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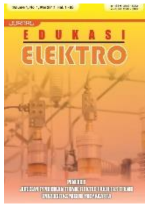

Feasibility Study of a Microgrid for Electrifying the Isolated Area

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Abstract— Guha Village in Aceh Singkil lacks access to electricity from PLN, with challenging road conditions further complicating energy access. This study explores a feasible microgrid solution, assessing local renewable energy potential and economic viability using HOMER Pro software. Calculations reveal an annual energy demand of 97,334 kWh for 41 households. The analysis identifies a standalone micro-hydro system as the most cost-effective option, capable of partially meeting this demand with an annual output of 296,077 kWh. However, due to a distribution efficiency of 79.6%, the effective supply is 235,961 kWh per year. Financially, the micro-hydro system offers significant advantages, reducing the Net Present Cost (NPC) from Rp5.82 billion to Rp1.10 billion, despite a higher initial capital requirement of Rp825 million. With minimal O&M costs of Rp15 million annually and a Levelized Cost of Energy (LCOE) of Rp987.66/kWh, the system demonstrates substantial long-term savings. Investment metrics show a 49% Internal Rate of Return (IRR), 44% Return on Investment (ROI), and a two-year payback period, making the micro-hydro system a sustainable as cost effective energy solution for Guha Village.

Keywords: microgrid, feasibility, isolated area, HOMER Pro.

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1 Introduction

The demand for electricity in remote areas to improve community welfare remains a critical issue [1]. Indonesia, as an archipelagic nation, continues to face challenges in reaching a 100% electrification rate, with many small islands still lacking access to electricity from the national power provider, PT. PLN [2]. Data from the Ministry of Energy and Mineral Resources (ESDM), accessible on its official website, reveals that 12,669 villages in Indonesia are without electricity access, with 2,519 of these villages entirely devoid of lighting [3]. This situation is primarily due to infrastructure limitations in delivering electricity to remote villages. Geographical barriers often hinder the transportation of electrical equipment, as many roads are unsuitable for vehicles. Additionally, disparities in purchasing power across regions exacerbate the challenges in achieving widespread electrification [4].

Achieving rural electrification aligned with SDG7 may require innovative, collaborative strategies that address unique local conditions and population dynamics [5]. For instance, most electricity generation still relies heavily on non-renewable fossil fuels, which pose considerable environmental challenges, including substantial greenhouse gas emissions [6]. With advances in technology and the increasing market viability of renewable energy systems, deploying clean, sustainable power sources in decentralized and remote areas has become more feasible and cost-effective [7]. Renewable resources such as wind, solar, hydro, and biomass are naturally abundant, self-renewing, and not confined by political or geographic boundaries, making them suitable for use across various regions through grid-connected or stand-alone solutions [8]-[10].

Several studies have designed hybrid microgrid systems to enhance energy independence and sustainability in remote areas. For example, [11] conducted a study optimizing a hybrid microgrid system powered by wind, solar, hydrogen, and fuel cells using a bio-inspired algorithm. Another study [12] focused on designing a hybrid power generation system (photovoltaic and micro-hydro) to establish an energy-independent village in Dosay Village, West Sentani District, Jayapura Regency, Papua. Additionally, [13] presented a planning study for a solar PV-diesel generator hybrid power plant on Kodingare Island, Sinjai Regency, while [14] analyzed the potential of solar and wind power in Bontang Kuala using Homer software. In another study, [15] proposed an autonomous photovoltaic system designed to meet the energy needs of a rural household in the Moroccan village of Tazouta.

The case study in this paper is focused on Guha Village, located in Aceh Singkil, Aceh. According to available data, out of the 116 villages in Aceh Singkil Regency, Guha Village is the only one without electricity from PLN [16]. The village head of Guha reported that the village has a population of 146 people, comprising 41 households [17]. This issue is further exacerbated by poor road conditions, which are especially challenging as the roads often become muddy and impassable [18]. Therefore, given these circumstances, a feasibility study for a microgrid design in Guha Village is essential.

