The Utilization of Cattle Manure Biogas as a Renewable Energy Solution and a Means to Improve Community Welfare in Kuripan Village, Karangawen District, Demak

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Abstract: *Kuripan Village, located in Karangawen District, Demak, holds significant opportunities for renewable energy advancement through the optimal management of cattle waste. When left untreated, livestock waste can cause serious environmental pollution, while local households continue to depend largely on fossil-based energy sources for daily use. This community engagement project was designed to empower residents by converting cattle waste into biogas as a sustainable energy alternative. The initiative involved awareness campaigns, hands-on workshops for building biogas installations, and ongoing technical guidance in their operation and upkeep. Beyond energy generation, the project also emphasized the transformation of waste by-products into organic fertilizer and complementary livestock feed. This practice not only reduces feed costs but also improves animal nutrition, establishing a circular livestock system that supports eco-friendly farming. The outcomes revealed that villagers successfully constructed and operated biogas facilities independently. The generated biogas is used for cooking activities, while the remaining slurry and solids are applied as fertilizer and feed material. Overall, the program has reduced environmental waste and greenhouse gas emissions, decreased monthly household energy spending by IDR 60,000–90,000, and enhanced farmers' quality of life. These results affirm that combining appropriate technology with active community involvement fosters sustainable and energy-resilient rural development*

Key Words*:* Biogas; Renewable Energy; Cattle Waste; Kuripan Village; Community Service

Introduction

The Energy issues and organic waste management remain strategic challenges in many rural areas of Indonesia. Energy is a fundamental need that supports various human activities, ranging from household purposes such as cooking and lighting to small-scale economic enterprises (Elly et al., 2020). The increasing demand for energy, coupled with the depletion of fossil fuel resources, has caused both economic and environmental concerns. Therefore, the adoption of renewable energy has become essential to achieve energy independence and environmental sustainability. One promising source of renewable energy is biogas, which can be produced from cattle manure (Putra et al., 2024).

Kuripan Village, located in Karangawen District, Demak Regency, is known for its active cattle farming sector. Based on secondary data from the Department of Animal Husbandry and Animal Health of Demak Regency (2022), the population of beef cattle in Kuripan Village reached 1,275 heads, managed by 216 cattle-farming households. This number indicates a significant livestock population, producing large volumes of manure daily. An adult cow weighing approximately 450 kg generates 20–30 kg of solid waste and 100–150 liters of liquid

waste per day (Aman Yaman, 2019), Consequently, the total waste potential in Kuripan Village exceeds 25 tons of solid manure and 20,000 liters of liquid waste per day.

This analysis highlights the substantial potential of biogas energy. Assuming that 25 tons of cattle manure per day can produce around 1,250 m^3 of biogas, the resulting energy would be sufficient to meet the daily cooking needs of over 180 households. These data demonstrate that the biogas utilization program in Kuripan Village is not only technically feasible but also has strong long-term sustainability potential. Moreover, the residue from biogas processing can be converted into organic fertilizer and livestock feed materials, forming a circular and sustainable farming system. espite this considerable potential, many households in Kuripan Village remain dependent on LPG and firewood for cooking. The fluctuating price of LPG and the scarcity of firewood pose serious challenges, especially for low-income families (Rozanna Dewi, 2023). This condition indicates a gap between the existing local resources and the community's energy needs. Therefore, it is necessary to develop appropriate technology-based solutions that can address both waste management and alternative energy supply simultaneously.

Biogas technology has been proven to be effective and relevant for rural communities. Biogas is produced through the anaerobic fermentation of organic materials such as animal manure, agricultural residues, and household organic waste (Lalu Ali Wardana, 2021). Its utilization not only provides a clean energy alternative but also helps reduce greenhouse gas emissions and promotes a healthier environment (Elizabeth & Rusdiana, 2011). Within the framework of sustainable development, this technology aligns well with the principles of resource efficiency and local energy self-sufficiency (Holik et al., 2023). The energy content in biogas is highly influenced by the concentration of methane (CH_4) produced; the higher the methane percentage, the greater the energy that can be utilized from the biogas(Erfiani et al., 2023).

