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Utilization of Fixed Dome Reactor for Biogas Production from Cow Manure: Supporting Green Economy in Labuan Ratu Satu Village

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ABSTRACT

One of the strategic steps in promoting a green economy is converting organic waste, particularly cow manure, into renewable energy in the form of biogas. The cow manure processing system utilizes a fixed dome technology. This fixed-dome features a dome-shaped construction of brick and concrete below the ground surface. Labuan Ratu Satu Village was selected as the site for implementing fixed dome reactor technology to convert cow manure into biogas. This activity aims to facilitate sustainable waste management and offer an eco-friendly alternative energy source. The method comprises an initial site survey, community engagement regarding the biogas concept, technical training, and the installation and operation of the reactor. The fixed dome reactor has been effectively installed and is operational, generating biogas for the local community's use. These accomplishments are anticipated to promote establishing a sustainable green economy at the village level, concurrently enhancing the community's quality of life through using renewable energy. This initiative is anticipated to serve as a paradigm for organic waste management in other regions.

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INTRODUCTION

Global per capita consumption of animal products has doubled in the last 40 years, driving the growth of the livestock sector, especially in developing countries (Wang et al., 2016). As a result, the amount of livestock waste and manure generated is enormous, leading to environmental concerns. Inadequate disposal of livestock manure results in several environmental problems, such as greenhouse gas (GHG) emissions that accelerate climate change, acidification, particulate matter formation caused by NH_3 and NOx, and soil eutrophication (Tasnim et al., 2020). This problem is also experienced by the Labuhan Ratu Satu village community.

Labuhan Ratu Satu Village, Way Jepara district, East Lampung Regency is ±68.4 km from the Sumatra Institute of Technology (ITERA). It has a total population of 7,759 people and a population density of 1,380 people/km^2. Labuhan Ratu Satu Village has the highest population density in the Way Jepara Sub-district and has an area of 555.55 km^2. Area of 555.55 km^2 with an altitude of 22 m above sea level. According to data from BPS South Lampung (2020), the profession of the people of Way Jepara Satu Village is dominated by farmers. Based on observation in the field, as shown in Figure 1, the cattle farming business is still on a family scale or as a side business.

(a) (b) (c)

FIGURE 1. (a) Condition of the cowshed, (b) Cow manure, (c) Fertilizer from cow manure

The study of cow manure is attracting increasing attention, and several attempts have been made to utilize its potential in the fields of energy production and pharmaceutical products (Kumar Gupta et al., 2019). Characteristics of cow manure are shown in Table 1; cow manure has been widely utilized in agriculture as a biofertilizer, biopesticide, and pest repellent and can also be used as an energy source (Kumar Gupta et al., 2019). Labuhan Ratu Satu Village utilizes cow manure using the vermicompost process. The vermicomposting technique uses earthworms mixed with cow manure to recycle nutrients and then use them in agricultural fields for crop production (Joseph et al., 2020). Biogas technology is considered one of the best technologies to treat waste to recycle organic waste while simultaneously generating energy (Gebregiorgis et al., 2023). The utilization of cow manure waste for biogas production is the scheme (Figure 3) that will be implemented by the proponent, hoping to provide significant economic, environmental, and social impacts. significant economic, environmental, and social effects. Biogas production has high benefits compared to other renewable energy sources (Banerjee et al., 2016; Bond & Templeton, 2011; Holm-nielsen et al., 2009; Rahman et al., 2021).

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TABLE 1. Characteristics of cow manure

Parameter	Value
pH	6 ±0.2
sCOD (mg.L^{-1})	931 ±760
COD (mg.L^{-1})	25.025 ±1025
VSS (mg.L^{-1})	15.680 ±320

Midst the need for energy, which is an aspect of vital needs and is the main requirement for the community, such as cooking. the community daily, such as cooking, the Labuhan Ratu Satu Village Community does not yet have the knowledge and information about using cow manure in biogas. knowledge and information about the utilization of cow manure in biogas. Community service team The ITERA community service team received information during their visit that this area also often experiences problems with gas distribution. Several parties, including the village head, sub-district Government, and the community in Labuhan Ratu Village, had previously conducted observation, review, and planning and showed a desire to make the village an example of community strengthening, development, and empowerment in strengthening, developing and empowering energy independent communities. During the visit of the ITERA Chemical Engineering service team in January 2024, it can be seen that the condition of the cowshed and land facilities is adequate and fully supported by the Government and the local community.