In this study, a feasibility assessment will be conducted using HOMER Pro. The process will begin with calculating the load profile of the village to determine energy demand. Next, the renewable energy potential in the surrounding area will be evaluated to identify viable energy sources. This will be followed by selecting suitable generation components and other system elements. Then, data analysis will be carried out to assess key financial metrics, including net present cost (NPC), initial capital, operational and maintenance costs, and the levelized cost of energy (LCOE). This paper contributes to bridging the energy access gap in remote areas by conducting a detailed feasibility study for a microgrid in Guha Village, Aceh Singkil.

2 Method

2.1 Research stage

The research methodology for this study focuses on designing a sustainable microgrid system for Guha Village, Aceh Singkil, using HOMER Pro software to simulate and optimize the system. The process begins by inputting specific location details of Guha Village and calculating daily load profiles to estimate the energy needs of its 41 households. Given the proximity of Sampuren Sipitu Waterfall to Guha Village, this study evaluates the potential use of this natural resource for hydropower generation. Important system components, including diesel generators and micro hydro turbines, are carefully selected based on their energy generation capacity, operational reliability, and cost-effectiveness. HOMER Pro software then runs a series of simulations to assess the economic viability of the proposed microgrid. This involves analyzing core financial metrics such as Net Present Cost (NPC), Initial Capital Cost, Operation and Maintenance (O&M) costs, and Levelized Cost of Electricity (LCOE). Through this detailed analysis, this study aims to identify the optimal configuration that balances reliability, sustainability, and cost-efficiency, thereby providing a viable energy solution for Guha Village.

2.2 Data processing

This research is focused on the feasibility of implementing a hybrid energy system in isolated regions, particularly those located near waterfalls. Given the abundant water resources available in these areas, it is important to evaluate the energy potential that can be harnessed from hydro sources. Therefore, the equations utilized in this study will assess the micro-hydropower potential, shown by equation (1) [19].

$$E = m.g.h \tag{1}$$

Explanation:
E : Energy produced (joules)
m : Mass of water flowing (kg)
g : Gravitational (9.81 m/s^2)
h : Height of waterfall (m)

The energy produced can also be associated with the kinetic energy generated by the flow of water. The formula for kinetic energy is shows by equation (2).

$$E = \frac{1}{2}mv^2 \tag{2}$$

Explanation:
E : Kinetic Energy (joules)
m : Mass of water (kg)
v : Velocity of the water flow (m/s)

The electrical power that can be generated by the micro-hydropower plant is calculated using the following formula shows by equation (3).

$$P = \frac{1}{2}\rho A v^3 \tag{3}$$

Explanation:
P : Power (Watts)
p : Density of water (kg/m^3)
A : Cross sectional area (m^2)
v : Velocity of the water flow (m/s)

Then, water discharge (Q) can be calculated with the following formula, shows by equation (4).

$$Q = \frac{P}{pgh} \tag{4}$$

Explanation:
Q : Water discharge (m3/s)
P : Power (Watts)
p : Density of water (kg/m^3)
g : Gravitational (9.81 m/s^2)
h : Height of waterfall (m)

The HOMER tool for optimizing hybrid power systems is utilized to achieve the minimum net present cost (NPC), which can be calculated as equations (5) and (6) [20].

$$C_{NPC} = \frac{C_{ann,tot}}{CRF\ (i,R_{proj})} \quad (5)$$

Explanation:
C_{NPC} : Total net cost ($)
C_{ann} : Total annualized cost ($/year)
CRF : Capital recovery factor (per year)
R_{proj} : Project lifetime (years)

$$CRF = \frac{i(1+i)^N}{(1+i)^N - 1} \quad (6)$$

Explanation:
CRF : Capital recovery factor (per year)
i : Interest rate (%)

Levelized Cost of Energy (LCOE) is a important metric for evaluating the economic viability of any hybrid system. The equation (7) and (8) shows to calculated TAC and COE.