Despite the abundance of livestock waste, the community in Kuripan Village still relies heavily on LPG and firewood for their daily cooking needs. The fluctuating price of LPG and the increasing scarcity of firewood pose significant challenges, particularly for low-income households (Rozanna Dewi, 2023). This situation highlights a clear disparity between the available local potential and the community's energy demands. Therefore, it is crucial to develop appropriate technology-based solutions capable of addressing both problems waste management and alternative energy provision.

One technology proven to be both effective and relevant for rural community application is biogas. Biogas is a renewable gas produced through the anaerobic fermentation of organic materials such as animal manure, agricultural residues, and household organic waste (Wahyuni, 2013). The adoption of biogas technology not only provides a clean energy alternative but also helps reduce greenhouse gas emissions and supports the creation of a healthier living environment (Elizabeth & Rusdiana, 2011).). In the context of sustainable development, this technology aligns with the principles of resource efficiency and local energy independence (Holik et al., 2023).

This community service program focuses on analyzing the potential and initial implementation of biogas utilization from cattle manure as a renewable energy solution. It seeks to transform the community from energy consumers into energy producers by optimizing untapped local resources. The implementation of biogas technology is expected to enhance community awareness of waste management, provide new technical skills, and create a direct impact on household welfare. Furthermore, this program aims to establish a sustainable local economic cycle, where livestock waste is converted into biogas for

household cooking energy and the remaining by-products are processed into organic fertilizer that supports agricultural productivity.

The main objectives of this community service activity are to provide education, technical training, and ongoing assistance to the community in building and operating household-scale biogas installations based on cattle manure. In addition, the program seeks to strengthen the community's technical capacity in renewable energy management, reduce dependence on fossil fuels, and create added economic value through the utilization of biogas residues. Through this initiative, Kuripan Village is expected to serve as a model of an energy-independent, environmentally friendly rural community empowered through appropriate technology.

Method

This community service activity was implemented using a participatory and community-based approach, designed to align with the local needs of Kuripan Village in Karangawen District, Demak Regency. The participatory approach was chosen to ensure that the local community was actively involved at every stage of the program—not merely as beneficiaries, but as key partners in the planning, execution, and evaluation processes. Through this approach, the program aimed to strengthen the sense of ownership among participants and to promote sustainable community-based energy management practices.

The planning process focused on the design and development of household-scale biogas installations derived from cattle manure. This was carried out through collaborative discussions and needs assessments involving local farmers and village stakeholders. The implementation stages were structured sequentially to ensure both technical and social readiness. The process began with identifying and mapping local problems related to livestock waste and energy consumption, followed by awareness and education activities on renewable energy concepts. Afterward, technical training sessions were conducted to equip participants with the necessary skills in constructing biogas units and managing the fermentation process effectively.

Once the installations were built, the community received continuous mentoring and operational assistance to optimize the use of biogas for daily cooking and to ensure proper maintenance of the system. Regular monitoring and evaluation were also carried out to assess the program's effectiveness, identify challenges, and plan for long-term sustainability. Overall, this participatory implementation method was designed not only to establish physical biogas installations but also to build technical capacity, ecological awareness, and household-level energy independence among the villagers. The combination of education, technical practice, and community involvement created a foundation for sustainable renewable energy utilization in Kuripan Village (Karim, 2021).

Results and Discussion

The community service activity conducted in Kuripan Village, Karangawen District, Demak Regency demonstrated positive outcomes in technical, social, and environmental aspects. Overall, the program has shown a significant impact on livestock waste utilization, household energy savings, increased community awareness of renewable energy, and the creation of added value in the livestock and agricultural sectors. The active participation of the local community at every stage of implementation played a crucial role in the program's success. The following section describes the results of each activity stage in more detail.