METHOD

This activity is divided into five stages: socialization, biodigester installation, mentoring, evaluation, and program sustainability. The socialization phase employs the deliberation method, inviting cattle farmers to comprehend the management of cattle farm waste and its potential conversion into biogas. The fermentation process and the resultant methane gas are illustrated at this stage through simulation and demonstration activities. After the activity, the community has a comprehensive understanding of the utility of biogas, the process of biogas formation, and the advantages of cow manure. Furthermore, this initial socialization is intended to cultivate community enthusiasm for constructing biodigesters and producing biogas for daily use. This phase is also accompanied by examining the technology utilized in field conditions.

The subsequent phase is the biogas installation phase. The team selected ten individuals from the Labuhan Ratu Satu Village community who owned livestock to receive training in the production of digesters at this stage. The design and installation of the digester were completed by a group of residents who have undergone training. After the fermentation process is complete, the community is invited to observe the ready-to-use energy that has been produced. However, it is essential to note that the biogas produced is low-risk. Biogas is relatively safe, as it does not explode like LPG gas.

The third phase is mentorship. During this phase, mentoring is implemented for two months to evaluate the effect of biogas utilization on daily life. Furthermore, the community receives support for maintenance and repair when issues arise in using the produced biogas. The utilization of bio-slurry by-products has been initiated at this stage, and they can be marketed as organic fertilizer. The proceeds from the sale of bio-slurry may fund the reactor maintenance process. Safety training and standard operating procedures for fixed-dome reactors were also implemented to enhance public awareness of safety.

During the evaluation phase, the advantages of the implemented technology were assessed, including the primary product, biogas, which reduces the community's reliance on LPG; the examination of environmental concerns arising from the improper management of cow dung waste; and the advantages of bio-slurry products in promoting self-sufficient fertilizer communities. The result of this evaluation phase is a sustainable practice model highlighting the benefits of biogas and the lifestyle modifications that can be achieved. The program's continuation necessitated the development of a bio-slurry processing system to

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convert by-products into a product that could be marketed as organic fertilizer. This would alleviate the financial constraints on reactor repair operations and provide the community with additional income.

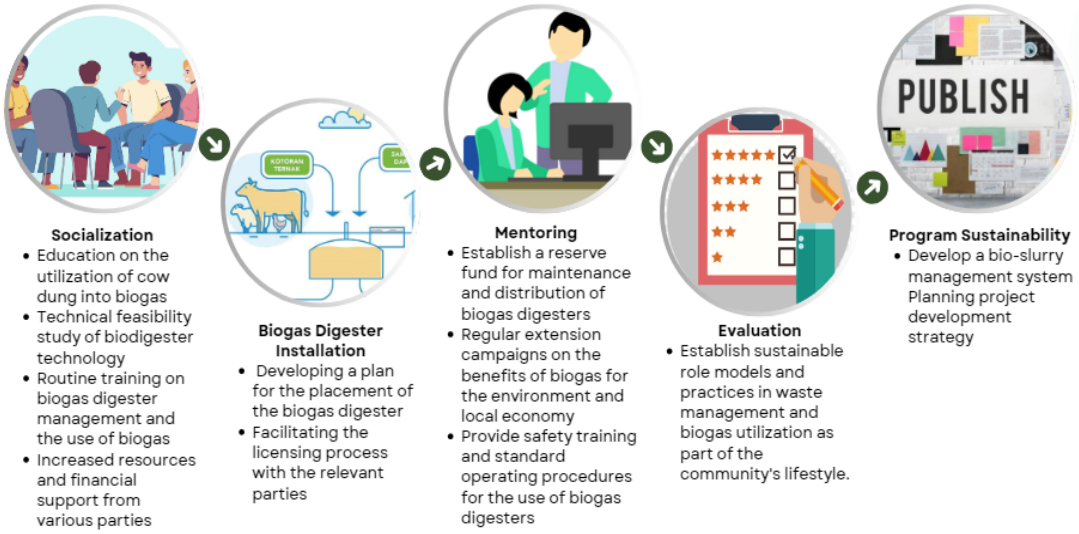

FIGURE 2. The implementation stage of community service

RESULTS AND DISCUSSION

Following the collection of suggestions for problem-solving ineffective and inefficient cow dung management, the ITERA team visited Labuan Ratu Satu, the village, to finalize the activity plan. During the visit, they reviewed the area and discussed the availability of land and cow manure as raw materials for the community service project. The crew also engaged in garbage sorting and discussed the possibility of using cow dung as a source of biogas with the local community and SDN 2 Labuan Ratu Satu students to lessen reliance on LPG. Both community comfort and thoughtful land selection were taken into account during the location review process for the construction of the biogas reactor. Furthermore, the process of using cow manure to create biogas and organic fertilizer was discussed through socialization with cattle farm owners, and a collaboration with the Rumah Energi Foundation was started.

