Application of Micro Hydro Power to Improve Community Welfare by Utilizing Alternative Energy in Remote Areas

Heri Suripto[1], Saiful Anwar[2] , Purwo Subekti[3]

[1,2,3]*Program Studi Teknik Mesin, Fakultas Teknik Universtias Pasir Pengaraian*

A B S T R A C T

Remote areas with access to steep roads and hills present challenges for the government's establishment of power plants, but these can be overcome by utilizing alternative energy sources available in the area, such as wind, solar, and hydro energy. In this study, we will develop a research-based hydro energy source that has been tested on a micro scale at Pasir Pengaraian University laboratory. The community-based research approach is used to meet the objectives' requirements, such as survey activities, planning, analysis, and application of the agreed-upon technology. Alternative hydro energy must be developed further to improve net-zero energy systems. As a result of this activity, the community no longer complains about electrical energy; rather, they can convert alternative energy sources into hydroelectric energy as a backup. The study's results show that a wheel with a diameter of 120 cm, a width of 40 cm, and 18 pcs of blades is able to generate 850 watts of energy with a gear and chain transmission ratio. This study allows the village to become energy independent and has the potential to improve welfare through the application of appropriate technology. It is hoped that by using this technology, the village will be able to generate their own electricity through mentorship activities

Keyword: remote areas, alternative energy sources, community-based research, energy independent

**Corresponding Author:*

Heri Suripto,
Program Studi Teknik Mesin, Fakultas Teknik Universtias Pasir Pengaraian
Email: heri.suriptodotone@gmail.com

1. INTRODUCTION

Sungai Bungo is situated in the village of Sialang Jaya, which covers an area of 69.07 km2. It is located in a hilly area and has a steep road with a distance of approximately 20 km from the city of Pasir Pengaraian. The total population of the village of Silang Jaya is around 1283 people and 10% of the population comes from Sungai Bungo hamlet. Because of the challenging terrain's contours, Sungai Bungo hamlet still does not have access to the full amount of electrical energy1. Currently, the people still use diesel power to light their homes, which is very expensive to run and can emit CO2 gas that have a significant impact on global warming2,3. Renewable energy sources like water, solar, and wind energy4 are available in Sungai Bungo Hamlet but have not been utilized to produce maximum electrical energy.

According to Government Regulation No. 79 of 2014 concerning the national energy policy, the processing of energy shall be guided by the principles of equity, environmental awareness, sustainability, the development of energy independence, and national energy security5. Energy is a fundamental human necessity that supports the availability of electricity which continues to be developed. Along with economic growth; energy consumption is expected to continue to increase, it is important to consider the increasingly limited use of fossil fuels. Utilization of renewable energy sources such as hydro, solar, and wind energy is highly recommended to support energy as a substitute for fossil fuels6.

Due to their enormous potential to exponentially meet the world's energy needs, renewable energy sources will play a crucial role in the future supply of energy on a worldwide scale7,8. Over the past two decades, the use of renewable energy sources has gained popularity. Various methods for evaluating renewable energy sources have been conducted in the literature, including the evaluation of energy policies, the selection of suitable renewable energy sources for power generation, the determination of the best location for facilities, and the selection of the best energy

among the renewable energies available9. The success of renewable energy implementation is measured by a fair energy transition, open decision-making, good analysis, technical knowledge, spatial planning and social science10.

The energy crisis and a shortage of electrical energy in remote areas exacerbate poverty in developing countries; renewable energy sources can be used as an alternative to reduce the energy crisis in remote areas where it requires large costs for the expansion of the country's electricity grid11. There are several renewable energy potentials that can be developed in remote areas, one of which is river flow hydro energy12,13,14. The development of riverine hydro energy in remote areas requires appropriate policies to encourage awareness of site owners, investors, project developers, and decision makers regarding the potential benefits of river flow hydro technology15. Utilization of river flow power plants can have an impact on of the community's economic and social life. From the economic aspect, the economic level of the community will also increase; the social aspect is seen from the rise of education, information and religious facilities16,17. This service activity aims to apply micro hydro energy to improve community welfare by utilizing alternative energy in remote areas.