$$TAC = NPC.CRF(i, N) \quad (7)$$

Explanation:
TAC : Total annualized cost ($/year)
NPC : Net Present Cost ($)
CRF : Capital recovery factor (per year)
i : Interest rate (%)

$$COE = \frac{TAC}{E_{prim}} \quad (8)$$

Explanation:
COE : Cost of a kWh electricity ($/kWh)
E_{prim}: Total annualized primary serves load (kWh/year)

3 Result

3.1 Load profile and distribution

Based on a report by the Head of Guha Village, it was noted that the village has 41 households with a total population of 146 people [17]. Accordingly, the microgrid design assumes a load profile based on these 41 households. Table 1 presents the estimated energy consumption per household over a 24-hour period, which serves for calculating the total daily energy demand and guiding the system's capacity requirements for reliable power delivery to the village.

Table 1. Household Load Profile Over a 24-Hour Period

Profile	Quantity	Power (Watt)	Usage Time (hour)	Energy (Wh)
Lamp	6	16	5	480
Fan	1	54	6	324
Rice Cooker	1	400	1.5	600
Iron	1	240	2	480
Television	1	60	3	180
Water Pump	1	270	1	270
Phone Charger	2	10	2	40
Total Energy				2374

If each household requires a load profile of 2374 Wh or 2.374 kWh per day, then the total daily load for 41 households is shown by Table 2.

Table 2. Total Load Calculation for 41 Households

Total Load	Energy (kWh)
Total Daily Load	97.334

Then, after calculating the total load, the next step is to input the previously computed load profile to supply 41 households in Guha Village with a total energy requirement of 97.334 kWh per day into HOMER Pro. The load data differs for each hour from 00:00 to 23:00. The hourly load distribution is shown in Table 3.

Table 3. The hourly load distribution

Time	Load (kWh)
00:00	2.0
01:00	1.5
02:00	1.5
03:00	1.5
04:00	1.5
05:00	1.5
06:00	3.0
07:00	4.0
08:00	4.0
09:00	4.0
10:00	2.9
11:00	2.7
12:00	2.0
13:00	4.2
14:00	2.0
15:00	3.9
16:00	3.8
17:00	4.9
18:00	7.0
19:00	9.8
20:00	9.9
21:00	7.9
22:00	7.9
23:00	4.0

Energy demand in the morning is low, ranging from 1.5 to 3 kWh per hour for 41 households, mainly for lighting and light appliances. In the afternoon, demand increases to 3 to 5 kWh due to more activity, including kitchen use. The evening peak occurs between 18:00 and 20:00, reaching 7 to 10 kWh for cooking and electronics. Nighttime demand declines to 3 to 5 kWh, focused on lighting and entertainment. Figure 1 illustrates the 24-hour energy load distribution.

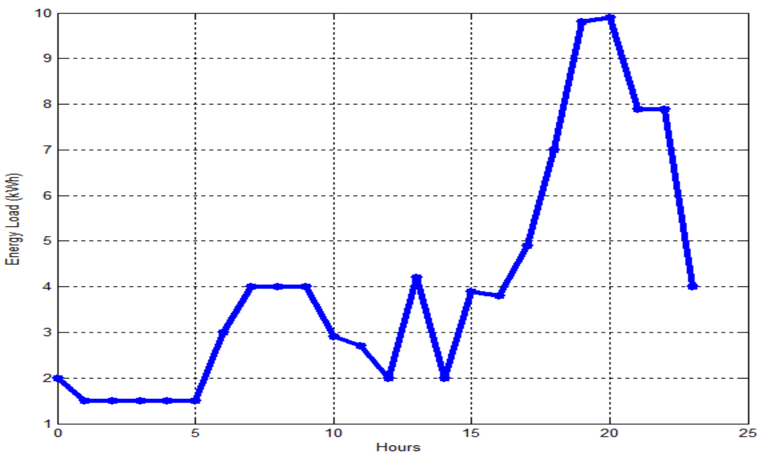

Figure 1. The 24-hour energy load distribution

Following the load distribution, the next step involves inputting the previously calculated load profile data into Homer Pro to supply 41 houses in Guha Village with 97,334 kWh per day, with varying hourly load data from 00:00 to 23:00. Figure 2 illustrates the load distribution data entered into Homer Pro for supplying 41 houses in Guha Village and Figure 3 shows the seasonal profile.