3.1 Identification and Problem Mapping

The initial stage of the activity began with field observations and coordination with village officials and local cattle farmer groups in Kuripan Village. This coordination included defining roles and responsibilities, setting implementation schedules, preparing materials and tools, and providing technical assistance to ensure the sustainability of the program.

The results of the identification process revealed that cattle manure in the village had not been properly managed and was mostly disposed of directly into the surrounding environment. This practice led to pollution, unpleasant odors, and potential health problems. On the other hand, the community still relied heavily on LPG and firewood for cooking, with an average household expenditure of IDR 120,000–150,000 per month.

These findings indicate a clear need for innovation in livestock waste management, particularly through the development of biogas as an alternative energy source that utilizes local potential and reduces both environmental impact and energy costs.

Figure 1. Training Activity for Making Educational Media Technology from Cow Dung Using Virtual Reality

3.2 Socialization and Renewable Energy Education

Following the identification stage, socialization and educational activities were conducted involving 30 participants, consisting of local cattle farmers, housewives, and village youth. The socialization focused on introducing the concept of renewable energy, the biogas formation process, its economic and environmental benefits, and simple examples of household-scale biogas installation practices. The educational sessions were delivered through visual presentations, educational video screenings, and open discussions to facilitate two-way learning and community engagement. The initial evaluation results showed that 92% of participants stated that it was their first time learning that cattle manure could be converted into gas usable for cooking. Participants demonstrated a high level of enthusiasm, with several expressing immediate interest and willingness to begin constructing biogas systems for household use

Figure 2. Socialization and Educational Activities

3.3 Technical Training on Biogas Installation Construction

The next stage was the technical training for the community, which was conducted directly at the site where the biogas systems were to be built. The training was implemented through hands-on practice sessions over five consecutive days. Participants learned various aspects of biogas installation, including selecting suitable locations for the digester, mixing manure and water, connecting gas pipes, and assembling biogas stoves. As a result of the training, three biogas units were successfully constructed, each with a digester capacity of 6 m^3, and are currently being utilized by three local farming families. Most of the construction materials used were locally sourced, such as plastic drums, PVC pipes, and cement, which helped reduce the cost to approximately IDR 2.5–3 million per unit. Participants demonstrated strong practical skills and a clear understanding of the basic principles of biogas systems, indicating the effectiveness of the training in building local technical capacity.

Figure 3. Biogas Production

3.4 Operational Assistance and Utilization of Biogas

After the installation was completed and the fermentation process had taken place for approximately two to three weeks, the community service team provided intensive mentoring to ensure proper operation and maintenance of the biogas systems. All three partner households successfully operated their biogas stoves independently and reported that the gas produced was stable enough to be used for cooking two to three times per day.

In addition, the households began to experience noticeable cost savings on their monthly energy expenses, as summarized in Table 1.

Table 1. Household Energy Savings After Biogas Utilization

No.	Partner Name	LPG Consumption Before (3 kg cylinders/week)	LPG Consumption After (3 kg cylinders/week)	Biogas Production (m^3/day)	Estimated Monthly Savings (IDR)
1	Warno	2	0,5	2,2	90.000
2	Sulastri	2	0,7	2,0	84.000
3	Minto	1,5	0,5	1,8	60.000

3.5 Monitoring and Evaluate.

After the installation was completed and the fermentation process had taken place for approximately two to three weeks, the community service team provided intensive mentoring to ensure proper operation and maintenance of the biogas systems. All three partner households successfully operated their biogas stoves independently and reported that the gas produced was stable enough to be used for cooking two to three times per day.

In addition, the households began to experience noticeable cost savings on their monthly energy expenses, as summarized in Table 1. Household Energy Savings After Biogas Utilization.