FIGURE 3. (a) Visit Stages Before Reactor Construction Project, (b) Socialization of SDN 2 Labuan Ratu Satu, (c) Socialization to Cow Shed Owners, (d) Digging a Hole for the Reactor, (e) Reactor Installation Process, (f) Community and Team Participation in Reactor Construction

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The fixed dome technology for anaerobic digesters processes cow manure into energy and organic fertilizer through synergistic devices, as shown in Figure 3. The process begins by introducing cow manure into a mixing tank to ensure consistency before it is channeled into the main reactor, where anaerobic microorganisms break down the organic material and produce biogas. The biogas trapped in the reactor dome is then channeled into households as an alternative energy source for daily needs, reducing dependence on fossil fuels and greenhouse gas emissions. Additionally, the bio-slurry produced from this process can be used as organic fertilizer to enhance soil fertility and support sustainable agriculture. With this technology, cow manure waste can be efficiently processed, providing significant benefits for communities and the environment, with specifications and sizes of the equipment designed in detail in Figure 4.

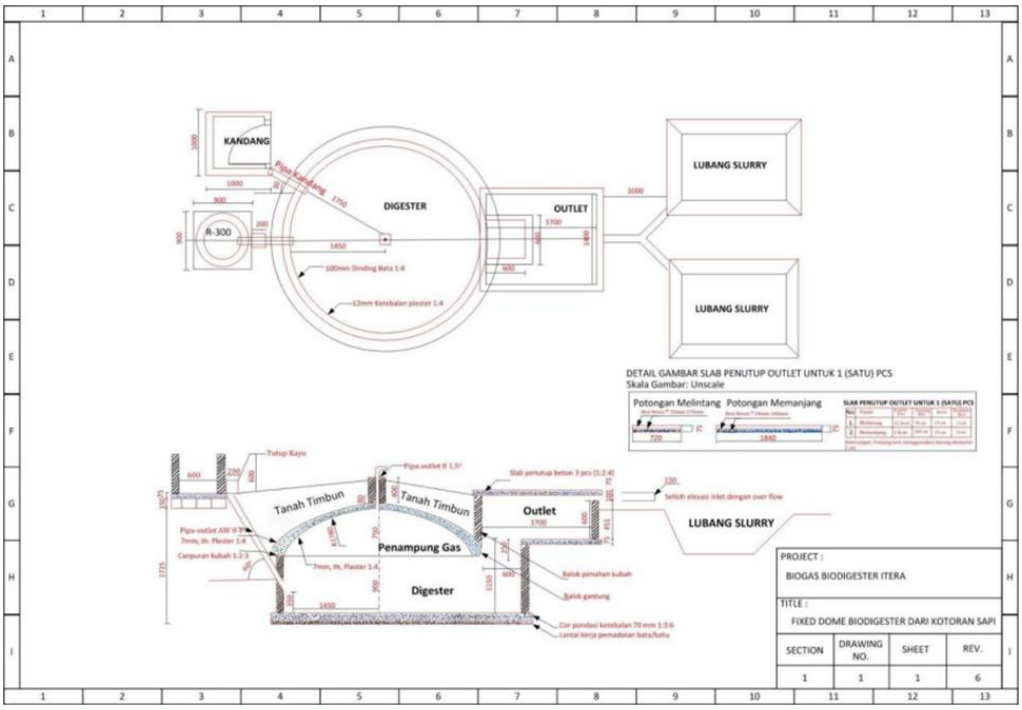

FIGURE 4. Fixed Dome Biodigester Design

The local population actively participates in its creation by receiving specialized training on how to use and maintain the biogas reactor. The first step involves adding cow dung to the reactor, and it takes roughly four days for biogas to be produced.

FIGURE 5. Biogas Reactor Manufacturing Process

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Assistance is provided to overcome community fears regarding the potential for explosions, although biogas from cow dung is not as flammable as petroleum gas. The flame from this biogas is blue and can be used for household needs. The community service team aims to help the community utilize fixed dome technology independently. By putting in cow dung regularly, biogas production will be sustainable, and the resulting bio-slurry can be used as organic fertilizer by the community, which is also made up of farmers. It is hoped that this technology can reduce the community's dependence on fossil energy sources and overcome the problem of energy scarcity and environmental management more effectively.