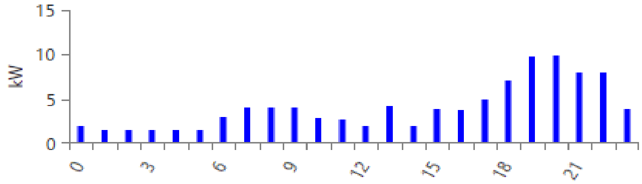

Figure 2. The 24-hour energy load distribution by HOMER Pro

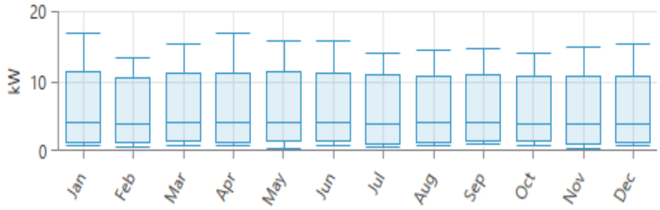

Figure 3. The seasonal profile by HOMER Pro

Upon entering the load data into the system, the resulting metrics include average (kWh/day), average (kW), peak (kW), and load factors, as shown in Table 4.

Table 4. Load Metric by HOMER Pro

Metric	Baseline	Scaled
Average (kWh/day)	97.34	165.44
Average (kW)	4.06	6.89
Peak (kW)	16.9	28.73
Load factor	0.24	0.24

3.2 Determination of generator components

In the process of establishing an energy supply system for the community, it is essential to determine the appropriate generator components. The potential for energy generation in this area is significant due to the presence of a waterfall, which will be utilized for micro hydro power generation. However, due to capacity limitations, it is necessary to supplement the micro hydro system with a generator set. The chosen generator for this project is the Generac 50 kW SD050**.** Table 5 shows the outlines of the specifications and operational characteristics of the Generac 50 kW SD050 generator.

Table 5. The outlines the specifications and operational Generac 50 kW

Parameter	Value
Name	Generac 50 kW SD050
Initial Capital Cost (Rp)	Rp 236,250,000.00
Fuel Type	Diesel
Fuel Price (Rp/L)	6800
Daily Energy Production (kWh/d)	165.44
Peak Load (kW)	28.73
Fuel Curve Intercept (L/hr)	1.10
Fuel Curve Slope (L/hr/kW)	0.305
CO Emissions (g/L fuel)	12.7
Unburned HC Emissions (g/L fuel)	0.72
Particulates (g/L fuel)	0.117
Fuel Sulfur to PM (%)	2.2

Parameter	Value
NOx Emissions (g/L fuel)	10.16
Minimum Load Ratio (%)	25.00
Lifetime (Hours)	15,000

The Generac 50 kW SD050 generator, with an initial capital of Rp 236,250,000 and a fuel cost of Rp 6,800 per liter, is designed to supply 51% of the energy needs for 41 households in Guha Village, amounting to approximately 165.44 kWh per day. With a minimum load ratio of 25% and a projected lifespan of 15,000 hours, the generator operates efficiently even during low demand periods, making it a sustainable choice for the community. Additionally, its emissions profile adheres to environmental standards, positioning the Generac 50 kW SD050 as a reliable and responsible energy solution for the village.

The next step involves determining the components for the micro hydro system. The Natel FreeJet FJ-7A, with a capacity of 49 kW, is selected for its efficiency in harnessing the local waterfall's potential. This turbine is projected to generate approximately 165.44 kWh per day, achieving a peak output of 28.73 kW. The initial capital cost for the turbine is estimated at Rp 825,000,000.00, along with an annual operation and maintenance cost of Rp 15,000,000. With a lifespan of 20 years, this micro hydro system offers a sustainable and renewable energy solution for the 41 households in Guha Village, complementing the existing generator set and contributing to the overall energy supply. Table 6 shows the outlines of the specifications and operational Natel FreeJet FJ-7A.

