Biogas power plant in kalipucang hamlet, bangunjiwo village, kasihan district, bantul regency

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ABSTRACT

Kalipucang hamlet is in *Bangunjiwo* Village and is home to 53 farmers from the "Andini Makmur" livestock farming group. The majority of the population works as cattle breeders, while others are farmers. The livestock farming group "Andhini Makmur" manages 80 cows in this village. The dung has only been dumped in the cage for a few months. Later, animal manure collectors buy it for a low price, if not for free. The lengthy sitting of the dung causes environmental pollution in the community, including air pollution and an unpleasant odor, and it can cause disease. The use of dung waste was a viable option for the prosperous farmer group. The conversion of livestock waste into electrical energy via a biogas process was a positive solution to livestock waste, which had been a major problem for the livestock community. The outcomes of the community service program carried out raised awareness among the "Andini Makmur" livestock group in particular, and the *Kalipucang* hamlet community in general, that livestock waste could be managed independently and produced electricity useful for lighting cages and moving water pumps at the livestock rearing site.

KEYWORDS
Renewable Energy;
Biogas;
Electricity;
Livestock Waste

1. Introduction

Kalipucang Hamlet is located in *Bangunjiwo* Village. It comprises 5 neighborhood association *Rukun Tetangga* (RT) with a total of 436 households and 53 farmers who are members of the "Andini Makmur", a livestock farming group. Most of the residents work as cattle breeders, as the other 18 Hamlets in the village. The livestock group "Andhini Makmur" manages 80 cows. This statistic is increased by 20 cows kept in individual cages owned by residents. The total number of cows in the *Kalipucang* hamlet is about 100. However, no effort has been made by the community to process cow waste of feces and urine because residents usually sell it directly to collectors, even though the waste produces biogas, which can then be converted into electricity, producing more value as an alternative energy source for residents.

Several previous studies can assist in resolving this issue. Wardle [1] investigated resource-seasonal variability as an unexplored adversary of biogas use in rural Ethiopia. Dabiri [2] looked into the effect of biogas bubbles in a mixing anaerobic digester. Life cycle assessment of household biogas production in Egypt: The effects of digester volume, biogas leakage, and digester vaporization as a biofertilizer were investigated by Ioannou-Ttofa [3]. Biogas policy dimensions and characteristics: Gustafsson's research into the European policy landscape [4]. Burg [5], applying an agent-based modeling approach, investigated farmers' willingness to adopt private and collective biogas facilities. Dittmer [6] forecasted power demand for demand-based energy production with biogas plants. A pilot-scale study of a granule-based anaerobic reactor for biogas recovery from municipal wastewater under sub-mesophilic conditions was conducted by Owusu-Agyeman [7]. Yuan [8] investigated the biogas feedstock potential and associated water footprint of residues in China and the European Union. Calbry-Muzyka [9] reviewed sampling and online and offline measurements of organic silicon compounds in a 175 kWe SOFC plant powered by industrial biogas. Carranza-Abaid [10] analyzed and made a selection of the best solvent-based technology for biogas enhancement.

From a circular and life-cycle perspective, biogas separates organic waste at its source was the investigation conducted by Ncube [11], a case study in Ontario, Canada. Chrispim [12] investigated biogas recovery for sustainable cities: a critical review of upgrading techniques and key local conditions for implementation. Kasinath [13] investigated the pretreatment and co-digestion of biomass in biogas production. The diffusion of biogas is also beneficial for freight transport, as studied by Björner Brauer in Sweden [14]. Bakkaloglu [15] investigated the quantification of methane emissions from UK biogas plants. The selection of a biogas-based polygeneration plant utilizing dairy farm waste: Villarroel-Case Schneider's study of Bolivia [16] Bakraoui [17] investigated optimal and mesophilic conditions for biogas production from recycled paper mill wastewater using the UASB digester. Sztancs [18] investigated the co-hydrothermal gasification of Chlorella Vulgaris and hydrochar and the effect of waste-to-solid biofuel production and mixing concentration on biogas generation. Biochemical methane potential trials from terrestrial weeds: The evolution of single digestion and co-digestion in biogas production was investigated by Saha [19]. Racho [20] analyzed increased biogas production from modified tapioca starch wastewater.