2. RESEARCH METHOD

2.1 Situation Analysis

Based on the results of the January 2022 survey, Sungai Bungo is one of those hamlets in Sialang Jaya that has not been served by the State Electricity Network (PLN). Sungai Bungo has only one amenity, a mosque erected independently by the local. There are currently 40 families living in Sungai Bunga, only one of which is a teaching family, while the remaining 39 families are employed in odd jobs. The development of renewable energy sources in the Sungai Bunga is quite feasible because it has three renewable energy opportunities: river water, solar energy, and wind energy. Based on economic studies, water energy and solar energy have great opportunities to be applied. The location of the Silang Jaya village is as shown in Figure 1.

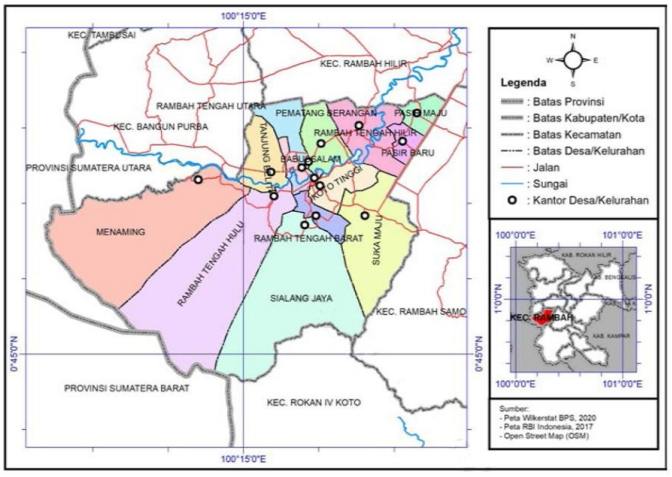

Figure 1. Location of the village of Silang Jaya, Rokan Hulu district

Sungai Bungo Hamlet has one SD building unit with three local classrooms and one teacher's room for educational purposes. Sungai Bungo Hamlet still relies on conventional kerosene lamps for lighting because the available diesel power is insufficient to meet all of the community's needs for electrical energy. For this reason, a strategy is required to address the energy crisis, including using alternative hydro energy in Sungai Bungo hamlet. By using the right technology, this community's welfare can be improved, and by using hydro energy, the river flow can later help lighting and can open up good business opportunities directly or indirectly.

Figure 2. Sungai Bungo mosque

Figure 3: Housing conditions in the local area

Figure 4. Sungai Bungo Hamlet's river flow

2.2 Solution Method

This service employs the community based research (CBR) method, which is effective in doing community-based research. Community Based Research (CBR) or Community Based Participatory Research (SBPR) is a type of research that combines community cooperation with action-oriented higher education via service learning to help social movements in the pursuit of social justice[18].

A. The basic principles of the CBR method

The key principles presented by this method are participatory, shared benefit, reciprocity, meeting community defined needs, and equity, where participatory activities include activities carried out jointly by researchers and the community, shared benefit activities are activities carried out to obtain mutual benefits, reciprocity activities are reciprocal activities, community defined needs meeting activities are activities with the aim of meeting community needs determined by the community itself, and equity activities are activities with the aim of realizing a form of mutual agreement on various matters including formulating common goals, research questions, goals end of the study, methods and mechanisms of research work, research instruments, methods and techniques of data analysis[18].

B. Function of CBR method

The main function in this method can be broken down into three categories, namely, knowledge production, knowledge mobilization and community mobilization. Knowledge mobilization activity in this scenario involves the collaboration of participants to take action and the actions included in the design will inadvertently create new knowledge. Knowledge mobilization initiatives involve distributing research findings to the general population in a creative fashion that takes into account their knowledge, education, social standing, and economic situation[18].

C. Stages of CBR method

The stages in CBR-based research activities are laying foundation, which is a negotiation activity with organizing techniques with partners to clarify their respective roles, identify issues that are developing in the community, and determine the ultimate goal of research, then research planning is an activity that considers obstacles, time, cost and analysis techniques. The next stage is information gathering and analysis, which is a data collection activity carried out by means of interviews, observation, documentation, FGD, storytelling, and community mapping, while data analysis is a process of searching and compiling data systematically. Then action on finding is an activity of mobilizing knowledge and the community towards research results and implementing them to be valuable to the community[19,20].

