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CARBON EMISSION REDUCTION POTENTIAL AND ECONOMIC VALUATION OF BIOGAS AT CENGKIR GADING EDUFARM IN BOYOLALI

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Abstract:
Cengkir Gading Edufarm is a cattle breeding center for livestock education and manure management purposes that focuses on creating green renewable energy. The program is supported by CSR schemes carried out by PT Pertamina Patra Niaga DPPU Adi Sumarmo. The study objective is to assess the effectiveness of biogas digester construction in Cengkir Gading in reducing carbon emissions and evaluate the reduction cost in energy used. The result showed that the digester unit could help convert cattle dung waste by installing a 30 cubic sized WWTP into biogas, the amount of cow manure being accommodated as much as ± 20 kg/day (10 kg for 2 cattle). Reduction of GHG from livestock activities by 0.0162 CO_2-eq Gg/year and LPG fuel by 45.377 CO_2-eq Kg/year. The potential of electrical energy converted from biogas is 6.16 kWh/day, which produces a power of 0.65 kW. This digester produces 0.8 m^3 biogas/day that can be converted into heat energy of 8658 kcal/day, so it potentially saved 0.19 kg/day of LPG consumption, reduced costs for purchasing LPG gas of 1,140 IDR/day or 34,200 IDR/month, it also saves the cost of paying for electricity 249,849 IDR/ month for a 900 VA.

Keywords: Biogas, Cattle Farm, Renewable Energy, Carbon Emission.
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INTRODUCTION

Boyolali is widely known as the City of Milk or the City of Cows. Some call Boyolali the New Zeeland Van Java because Boyolali Regency produces high-quality milk, meat and other processed cattle. Cattle production from Boyolali is dominated by the livestock of individuals or communities who are members of a livestock group within the scope of a village. In Ngemplak, according to BPS data (2018), there are at least 1,192 owners and 2,143 beef and dairy cattle in this area.

The significant potential of cattle farming resources in the Ngemplak sub-district was why PT Pertamina (Persero) DPPU Adi Soemarmo is interested in developing its corporate social responsibility program in this area. The Ngemplak area is included in the company's Ring 2 area and is in close contact with the company's operational activities. As a mandate from the Ministry of Environment and Forestry, companies must contribute to the socio-economic improvement of communities around their operational areas and preserve the environment around them. Following the Assessment of Obligations in the Regulations, namely, Law No. 40 of 2007 Article 74 and PP No. 47 of 2012, which states that every company has a social responsibility for the Ring 1

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operational area, PT Pertamina DPPU Adi Sumarmo as a GREEN PROPER winner in 2018, 2019 and 2020 have an awareness of having carried out empowerment activities beyond social responsibility not only in Ring 1 but also in the Ring 2 area. The cattle breeder assistance program in the Ring 2 zone is focused on realizing the company's participation efforts in protecting the environment and reducing the impact of environmental damage as well as being a step to overcome the climate crisis disaster that has hit the world.

Various cattle breeder groups have been formed in the Ngemplak area, including the Cengkir Gading cattle breeder group. The "Cengkir Gading" cattle breeder group is in Padokan hamlet, Sawahan village, Ngempak sub-district, Boyolali district. There are 24 cows on the farm. If one cow produces ±10 kg of manure daily, then of course, if there are 24 cows, the amount of manure produced is ±240 kg/day. Cow manure contains methane gas, which is one of the triggers of global warming/Greenhouse Gas effect. In 2015, the IPCC/Intergovernmental Panel on Climate Change once calculated methane gas in the air and became one of the contributors to existing greenhouse gases. As a result, as much as 16% of greenhouse gases globally are controlled by methane gas. Besides emitting methane, cow dung also causes environmental pollution in the farm's soil, surface water and air.

Livestock waste is generally used as compost (Budiyanto, 2011; Syamsuddin et al., 2012), and only a few are used as biogas (Dianawati et al., 2014; Farahdiba et al., 2014), even though livestock waste has the potential to be used as an energy source when energy fuels are limited. Biogas is one type of energy that can be used in terms of technical, social, and economic aspects, especially to meet energy needs in rural areas (Rajendran et al., 2012; Orskov et al., 2014). The utilization of biogas energy provides several advantages, namely reducing the unpleasant smell of livestock manure, preventing the spread of disease, reducing greenhouse gases, generating heat and mechanical/electric power, and providing by-products in the form of solid and liquid fertilizers (Orskov et al., 2014; Insam et al., 2015). Biogas can be utilized primarily for cooking, lighting, and powering water pumps at the individual level and for electricity, heat, power generation, and fuel for vehicles at the industrial level (Minde et al., 2013). Biogas can also solve environmental problems such as soil degradation, deforestation, CO2 emissions, indoor air pollution, organic pollution, and social issues such as replacing wood and fossil fuels.

Electrical energy has become a basic necessity in this day and age. The need for electrical energy every year is continually increasing, while the reserves of non-renewable/exhaustible sources of electrical energy, such as coal, petroleum, and natural gas, are running low. Biogas contains the main ingredient CH4 which can be used as fuel in electrical energy generation because it has a large enough calorific value of 23,880 Btu / lbm.

In order to manage cow dung into a more valuable product, PT Pertamina (DPPU), Adi Sumarmo took the initiative to assist the "Cengkir Gading" cattle breeder group in the form of building a biogas digester and converting energy from biogas into electrical energy. The electricity generated from the biogas is expected to provide lighting for the cowsheds and the road to the cowshed—the previous lighting utilized electricity from PLN. Electricity from PLN is generated using less environmentally friendly fuel, namely coal.