FIGURE 6. Flames from Cow Manure Biogas

After applying a fixed dome reactor for processing cow dung into biogas at a resident's house, the ITERA Team provided socialization to the community at the Labuan Ratu Satu village hall office on October 2, 2024. The community attended this activity, namely representatives from village officials and residents totaling 61 people.

FIGURE 7. Socialization to the Labuan Ratu Satu village community

Before the socialization activity related to processing cow dung into biogas was carried out, the community was given questions in the form of a questionnaire or preliminary test (pre-test) to determine the residents' understanding of processing cow dung into biogas. In the test design analysis, according to Peter L. Bonate (2000:1) in (Mawaddah, 2023) (Mawaddah et al., 2023) explains that the pretest-posttest design falls under the broad category of paired data analysis. Paired data arises when the same experimental unit, such as a person or laboratory animal, is measured on some variables on two different occasions or under different testing conditions.

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This community service uses a quasi-experimental design with one group pre and post-test design with an active and participatory learning method. This method is carried out using a pre-test and post-test as a measure of the level of knowledge of respondents and the activeness and participation of respondents during the community service. The characteristics of respondents are not differentiated or specified based on education level, organization, incentives, or employment status but rather respondents who are selected generally (Hamzah & Rafsanjani, 2022). The implementation of the pre-test and post-test is carried out by filling out a questionnaire. The implementation is carried out before and after socialization or provision of materials to the community. The results of the percentage recapitulation of the pre-test and post-test questionnaires for each question can be seen in Figure 8 and Figure 9.

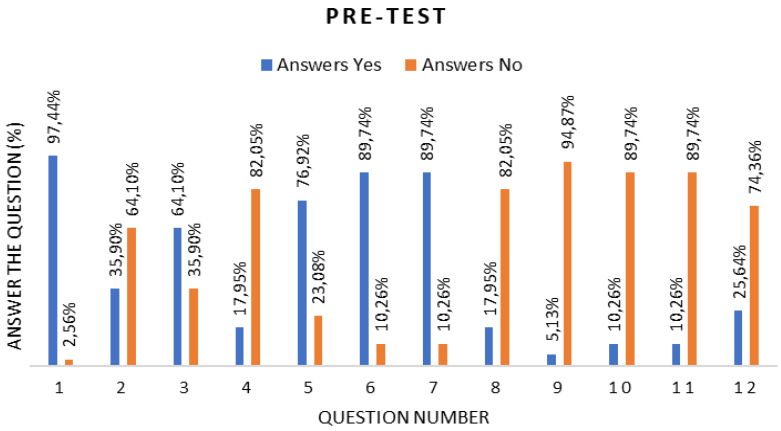

FIGURE 8. Percentage of pre-test results per question number

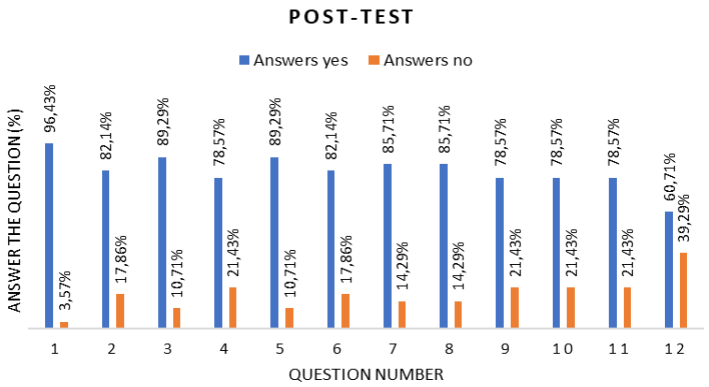

FIGURE 9. Percentage of post-test results per question number

Based on Figures 8 and 9. The results of the pre-test and post-test conducted on residents of Labuan Ratu Satu Village show that there was an increase in the knowledge obtained by residents after the delivery of material by the ITERA Team. This can be seen from the increase in the percentage of correct answers from residents. The use of pre-test and post-test methods can be an indicator of the success of extension activities as seen from the knowledge figures in each respondent group which have increased (Damayanti et al., 2017).

CONCLUSION

Community service activities that focus on the application of fixed dome reactors for processing cow dung into biogas in Labuan Ratu Satu Village have shown positive results. With 60% of the implementation achieved, one fixed dome reactor package has been successfully installed at the partner's house. This

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initiative not only has the potential to reduce cow dung waste but also provides a renewable energy source that supports implementing a green economy in the area. Publication of news in national media indicates wider attention to this activity, which can inspire other villages to implement similar technology.

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