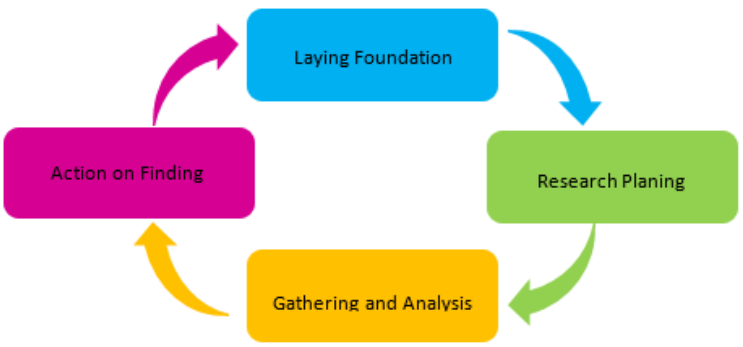

Figure 5. Stages of the CBR method in community research activities

3. RESULTS AND DISCUSSION

A. The development of river water energy potential

The development of micro hydro technology for river flows currently has significant potential for rural areas, in addition to helping to reduce climate change, offer job opportunities, and have minimal maintenance costs[21,22]. Accelerating the development of riverine hydropower plants has the potential to alleviate energy poverty in rural and distant locations[23], as well as play a role in economic progress[24]. Micro hydro power plants have the potential to be developed in locations with low water levels, such as river flows[25].

B. Laying foundation

Negotiation activities become important in organizing to examine priority factors, social interaction strategies, and outcomes[26]. Negotiation activities can be seen in table 1 below:

TABEL 1. Kegiatan negosiasi

Negotiation	Description
Problems	Improving the economic aspect through the application of hydro energy technology
Energy sources that can be utilized	River flow hydro energy
Stakeholder	The Team and community of Sungai Bungo Hamlet
The role of stakeholder	The community serves as the agent for carrying out fieldwork operations with the assistance of the service team.

Figure 6. Overview of negotiation results

C. Research Planing

The research planning strategy involves a number of elements that provide an emphasis on work planning, the outcomes of the planning, and the contribution to the success of planning[27]. Some factors that can be taken into account are planning limits, the amount of time needed for manufacturing and planning, planning costs, and planning analysis techniques. The following table 2 lists the phases of research planning.

TABEL 2. Research planing

Dimension	Criteria	Description
Constraint	Activity planning process	Constraints in material supply, delivery, and assembly.
Time	Negotiation, planning, Daata gathering and analysis, and action and finding	Communities as stakeholders, planning, data analysis and application of research results are carried out based on time according to planning and agreement
Cost	The cost of community research activities	The ability to estimate costs makes it much easier to carry out tasks[28]

Dimension	Criteria	Description
Analysis technique	Post-negotiation data analysis	The analysis technique is used to decide which community research activities to conduct.

D. Gathering and Analysis

The results of interviews and observations in this activity in the form of activity designs and application of community-based research, interview and observation activities can be seen in table 3 below

TABLE 3. Results of interviews and observations[29]

Dimension	Criteria	Description
Energy	Potential source of energy	The available energy sources for the river flow of the Sungai Bunga village reflect that it can be developed
Economy	Economic aspects include power generation costs and investment costs	Energy independent investment, operational costs, maintenance costs, equipment and technology costs
Technology	Readiness of energy conversion technology	Reliability and availability of technology, as well as the efficiency of renewable energy power plants
Social	Better economic conditions and employment prospects	Social benefits and social effects of implementing riverine hydro energy technology in rural areas
Environment	Ecosystem impact due to CO2	Utilization of renewable energy can reduce CO2 emissions, reduce the greenhouse effect, and pollution

D. Action on finding

The application of technology is carried out by mobilizing knowledge on research results. The activity starts with training on how to use and maintain technology and then moves on to the assembly of tools and equipment. Figure 7 shows the outcomes of a number of community-based research programs.

Figure 8. Assembly and implementation of community-based research activities

This community-based research activity produces an output in the form of hydro energy technology that can be used as electrical energy to support community activities and provide lighting in Sungai Bungo hamlet. Stakeholder

enthusiasm for participating is extremely strong in a series of activities from start to finish. From this activity, the benefits obtained by stakeholders are in the form of information, employment opportunities to operate pico hydro, as well as new knowledge on how to process good and sustainable alternative energy. This research project may also stimulate stakeholders' interest in processing and utilizing existing renewable energy sources for conversion into inexpensive and ecologically beneficial electrical energy.

