi Kebutuhan Energi Listrik Wilayah PLN Kota Parapat Simalungun Sampai Tahun 2024. *Journal of Electrical and System Control Engineering*, *5*(2), 52-58. https://doi.org/10.31289/jesce.v5i2.5757

IMIDAP. (2009). Pedoman Studi Kelayakan PLTMH (Vol. 2). Direktorat Jenderal Listrik dan Pemanfaatan Energi Departemen Energi dan Sumber Daya Mineral.

Isa, M. A., Sudjono, P., Sato, T., Onda, N., Endo, I., Takada, A., Muntalif, B. S., & Ide, J. (2021). *Assessing the sustainable development of micro-hydro power plants in an isolated traditional village west java, indonesia*. *Energies*, *14*(20). https://doi.org/10.3390/en14206456

Imanuddin, N. (2022). Studi Pemilihan Lokasi Pembangkit Listrik Tenaga Mikro Hidro Berbasis Teknologi *Geographical Information System* Dan *Analytic Hierarchy Process* (*Doctoral dissertation*, Universitas Pendidikan Indonesia). Studi Pemilihan Lokasi Pembangkit Listrik Tenaga Mikro Hidro Berbasis *Teknologi Geographical Information System* Dan *Analytic Hierarchy Process* - Upi Repository

Iskandar, H. R., Taryana, E., & Syaidina, S. (2018). Perancangan Kebutuhan Energi Listrik Pembangkit Listrik Tenaga Surya Di Hanggar *Delivery Center* Pt. Dirgantara Indonesia. *Prosiding Semnastek*.

Jamal, T., Urmee, T., & Shafiullah, G. M. (2020). *Planning of off-grid power supply systems in Remote areas using multi-criteria decision analysis*. *Energy*, *201*, 117580. https://doi.org/10.1016/j.energy.2020.117580

Juliansyah, H. (2018). Analisa Kelayakan Investasi Proyek Pembangunan Pembangkit Listrik Tenaga Mini Hidro (Pltmh) Studi Kasus: Proyek Pt Sumber Energi Lestari Lokasi di Bone Bolango, Provinsi Gorontalo, Sulawesi (*Doctoral dissertation*, Universitas Gadjah Mada).

Karya, D. C. (2012). Identifikasi lokasi desa terpencil desa tertinggal, dan pulau-pulau kecil.

Kementerian ESDM RI - *Media Center* - Arsip Berita - Program Subsektor Ketenagalistrikan Tahun 2024: Lebih Dari 50% Anggaran untuk Program Yang Berdampak Langsung Terhadap Rakyat. (n.d.). pada 14 agustus, 2024, from https://esdm.go.id/id/media-center/arsip-berita/program-subsektor-ketenagalistrikan-tahun-2024-lebih-dari-50-anggaran-untuk-program-yang-berdampak-langsung-terhadap-rakyat-

Kholiq, I. (2015). Analisis pemanfaatan sumber daya energi alternatif sebagai energi terbarukan untuk mendukung subtitusi BBM. Jurnal Iptek, 19(2), 75-91. https://doi.org/10.31284/j.iptek.2015.v19i2.12

Koloay, A. C., Tumaliang, H., & Pakiding, M. (2018). Perencanaan Dan Pemenuhan Kebutuhan Energi Listrik Di Kota Bitung. *Jurnal Teknik Elektro dan Komputer*, *7*(3), 285-294 https://doi.org/10.35793/jtek.v7i3.22504

Kurniawan, R. (2010). Kajian Potensi Pembangkit Listrik Tenaga Mikrohidro (PLTMH) Sebagai Pembangkit Tenaga Listrik Alternatif Dikelurahan Mamburungan Timur Kecamatan Tarakan Timur Kota Tarakan.

Lastina, D, & Alfian, A. 2019. Analisis Kelayakan Investasi Mesin Pembangkit Listrik Di PT Sungai Bahar Pasifik Utama.

Mahabbah, R., Hidayatullah, R. A., Rizky, M., Awalia, K. M. F., & Aribowo, D. (2024). Potensi Pembangkit Listrik Berbasis Energi Air Mikrohindro Bendungan Di Banten. Jurnal Sains dan Teknologi, 3(1), 11-20.