Table 6. The outlines the specifications and operational Natel FreeJet FJ-7A

Specification	Value
Name	Natel FreeJet FJ-7A
Abbreviation	Nate149
Capacity	49 kW
Daily Energy Production	165.44 kWh
Peak Output	28.73 kW
Capital Cost	Rp 825,000,000
O&M Cost	Rp 15,000,000 per year
Lifetime	20 years

This micro hydro system is designed to be installed at the nearest waterfall, which has a height of 10 meters. Using equations (1)-(4), Table 7 shows the results of flow rate and flow ration.

Table 7. The description of waterfall location with flow rate and flow ratio

Description	Value
Waterfall Height	10 m
Design Flow Rate	499.00 L/s
Minimum Flow Ratio	25.00%
Maximum Flow Ratio	150.00%

Then, after the simulation Figure 4 shows, micro hydro system power output.

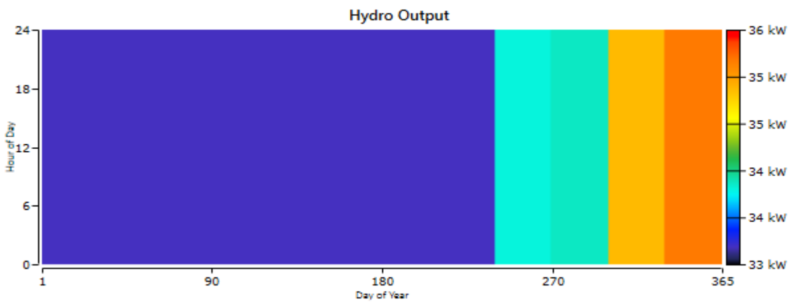

Figure 4. Micro hydro system power output

3.3 Feasibility optimization simulation with Homer Pro

Based on equations (5) to (8), the values for NPC and LCOE are calculated and presented in Table 8 by simulation HOMER Pro.

Table 8. Result Economy Simulation by HOMER Pro

Metric	Base Case System	Lowest Cost System
NPC (Net Present Cost)	Rp 5.82B	Rp 1.10B
Initial Capital	Rp 236M	Rp 825M
O&M (Operations & Maintenance)	Rp 302M/year	Rp 15M/year
LCOE (Levelized Cost of Energy)	Rp 5,217/kWh	Rp 987.66/kWh

Then, the results simulation of IRR, ROI, and Simple Payback show by Table 9.

Table 9. Result Economy Metric of IRR, ROI, and Simple Payback

Economic Metric	Result
IRR (Internal Rate of Return)	49%
ROI (Return on Investment)	44%
Simple Payback	2.0 years

4 Discussion

Based on this case, a total annual energy requirement of 97,334 kWh for 41 households in Guha Village, but on the optimization by HOMER Pro on Table 8, the best architecture is the micro-hydro system only, which can generate only 25 kWh per day approximately 296,077 kWh annually, falls short of meeting the total energy demand. Figure 5 and Figure 6 show the schematic and the winning architecture of the system.

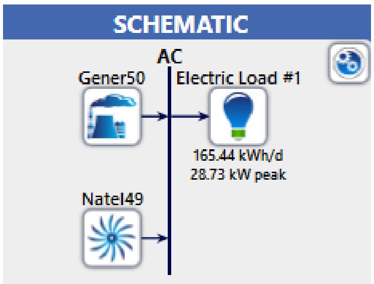

Figure 5. The schematic system of Homer PRO

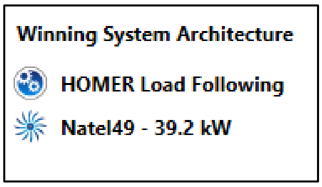

Figure 6. Results of the optimization system

This means that the micro hydro system can satisfy only about 25.9% of the overall energy needs, leaving 74.1%, or roughly 72,334 kWh per day, unmet. Given the average energy consumption per household of 2,374 kWh per year, the micro hydro system is only capable of supporting approximately 11 households, thereby resulting in 30 households being without electricity supply. Figure 7 illustrates the daily output generated from the micro-hydro system.