4. CONCLUSION

The community-based research approach generates research outputs such as negotiation, planning, interviewing, and observing activities, as well as application the final agreed-upon community research results. Each level leads in a greater awareness and knowledge of the usage of alternative energy in the local hamlet for conversion into electrical energy. The stakeholders have mutually agreed on and fully handled the task division in the form of maintenance activities and operating activities. The use of technology is in the form of river flow hydro energy with a wheel diameter of 120 cm, a breadth of 40 cm, and a number of 18 blades. This hydro energy technology uses gear and chain transmission in order to avoid slipping and the amount of friction between the belt and pulleys which causes the turbine wheel to slow to turn the electric generator. The application of this technology can increase people's finances by saving expenses per day to buy fossil fuels as diesel fuel. The application of the right technology can improve the welfare of the community.

ACKNOWLEDGMENTS

We would like to express our gratitude to the Mechanical Engineering Laboratory of Pasir Pengaraian University, the Ministry of Education and Culture Grants 2021–2022, and LPPM Pasir Pengaraian University for their support and facilities in making this service activity a success.

REFERENCES

1 BPS, Rokan Hulu (2021).
2 T.R. Anderson, E. Hawkins, and P.D. Jones, Endeavour 40, 178 (2016).
3 H. Caliskan, J. Clean. Prod. 154, 125 (2017).
4 G. Perlaviciute, L. Steg, N. Contzen, S. Roeser, and N. Huijts, Sustain. 10, (2018).
5 PP. No. 79, (2014).
6 R.M. Elavarasan, Eur. J. Sustain. Dev. Res. 3, 1 (2018).
7 O. Ellabban, H. Abu-Rub, and F. Blaabjerg, Renew. Sustain. Energy Rev. 39, 748 (2014).
8 N.L. Panwar, S.C. Kaushik, and S. Kothari, Renew. Sustain. Energy Rev. 15, 1513 (2011).
9 E. Ilbahar, S. Cebi, and C. Kahraman, Energy Strateg. Rev. 25, 18 (2019).
10 C.E. Hoicka, J. Lowitzsch, M. Claire, A. Kumar, and L. Ramirez, Energy Policy 156, 112435 (2021).
11 H. Borhanazad, S. Mekhilef, R. Saidur, and G. Boroumandjazi, Renew. Energy 59, 210 (2013).
12 S. Hoseinzadeh, M.H. Ghasemi, and S. Heyns, Renew. Energy 160, 323 (2020).
13 J. Hanafi and A. Riman, Procedia CIRP 29, 444 (2015).
14 S.P. Adhau, R.M. Moharil, and P.G. Adhau, Renew. Sustain. Energy Rev. 16, 4785 (2012).
15 S. Kumara, 8 (2020).
16 A. Kumar Sharma and N.S. Thakur, Renew. Sustain. Energy Rev. 78, 233 (2017).
17 A. Susilawaty, D. Ahmad, T. Babcock, T. Babcock, and R. Janzen, Riset Berbasis Komunitas (n.d.).
18 M. Hanafi, N. Naily, N. Salahuddin, A. Kemal Riza, L.M. Fikri Zuhriyah, Rakhmawati, I. Ritonga, A. Muhid, and Dahkelan, LPPM UIN Sunan Ampel Surabaya 1 (2015).
19 K. Strand, S. Marullo, N. Cutforth, R. Stoecker, and P. Donohue, (n.d.).
20 D.K. Okot, Renew. Sustain. Energy Rev. 26, 515 (2013).
21 C.O. Ugwu, P.A. Ozor, and C. Mbohwa, Fuel Commun. 10, 100046 (2022).
22 M. Bilgili, H. Bilirgen, A. Ozbek, F. Ekinci, and T. Demirdelen, Renew. Energy 126, 755 (2018).
23 J.I. Razan, R.S. Islam, R. Hasan, S. Hasan, and F. Islam, ISRN Renew. Energy 2012, 1 (2012).
24 S.K. Singal, R.P. Saini, and C.S. Raghuvanshi, Energy Sustain. Dev. 14, 117 (2010).
25 J. Brett and L. Thompson, Organ. Behav. Hum. Decis. Process. 136, 68 (2016).
26 J.M. Bryson, L.H. Edwards, and D.M. Van Slyke, Public Manag. Rev. 20, 317 (2018).

27 X.X. Huang, L.B. Newnes, and G.C. Parry, Int. J. Comput. Integr. Manuf. 25, 417 (2012).
28 T. Li, A. Li, and X. Guo, Energy **212**, 118694 (2020).