Maruf Al Bawani, A., & Sudarti, S. (2022). Analisis Kelemahan Dan Kelebihan Pembangkit Listrik Tenaga Mikrohidro (Pltmh) Sebagai Alternatif Sumber Energi Listrik. Jurnal Kumparan Fisika, 5(2), 99-104.

Microhydro Power Project (2009). Panduan Singkat Pengembangan Pembangkit Listrik Tenaga Mikrohodro (PLTMH). Kementerian Energi dan Sumber Daya Mineral Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi

Nouni, M. R., Mullick, S. C., & Kandpal, T. C. (2009). *Providing electricity access to Remote areas in India: Niche areas for decentralized electricity supply*. *Renewable Energy*, *34*(2), 430–434. https://doi.org/10.1016/j.renene.2008.05.006

Open Data Jabar. (2024). Jumlah Keluarga di Desa yang Belum Teraliri Listrik Berdasarkan Kabupaten/Kota di Jawa Barat (jabarprov.go.id)

Panwar, N. L., Kaushik, S. C., & Kothari, S. (2011). *Role of renewable energy sources in environmental protection: A review. Dalam Renewable and Sustainable Energy Reviews* (Vol. 15, Nomor 3, hlm. 1513–1524). https://doi.org/10.1016/j.rser.2010.11.037

Penche, Celso. (2004). *ESHA is founding member of EREC, the European Renewable Energy Council Guide on How to Develop a Small Hydropower Plant ESHA 2004*.dari *https://www.canyonhydro.com/images/Part_1_ESHA_Guide_on_how_to_develop_a_small_hydropower_plant.pdf*

Peraturan Menteri Desa, Pembangunan Daerah Tertinggal, dan Transmigrasi Nomor 11 Tahun 2020 tentang Indikator Penetapan Daerah Tertinggal. Permendesa PDTT No. 11 Tahun 2020 (bpk.go.id)

Peraturan Menteri Lingkungan Hidup Dan Kehutanan Nomor 8 Tahun 2021 tentang Tata Hutan Dan Penyusunan Rencana Pengelolaan Hutan, Serta Pemanfaatan Hutan Di Hutan Lindung Dan Hutan Produksi. Permen LHK No. 8 Tahun 2021 (bpk.go.id)

Peraturan Pemerintah (PP) Nomor 79 Tahun 2014 tentang Kebijakan Energi Nasional. PP No. 79 Tahun 2014 (bpk.go.id)

Peraturan Presiden (Perpres) Nomor 18 Tahun 2020 tentang Rencana Pembangunan Jangka Menengah Nasional Tahun 2020-2024. PERPRES No. 18 Tahun 2020 (bpk.go.id)

Peraturan Presiden (Perpres) Nomor 38 Tahun 2018 tentang Rencana Induk Riset Nasional Tahun 2017-2045. PERPRES No. 38 Tahun 2018 (bpk.go.id)

Peraturan Presiden (PERPRES) Nomor 63 Tahun 2020. Penetapan Daerah Tertinggal Tahun 2020-2024. PERPRES No. 63 Tahun 2020 (bpk.go.id)

Purba, N. A. H., Lukman, A., & Sarifah, J. (2021). Perbandingan Metode Mononobe dan Metode Van Breen Untuk Pengukuran Intensitas Curah Hujan Terhadap Penampang Saluran Drainase. Buletin Utama Teknik, 16(2), 119-125.

Purboyo, A. A., Ramadan, A. H., Arifin, E. T., Noviandi, I. E., & Arizqi, M. (2024). Pemanfaatan Penginderaan Jauh dan Sistem Informasi Geografis untuk Identifikasi Morfometri di DAS Ciliwung. *Aerospace Engineering*, *1*(1), 12-12.

Persia, A. N. (2018). Studi Tentang Cadangan Penyangga Minyak (CPM) Untuk Mewujudkan Ketahanan Energi Indonesia. *Ketahanan Energi*, *4*(2). Vol. 4 No. 2 (2018): Jurnal Ketahanan Energi (idu.ac.id)

Purwadhi, S. H. (2021). Interpretasi citra digital.

Purwanto, T., Ernawati, I., & Wiranta, S. (2017). Pembangkit Listrik Mikrohidro (PLTMH) Sebuah Pilihan: Belajar dari Koperasi Mekar Sari Subang.