A comparative study of industrial-scale solid biogas production from food waste was conducted by Westerholm [21], focusing on process operations and microbiology. O'Shea [22] studied the use of biogas to reduce natural gas consumption and greenhouse gas emissions in large refineries. Artificial neural networks for predicting biogas production from chemically treated agricultural waste are studied by Almomani [23]. Active social media presence? Rantala [24] answered strategic niche management and Finland's Facebook debate on biogas and heat pumps biogas reformation model using a Ni-Rh/MgAl2O4 catalyst. Yin [25] investigated the effect of gas impurities. Nilsson [26] probed regional variations in the climate impacts of grass-based biogas production. Sritrakul investigated the economic value and satisfaction of replacing LPG in households with biogas grids in Bo Rae District, Chai Nat Province, Thailand [27]. Other research is the efficiency of a 50 kWe SOFC system using biogas from wastewater by Langnickel [28], Bali's lessons for small-scale biogas development in Indonesia by Silaen [29], and a by-product of fish oil refining as a potential substrate for biogas production in Norway Sarker [30].

Sonochemistry is a branch of ultrasonics. Lamb [31] investigated the effect of power ultrasound and Fenton's reagent on the biomethane potential of steam-exploding birch wood. Lai [32] created a financial model for lithium-ion storage in photovoltaic energy systems and biogas. Research on slurry was conducted by Donat [33] and Chen, who studied slurry subjected to anaerobic digestion in a biogas plant and a heat exchanger to improve slurry heat transfer in a biogas plant, respectively [34]. The factors affecting household decisions about adopting and utilizing biogas technology in South Africa were investigated by Uhunamure [35]. Mockaitis [36] investigated biogas production and metagenomic data from anaerobic acidogenic digestion for hydrogen production, using xylose as a substrate. Jeanmonod [37] set up a trade-off design of a power-to-methane system using a solid oxide electrolyzer and its application to biogas enhancement. Applying surface-modified clay (cantarito) microbial fuel cell, Kamaraj [38] examined the electricity generator from Nopal biogas waste. De Oliveira [39] investigated the contextual structure and interaction dynamics of the biogas. Saengprajak [40] applied the biogas solid oxide fuel cell system directly to a biogas plant in Thailand.

Biogas production has an impact on the environment. Hijazi [41] deeply learned the environmental impact of flexible power generation in biogas production. By modeling and simulation studies, Saxena [42] investigated batch anaerobic digestion of hydrodynamically cavitated tannery effluent for higher biogas yield. Rodero [43] validated photosynthetic biogas enhancement technology in a semi-industrial-scale bacterial-algal photobioreactor. Saadabadi [44] investigated the potential and constraints of biogas-fueled solid oxide fuel cells. Using the GA and ACO input feature selection methods for the ANN model, Beltramo [45] predicted biogas production. Abdel Daiem [46] studied the potential energy of the remaining biomass of rice straw and sewage sludge in Egypt. An innovative business model, Liberti's i-REXFO LIFE, was launched to reduce food waste [47]. Scarlat [48], [49] researched the developments and prospects of biogas and conducted a spatial analysis of biogas potential from manure in Europe. Dorella [50] designed a biogas installation that fed Cladophora sp. algae and wheat straw.

Silkworm waste has the potential to be converted into biogas, as research carried out by Ochyska [51]. Biogas development has not progressed well in some countries, in line with Mittal's [52] study on the barriers to biogas deployment in India. Manyuchi [53] investigated the anaerobic treatment of opaque beer wastewater with enhanced biogas recovery via bio Acti-zyme augmentation. Attention must be paid to the quality of biogas. Hence, Marn [54] explored the seasonal variation of biogas quality improvement, coupled with digestate treatment in an outdoor pilot-scale algal bacteria photobioreactor. Dahunsi [55] investigated the anaerobic conversion of Chromolaena odorata (Siam weed) into biogas. Di Marcoberardino [56] investigated the potential of biogas membrane reformers for decentralized hydrogen production. Biogas can be used as vehicle fuel, as has been researched by Haider [57] on vehicle fuel from biogas. Tian [58] examined the use of concentrated PV in biogas enhancement. The effect of copper supplementation on biogas production, co-digestion of food waste, and domestic wastewater was investigated by Chan [59]. Studying a biogas-powered generator, Solarte-Toro [60] used lignocellulosic biomass as feedstock for biogas and syngas as heat and power generation energy vectors.