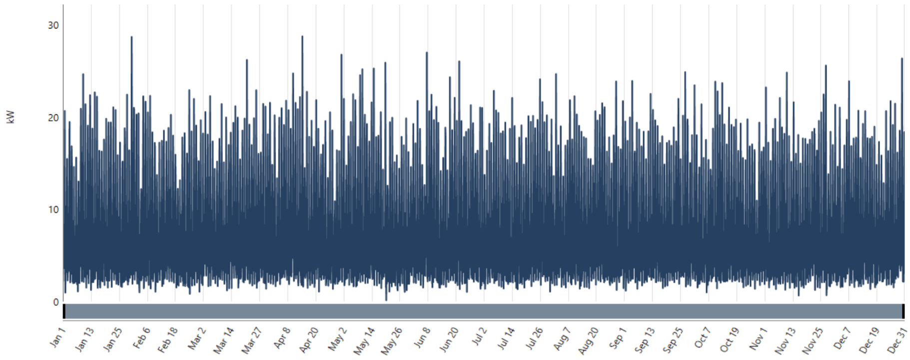

Figure 7. The daily output generated from the micro-hydro system as the best architecture

To ensure that all 41 households receive electricity, each household would need to reduce its energy consumption to approximately 0.609 kWh per day. The total energy demand for the 41 households amounts to 97,334 kWh annually, while the micro-hydro system has the capacity to generate 296,077 kWh per year. However, considering the distribution efficiency of only 79.6%, the effective energy supplied is reduced to 235,961 kWh annually. Despite this reduction, the available capacity remains more than sufficient to meet the community's needs, with a surplus of energy that could be utilized for additional requirements in the future. Figure 8 shows the monthly electricity production and Figure 9 shows the highest probability of annual production.

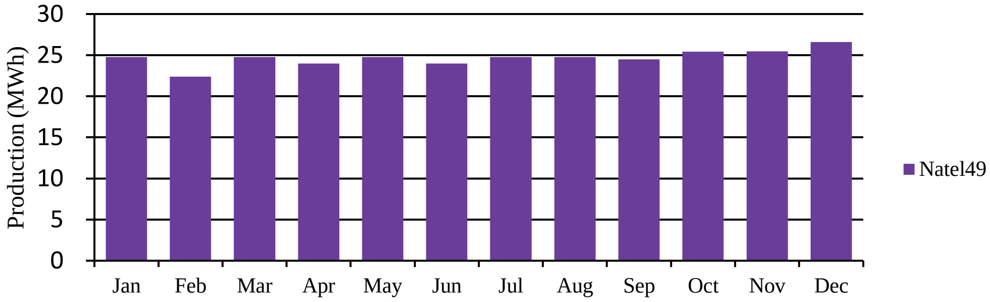

Figure 8. The monthly electricity production

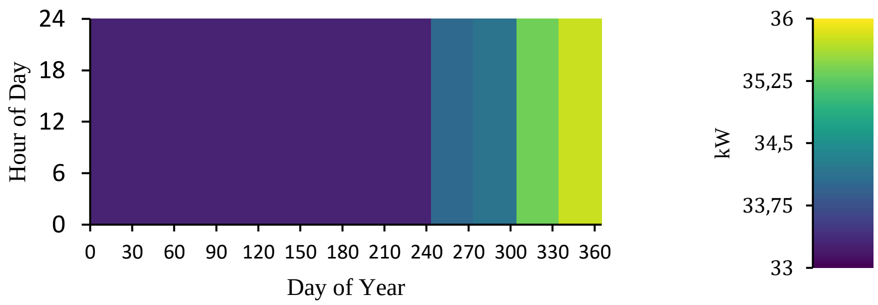

Figure 9. The highest probability of annual production

From an economic perspective, the micro hydro system presents a significant advantage over traditional grid-based systems, with a Net Present Cost (NPC) of Rp1.10 billion, significantly lower than the Rp5.82 billion associated with grid systems. Although the initial investment for the micro-hydro system is higher (Rp825 million), its annual operational costs are minimal, amounting to Rp15 million compared to Rp302 million for the grid-based system. Additionally, the Levelized Cost of

Energy (LCOE) for the micro-hydro system is substantially lower at Rp987.66/kWh, as opposed to Rp5,217/kWh for grid systems.