Puspita, D. (2024). Energi Bersih Dan Terjangkau Dalam Mewujudkan Tujuan Pembangunan Berkelanjutan (SDGs). Jurnal sosial dan sains, 4(3), 271-280. https://doi.org/10.59188/jurnalsosains.v4i3.1245

Rahayu, L. N., & Windarta, J. (2022). Tinjauan Potensi dan Kebijakan Pengembangan PLTA dan PLTMH di Indonesia. Jurnal Energi Baru dan Terbarukan, 3(2), 88-98. https://doi.org/10.14710/jebt.2022.13327

Ridwansyah, I., Pawitan, H., Sinukaban, N., & Hidayat, Y. (2015). Potensi Sumberdaya Air Untuk Pengembangan Pltmh Di Das Cisadane Hulu Berdasarkan Pemodelan Hidrologi Swat. *Limnotek: Perairan darat tropis di Indonesia*, *22*(1). http://dx.doi.org/10.14203/limnotek.v22i1.26

S., Hasbi A. "Studi Pemanfaatan Energi Matahari sebagai Sumber Energi Alternatif Terbarukan Berbasis Sel Fotovoltaik untuk Mengatasi Kebutuhan Listrik Rumah Sederhana di Daerah Remote." *Al Jazari*, vol. 3, no. 2, 2018.

Saidah, H., Wirahman, L., & Hidayaturrohmi, L. (2023). Evaluasi Kinerja Metode Perhitungan Koefisien Pengaliran: Evaluation of Runoff Coefficient's Calculation Methods Performance. *Jurnal Sains Teknologi & Lingkungan*, *9*(1), 74-85.

Saleh, C., Thoif, A., Achmad, R., Leuveano, C., & Rahman, A. B. (2016).*Assessment And Decision Making Scenario Of Carbon Emission In Sugar Industry Based On Energy Consumption Using System Dynamics*. Dalam *Journal of Engineering Science and Technology Special Issue on ICE & ICIE* (Vol. 2015).

Sandy, J. (2021). Geologi Dan Studi Alterasi Hidrotermal Lapangan Panasbumi Darajat, Desa Mekarjaya, Kecamatan Cisurupan, Kabupaten Garut, Jawa Barat. *Jurnal Ilmiah Geologi PANGEA*, *2*(1).

SDGs Indonesia, Kementerian PPN/Bappenas. (2024). BERANDA - SDGs Indonesia (bappenas.go.id)

Setyawan, D. A. (2014). Kajian Potensi Sungai Curuk Untuk Pembangkit Listrik Tenaga Mikro Hidro (Pltmh) Di Padukuhan Gorolangu, Kab. Kulon Progo, Yogyakarta (Doctoral Dissertation, Uajy). Http://E-Journal.Uajy.Ac.Id/Id/Eprint/7094

Siahaan, Y. (2023). *Model Assesmen Potensi Energi Terbarukan Berbasis Sumberdaya Air Untuk Pengukuran Berpikir Kritis Mahasiswa Rumpun Geografi: Studi Kasus di DAS Cipunagara, Provinsi Jawa Barat* (Doctoral dissertation, Universitas Pendidikan Indonesia).

Siahaan, Y., Rohmat, D., Yani, A., & Somantri, L. (2023). *Potential of Hydropower-Based Renewable Energy in Cipunegara Watershed*. *Geosfera Indonesia*, *8*(3), 277-300.

Siahaan, Y., PSDA, M., Dede Rohmat, M. T., Yani, A., & Somantri, L. (2024). *Asesmen Potensi Energi Terbarukan Berbasis Sumberdaya Air: Sebuah Transformasi Instrumen Pengukur Berpikir Kritis Mahasiswa Rumpun Geografi*. Penerbit Adab.

Siregar, S. A., & Warman, E. (2013). studi prakiraan kebutuhan energi listrik tahun 2013-2017 wilayah Kota Padang Sidimpuan dengan metode gabungan. *J. Singuda Ensikom*, *1*(2).

Subandono, A. (2013). Pembangkit listrik tenaga mikrohidro (pltmh). *J. Rekayasa Elektr*, *10*(4), 1-13.

Subekti, R. A. (2012). Survey Potensi Pembangkit Listrik Tenaga Mikro Hidro di Kuta Malaka Kabupaten Aceh Besar Propinsi Nanggroe Aceh Darussalam. *Journal of Mechatronics, Electrical Power, and Vehicular Technology*, *1*(1), 5-12. 10.14203/j.mev.2010.v1.5-12 (doi.org)

Sugiyono, P. D. (2010). Metode penelitian kuantitatif dan kualitatif. *Bandung: CV Alfabeta*.