Currently there is no effort from the community to process cow waste so that it can be used as useful goods. Whereas the average amount of cow dung produced by the “Andhini Makmur” livestock group every day is more than five quintals. The amount is not small, therefore it would be in vain if it is not managed properly because it can disturb the comfort of the surrounding environment. The output target is a biogas to electricity conversion tool made to drive a generator using biogas fuel. The output targets are daily records: biogas production capacity of cow dung produced (kg), residents’ schedules to fill degesting (biogas bins) processed to turn on water pumps or lights and cook in cattle rearing areas.

2. Method

Fig. 1 outlines the five stages of community partnership program activities that will be carried out. The first activity depicted in the figure is the submission of materials for the production of cow dung biogas for power plants. The second activity is a survey of biogas-producing cow dung processing plants. The third activity is collecting livestock manure. The fourth activity is to install and launch biogas equipment, and the final activity is to monitor and evaluate.

2.1. Submission of Materials for Making Cow Manure biogas for Power Generation

The community service members provided training materials to the community. The presented material was about using cow dung as biogas in biogas power plants to generate alternative fuels. It was the fuel that power generators for producing organic fertilizers. Participants in this activity would learn how to convert cow dung into biogas.

2.2. Locations for processing cow dung into biogas

Manufacturing Processing of cow dung into biogas was carried out in collaboration with the community. This processing site was made to facilitate and process the processing of raw materials or dungt during the biogas processing.

2.3. Animal manure collection

Animal manure collection is the process of collecting and managing the excrement produced by livestock, such as cows. In the case of the livestock farming group "Andhini Makmur," they manage 80 cows in a village and for a few months, the dung is dumped in the cage. Later, animal manure collectors buy it for a low price or even for free. This is a common practice in many areas where livestock is raised, as the manure can be used as a valuable resource for fertilizer and other agricultural purposes.

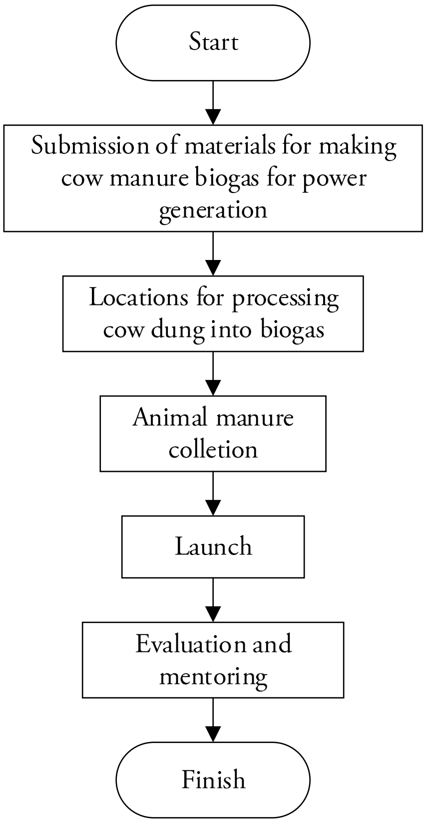

Fig. 1. Activity implementation method

2.4. Launch

The program's launch is a series of activities that serve to inform the public and local governments about the program for processing cattle and livestock waste into biogas as a fuel for power plants (generators) as an alternative fuel.

2.5. Evaluation and mentoring

The evaluation was carried out to determine how effectively this program was running and how much benefit the community had gained from its existence. The breeder community was provided with assistance so that this program could continue after it was completed.

3. Results and Discussion

3.1. Socialization

Before the entire series of community service activities through the community partnership program begins, socialization about this program is required, as shown in Fig. 2. The figure shows that the socialization is attended by the head of the neighborhood association *Rukun Tetangga* (RT), the head of neighborhood association *Rukun Warga* (RW), and the local village headman, as well as the community, to ensure that the community understands the program and that there are no misunderstandings in the program's future implementation. Furthermore, socialization aimed to dig deeper into the community's problems and give the solutions required. It was hoped that by doing so, this community service program would result according to the wishes and needs of the participants.