From the perspective of investment returns, the micro-hydro system achieves an Internal Rate of Return (IRR) of 49%, a Return on Investment (ROI) of 44%, and a Simple Payback period of two years. These metrics indicate that the micro-hydro system not only meets the energy needs of the community but also provides significant financial benefits, rendering it an extremely efficient, environmentally friendly, and sustainable option for Guha Village.

5 Conclusion

The economic analysis using HOMER Pro confirms that a standalone micro hydro system is the most cost effective and sustainable solution for meeting the energy needs of off-grid Guha Village. This option reduces the Net Present Cost (NPC) significantly from Rp5.82 billion (Base Case) to Rp1.10 billion, despite a higher initial investment of Rp825 million. The system also offers substantial savings in Operation and Maintenance (O&M) costs, amounting to just Rp15 million per year, compared to Rp302 million for the generator-only setup. With a much lower Levelized Cost of Energy (LCOE) at Rp987.66/kWh, the micro-hydro system is more affordable and financially viable over the long term. Additionally, strong financial metrics, including a 49% Internal Rate of Return (IRR), 44% Return on Investment (ROI), and a two-year payback period, make it a robust solution that leverages local renewable resources. It is recommended to explore supplementary renewable options, such as photovoltaic (PV) systems, to further diversify and enhance Guha Village's energy resilience.

6 References

[1] Y. I. Nakhoda and C. Saleh, "Pembangkit Listrik Tenaga Angin Sumbu Vertikal Untuk Penerangan Rumah Tangga Di Daerah Pesisir Pantai," Industri Inovatif: Jurnal Teknik Industri, vol. 7, no. 1, pp. 20-28, 2017.
[2] H. Asyari, R. A. Firmansyah, and M. Kusban, "Analisa Tingkat Potensi Sinar Matahari Untuk Pembangkit Listrik Tenaga Surya Di Daerah Pantai," in Prosiding Simposium Nasional Rekayasa Aplikasi Perancangan dan Industri, pp. 82-89, 2020.
[3] H. A. El Islamy and W. D. Aryawan, "Desain Pembangkit Listrik Tenaga Surya Apung untuk Wilayah Kepulauan Selayar, Sulawesi Selatan," Jurnal Teknik ITS, vol. 7, no. 2, pp. G161-G166, 2019.
[4] S. Suardi, W. Setiawan, and S. N. N. Pos-Pos, "Desain Ship Power Plant Sebagai Alternatif Krisis Listrik di Pulau Kagean, Jawa Timur," JST (Jurnal Sains Terapan), vol. 6, no. 2, pp. 68-73, 2020.
[5] B. Batidzirai, P. Trotter, A. Brophy, S. Stritzke, A. Moyo, P. Twesigye, A. Puranasamriddhi, and A. Madhlopa, "Towards people-private-public partnerships: An integrated community engagement model for capturing energy access needs," Energy Res. Soc. Sci., vol. 74, 2021, Art. no. 101975.
[6] A. Allouhi, Y. El Fouih, T. Kousksou, A. Jamil, Y. Zeraouli, and Y. Mourad, "Energy consumption and efficiency in buildings: current status and future trends," J. Clean. Prod., vol. 109, 2015.
[7] A. Allouhi, "Solar PV integration in commercial buildings for self-consumption based on life-cycle economic/environmental multi-objective optimization," J. Clean. Prod., vol. 122375, 2020.
[8] A. Allouhi, "Advances on solar thermal cogeneration processes based on thermoelectric devices: a review," Sol. Energy Mater. Sol. Cells, vol. 200, Art. no. 109954, 2019.
[9] R. Billinton, "Evaluation of different operating strategies in small stand-alone power systems," IEEE Trans. Energy Convers., vol. 20, pp. 654-660, 2005.
[10] S. Rehman, M. M. Alam, J. P. Meyer, and L. M. Al-Hadhrami, "Feasibility study of a wind-diesel hybrid power system for a village," Renew. Energy, vol. 38, pp. 258-268, 2012.