Sukmadinata. “Metode Penelitian Pendidikan”. Bandung: Remaja Rosdakarya. 2006.

Suripin Dr.Ir. M.Eng 2004. Sistem Drainase Perkotaan yang Berkelanjutan, Andi Offset, Yogyakarta

Sutopo, A. A. C. R., Sugianto, D. N., & Yosi, M. (2015). Potensi Arus Laut Sebagai Sumber Energi Listrik di Desa Sabangmawang, Kabupaten Natuna. *Journal of Oceanography*, *4*(2), 479-486.

Tang, S., Chen, J., Sun, P., Li, Y., Yu, P., & Chen, E. (2019). Current and future hydropower development in Southeast Asia countries (Malaysia, Indonesia, Thailand and Myanmar). *Energy Policy*, *129*, 239–249. https://doi.org/10.1016/j.enpol.2019.02.036

Taufiqurrahman, A., & Windarta, J. (2020). Overview Potensi dan Perkembangan Pemanfaatan Energi Air di Indonesia. *Jurnal Energi Baru dan Terbarukan*, *1*(3), 124–132. https://doi.org/10.14710/jebt.2020.10036

Trissiana, J., & Wilopo, W. (2019, December). Studi Potensi Pengembangan Pembangkit Listrik Tenaga Mikrohidro (PLTMH) Di Kawasan Wisata Air Terjun Sumberwangi Desa Tirtomarto Kecamatan Ampelgading Kabupaten Malang. In *Seminar Nasional Inovasi Dalam Penelitian Sains, Teknologi Dan Humaniora-InoBali* (pp. 93-98).

Undang-undang (UU) Nomor 30 Tahun 2007 tentang Energi. UU No. 30 Tahun 2007 (bpk.go.id).

Van, Z. R., & van Cancelado Zuidam, F. I. (1985). Aerial photointerpretation in terrain analysis and geomorphologic mapping. *Hague Netherl*.

Wardhana, A. R., & Marifatullah, W. H. (2020). Transisi Indonesia menuju energi terbarukan. Tashwirul Afkar, 38(2). https://doi.org/10.51716/ta.v38i02.27

Wardhani, D. S., Santoso, A. T., aditya, a., & galaxi, a. p. (2023, January 10). Pengembangan Sumber Energi Terbarukan Di Indonesia Berbasis Mikro Hidro. https://doi.org/10.31219/osf.io/7n9bg

Weimer, M. A., Paing, T. S., & Zane, R. A. (2006, June). Remote area wind energy harvesting for low-power autonomous sensors. In *2006 37th IEEE Power Electronics Specialists Conference* (pp. 1-5). IEEE. — https://doi.org/10.1109/pesc.2006.1712213

Yudistira, M. I., & Rofii, M. S. (2023). Penerapan Sumberdaya Pembakit Listrik Tenaga Uap Batubara Di Indonesia Dari Perspektif Pengembangan Energi Hijau (Green Energy). *Nusantara: Jurnal Ilmu Pengetahuan Sosial*, *10*(2), 935-941. http://dx.doi.org/10.31604/jips.v10i2.2023.%25p

Yuningsih, A., & Masduki, A. (2011). Potensi energi arus laut untuk pembangkit tenaga listrik di kawasan pesisir Flores Timur, NTT [*Potential energy of ocean current for electric power generation in coastal areas of East Flores*, NTT]. *J Tropical Marine Science and Technology*, *3*(1), 13-25.

Yunus, H. S. (2016). Metodologi Penelitian Wilayah Kontemporer. Pustaka Pelajar.

Yusuf, F., & Rahayan, R. (2018). Sistem Monitoring Rasio Elektrifikasi Di PT PLN (Persero) Wilayah Sulselbar Berbasis Web. *Jurnal Insypro: Information System and Processing*, *3*(1), 1-10.

Zhang, T., Liu, Y., Zhong, S., & Zhang, L. (2020). *AOPs-based remediation of petroleum hydrocarbons-contaminated soils: Efficiency, influencing factors and environmental impacts*. Chemosphere, 246, 125726. https://doi.org/10.1016/j.chemosphere.2019.125726