Monitoring activities were conducted through field visits, interviews, and evaluation questionnaires over a one-month period after the biogas installations became operational. The monitoring results showed that all units functioned properly, and the participants were able to carry out daily maintenance independently, including stirring the manure mixture, cleaning the inlet and outlet, and maintaining gas pressure stability. In addition to economic benefits, residents reported an improvement in environmental sanitation, as they no longer disposed of livestock manure in open areas. The community's perception evaluation revealed a high level of satisfaction with the program, as presented in Table 2.

Table 2. The Community's Perception Evaluation Revealed a High Level of Satisfaction With the Program

Assessed Aspects	Average Score (Scale 1–5)
Ease of using the biogas stove	4,6
Effectiveness in reducing LPG consumption	4,8
Benefits of slurry as organic fertilizer	4,4
Improvement in renewable energy knowledge	4,7
Overall satisfaction with the program	4,9

Overall, all stages of the activity proceeded smoothly and achieved the intended objectives. The success of this program was not only reflected in the technical performance and energy cost savings, but also in the behavioral and attitudinal changes among the residents regarding waste management and renewable energy awareness. This community service initiative demonstrated that biogas utilization can serve as a practical, low-cost, and impactful renewable energy solution that directly enhances community welfare and can be replicated to develop other sustainable, energy-independent villages.

The results indicated that the conversion of cattle manure into biogas is not only technically feasible but also provides significant economic, environmental, and social benefits for the Kuripan Village community. These findings are consistent with Fauziah & Hidayatullah

(2023), who stated that biogas technology represents an environmentally friendly and cost-effective energy alternative, particularly for rural communities engaged in livestock farming.

During the problem identification stage, the discovery of suboptimal waste management practices served as a strong indicator of the need for appropriate technological intervention. Cattle manure, which was previously regarded as a pollutant and environmental burden, has now been transformed into a valuable energy resource. This transformation reflects a paradigm shift within the community, where waste is no longer perceived as useless material but as a resource with economic potential. This finding aligns with the circular economy theory proposed by Geissdoerfer et al. (2017), which emphasizes the importance of converting waste into added value to create a sustainable and regenerative system.

The implementation of technical training and the construction of biogas installations provided concrete evidence that local communities are capable of adopting simple technologies when provided with intensive and context-appropriate guidance. As explained by Rumbayan et al. (2020), the success of alternative technology implementation largely depends on the participatory approach and the active involvement of the community as subjects rather than mere objects of development.

Quantitative data indicated a significant reduction in LPG consumption, with an average decrease of 1.2 cylinders per week per household. When converted into monetary value, each participating family was able to save approximately IDR 60,000–90,000 per month. This result reinforces the findings of Meidiana et al. (2020), who reported that the use of household-scale biogas can reduce energy expenditures by 40–60%.

From a social perspective, satisfaction surveys showed consistently high scores across almost all indicators, indicating that biogas technology was positively received by the community. This acceptance factor is crucial for ensuring program sustainability, as emphasized by Kartiwi and Abdullah (2016), who stated that the success of technology adoption is strongly influenced by public perceptions of its benefits, ease of use, and social value.

4 Conclusion

The community service program conducted in Kuripan Village, Karangawen District, Demak Regency, successfully demonstrated that the utilization of cattle manure for biogas production is a strategic solution for achieving environmentally friendly and sustainable energy-independent villages. Through five structured stages problem identification, socialization, technical training, operational assistance, and monitoring and evaluation the program not only improved the community's literacy on renewable energy, but also effectively reduced dependence on LPG and minimized environmental pollution caused by livestock waste.

The community showed high enthusiasm and strong adoption levels toward biogas technology, while its economic impact was reflected in tangible household energy savings. For the sustainability and expansion of this program's impact, it is recommended that the village government, together with local farmer groups, establish a village renewable energy management unit responsible for managing, maintaining, and developing biogas installations collectively. In addition, further training is encouraged on the diversification of biogas utilization, such as for lighting, livestock product processing, and organic compost production. The active involvement of higher education institutions and the private sector should also be continuously strengthened through partnership schemes to support technology transfer and ongoing technical assistance for sustainable rural energy development.

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