[11] C. Yan, Y. Zou, Z. Wu, and A. Maleki, "Effect of various design configurations and operating conditions for optimization of a wind/solar/hydrogen/fuel cell hybrid microgrid system by a bio-inspired algorithm," Int. J. Hydrogen Energy, vol. 60, pp. 378-391, 2024.

[12] B. R. Putra, J. Kariongan, J. A. P. Bay, M. Liga, and A. S. Sinaga, "Perancangan Pembangkit Listrik Tenaga Hybrid (Photovoltaic-Mikrohidro) Menuju Desa Mandiri Energi Di Kampung Dosay, Distrik Sentani Barat, Kabupaten Jayapura, Papua," Jurnal teletronic, vol. 1, no. 1, pp. 1-11, 2023.

[13] M. Y. Yunus, A. S. Lewi, A. S. Rijal, N. Huda, and A. Ikram, "Planning Study Of Hybrid Power Plant Solar Pv-Diesel Generator On Kodingare Island, Sinjai Regency," PLANNING, vol. 5, no. 2, 2023.

[14] B. Sakti, A. E. Burhandenny, R. M. Utomo, H. Nugroho, and A. P. Wirawan, "Analysis Potential of Solar and Wind as Power Plant in Bontang Kuala Using Software Homer," JEEE-U (Journal of Electrical and Electronic Engineering-UMSIDA), vol. 8, no. 1, pp. 46-59, 2024.

[15] H. El-Houari, A. Allouhi, S. Rehman, M. S. Buker, T. Kousksou, A. Jamil, and B. El Amrani, "Design, simulation, and economic optimization of an off-grid photovoltaic system for rural electrification," Energies, vol. 12, 2019. https://doi.org/10.3390/en12244735.

[16] R. Brizik and R. Brizik, “Belum Dialiri listrik, Desa Guha Aceh Singkil Desak Pemerintah Segera Atasi | Tekape.co,” TEKAPE.co, Jun. 28, 2024. [Online]. Available: https://tekape.co/belum-dialiri-listrik-desa-guha-aceh-singkil-desak-pemerintah-segera-atasi/. Accessed: Oct. 31, 2024.

[17] S. Sabran, “Pj. Bupati Aceh Singkil Kunjungi Desa Guha, Ternyata masyarakatnya belum dapat menikmati PLN.” [Online]. Available: https://setdakab.acehsingkilkab.go.id/berita/kategori/berita-aceh-singkil/pj-bupati-aceh-singkil-kunjungi-desa-guha-ternyata-masyarakatnya-belum-dapat-menikmati-pln. Accessed: Oct. 31, 2024.

[18] Habaaceh.Id, “Warga Desa Guha Aceh Singkil belum merdeka, sudah 78 tahun hidup dalam gelap,” HABA ACEH. [Online]. Available: https://www.habaaceh.id/news/warga-desa-guha-aceh-singkil-belum-merdeka-sudah-78-tahun-hidup-dalam-gelap/index.html. Accessed: Oct. 31, 2024.

[19] R. Syahputra and I. Soesanti, "Planning of Hybrid Micro-Hydro and Solar Photovoltaic Systems for Rural Areas of Central Java, Indonesia," J. Electr. Comput. Eng., vol. 2020, no. 1, Art. no. 5972342, 2020.

[20] R. Rajbongshi, D. Borgohain, and S. Mahapatra, "Optimization of PV-biomass-diesel and grid base hybrid energy systems for rural electrification by using HOMER," Energy, vol. 126, pp. 461-474, 2017.

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