Fig. 2. Introduction of the team to the *kalipucang* residents

3.2. Methods of processing biogas into electrical energy

Biogas fuel can be used to replace conventional fuel in gasoline engines. The biogas generator has been modified, as illustrated in Fig. 3. However, modifications such as ignition timing, compression ratio, and carburizing system are required to achieve the best results. In addition, a biogas purification mechanism is also required to remove impurities to increase the methane gas concentration. As a result, the carburetor must be modified because it is designed for atomized liquid gasoline under standard conditions. Meanwhile, biogas is a gas that can mix with air without being carbureted like gasoline. Furthermore, before entering the intake manifold, biogas already has pressure from the reactor, which is taken into account when determining the size of the biogas inlet.

The biogas produced is not entirely combustible. It frequently only achieves 40%–60% of the methane content. Methane is the burnable gas in biogas. Biogas contains 55-75% methane (CH4), 25-45% carbon dioxide (CO2), 0-0.3% nitrogen (N2), 1-5% hydrogen (H2), 0-3% hydrogen sulfide (H2S), 0.1-0.5% oxygen (O2), and water vapor (H2O). As a result, simple purification is required to ensure that biogas-powered machines run smoothly. The most basic purification system is to capture water vapor (H2O) and hydrogen sulfide (H2S), which can cause engine damage and rust. We create simple tools for that purpose.

Fig. 3. Design of a biogas power plant

3.3. Processing and Testing

The community service team attempted to reactivate the reactor at the site of the first digester in Kalipucang hamlet, *Bangunjiwo* village, Kasihan district, Bantul. Water filling was done to check for leaks.

Fig. 4 shows that a community service team member discovers the leak, cuts the leaking hose, and installs a valve and a stop valve to control the flow rate of biogas. The difference in water level due to gas pressure will indicate the pressure and amount of biogas contained in the digester.

Fig. 4. Biogas checking process

3.4. The performance of the generator set using biogas fuel

The researchers first measured the amount and pressure of biogas in the digester before testing the generator set at the first site. A 9 cm diameter PVC tube with a length of 92 cm is used to measure digester volume (Volume: 5.84982 liters). The PVC tube is closed on both ends and has a compressor tap on each end. The tube is filled with water to prevent outside air from entering. Pressurized biogas is fed into the tube via a hose while the water movement in the manometer is monitored.

Fig. 5 depicts the experiment of 5, 5.84982 liters of biogas that reduces the pressure on the water manometer by up to 1 cmH2O. The maximum volume of biogas in the digester is approximately 444.58632 liters, with a maximum digester pressure of 76 cmH2O. The accuracy of the digester volume calculation using this method is 93% because pressurized biogas is compressed, reducing the accuracy of the measure.

Fig. 5. Biogas checking process

4. Conclusion

The biogas power plant has been successfully designed and built, and the electricity generated can be used to support household needs. This plant is suitable for use in places difficult to reach by the State

Electricity Company and fuel distributors. The quality of biogas is strongly influenced by many factors, as shown by the results of testing at the first site in *Bangunjiwo* village and the second location in *Poncosari* village. The biogas purifier, Zeofilter, has been proven to reduce CO2 levels in biogas. The first site using a zeofilter allows biogas to turn on generators up to 180 Watts/100 Volts. In the second site, the generator performance increased from 420Watt/220Volt to 720 watts/220Volt. The fuel consumption of the gasoline-fueled generator set at a load of 0, 180, 300, 600, and 900 Watt, respectively, is 0.496758, 0.499686, 0.529875, 0.693025, 0.862169 liter/hour while with biogas fuel it is 0.136 m3/hour or equivalent to 136 liters/hour. Comparison of the use of gasoline and biogas at a power of 180 Watts is 0.391254 kg/hour and 0.177951 kg/hour, respectively.

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Author Contribution

The series of community partnership program activities that will be carried out include 5 stages as that the first activity is the delivery of materials for making cow dung biogas for power plants, the second activity is a survey of locations where cow dung is processed into biogas, The third activity is collecting livestock manure, the fourth activity is the launching of biogas equipment, and the fifth activity is a monitoring and evaluation activity.

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Conflict of Interest

The authors declare no conflict of interest.

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