This study aims to evaluate the program's implementation and estimate carbon emission reductions and energy savings from using biogas in electrical energy by the "Cengkir Gading" cattle breeder group in Sawahan Village, Ngemplak, Boyolali. The evaluation was specified to analyze the value of energy conversion from biogas into heat and electrical energy; it also measured the economic value of biogas energy conversion from digester installation in Cengkir Gading farm. The program's success will be used as a direction for developing social innovation programs by PT Pertamina (DPPU) Adi Sumarmo.

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METHODS

A detailed step-by-step explanation of the paper on empowering energy-independent communities by utilizing cattle waste as a source of biogas for household energy in Boyolali is shown in this section.

Survey data collection. This study was conducted using a direct survey and application to the Boyolali Regency area, precisely in Sawahan village, Ngemplak sub-district, Boyolali district, Central Java province. The activity began with a survey to find out the most real number of cattle population, human population, and potential biogas that can be produced by cattle population and for households in the area. The survey has been carried out, calculations have been made and the manufacture of tools in the form of a biogas-producing digester from cow dung based on the survey results and data obtained.

Construction of a prototype digester. A Biogas digester is where cow dung is fermented, and a biogas container from cow dung fermentation. The construction of generator/digester is made from plastic drums. For this purpose, it will be adjusted to the region's and the community's conditions. The construction of the digester uses used plastic drums to make it easy to move, not easily damaged and flexible and cheap. The Boyolali District Environmental Office guided the construction of the digester. After the digester is installed correctly and without leaks, the drum is ready to be filled with cow dung. Cow manure put into the drum must be mixed with very little water where the water is to facilitate the filling into the drum. The maximum amount of manure put into the drum is half the volume. The gas in the drum will be able to be used for 60 days, so after 60 days, it must be replaced with new cow dung. The biogas produced in the digester can be used as a substitute fuel for LPG for cooking and electrical energy for lights.

The steps for the production of biogas using cow dung are as follows:

1. Mix enough cow dung with a predetermined amount of water and keep stirring so that it will form like mud with a ratio of 2:1 in a tub that will temporarily deposit it.
2. The first filling must require much sludge to fill the volume in the digester. Flow the sludge to the digester inlet hole. To facilitate the addition of sludge into the digester, it is first necessary to open the gas tap above the digester. It will displace the air in the digester, allowing the sludge to be added more easily.
3. Add 1 liter of starter and 5 sacks of fresh rumen from the abattoir for a digester capacity of 3.5 to 5.0 m3. After the digester is filled with sludge, the gas tap on the digester must be closed so that the fermentation process occurs.
4. Remove the first gas produced from day 1 to day 8. From day 10 to day 14, methane gas (CH4) and CO2 gas will be formed and decrease in fermentation. On day 14, gas will be formed to light a fire in a gas stove.

Conversion of gas stoves and light installations using biogas. It is necessary to convert from a gas stove to a biogas stove by changing the biogas intake system that will enter the stove. In addition to stoves, installing electrical installations that use biogas fuel as a source of energy and flow into the lights is necessary. After the construction phase of the biogas generator is completed and has produced potential biogas, it can be utilized as a source of biogas fuel for biogas stoves for the community.

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Technical analysis. Carbon emission reduction from converting process of biogas at Cengkir Gading Farm was calculated following the procedures and formulas from Yulianto et al. (2010), IPCC (2006), and IRENA (2016). The procedure and formula are based on Yulianto et al. (2010); Semin et al. (2020). The technical analysis of this study is a technical comparison between the performance of the original gas stove and the biogas-fueled stove, as well as the electrical energy power produced by biogas. The economic valuation in this study is limited to calculating the enormous cost incurred for using biogas compared to fossil energy.

RESULT AND DISCUSSION

The Boyolali Region: Has an area of 1,015.10 km2, a total population of 930,531 people (SP2010), with a density of 916.69 people/km2. The administrative division consists of 19 sub-districts, 267. The administrative center is in Boyolali Sub-district, about 25 km west of Surakarta City. Semarang Regency and Grobogan Regency border the district to the north; Sragen Regency, Karanganyar Regency, Sukoharjo Regency, and Surakarta (Solo) City to the east; Klaten Regency and Yogyakarta Special Region to the south; and Magelang Regency and Semarang Regency to the west. The regency is part of the Greater Solo region (Ex. Surakarta Prefecture).

Demographic conditions: The population of Boyolali Regency in 2008 totaled 949,583 people, with 464,837 men and 484,757 women, and a population density of 935 people/Km2. In 2007, the total population was 947,012, with 463,286 men and 483,726 women and a population density of 933 people/Km2. This data illustrates that the population of Boyolali Regency in 2008 increased by 2,582 people or a growth of 0.27%. Cattle farming in Boyolali: One of the regencies in Central Java, Boyolali Regency has a relatively large potential in cattle farming. Approximately 256,560 people, or almost one-third of Boyolali's 1 million population, work as cattle farmers. These farmers keep around 62,130 dairy cows and 88,910 beef cows. Boyolali can produce around 12,000 liters of milk per day from these dairy cows. 80 to 90 cows are slaughtered daily in Boyolali, producing around 22.7 tons of meat. Boyolali has an essential role in food security, especially meat, due to its large livestock sector. Around 256,560 people, or 27.79 percent of the total population of almost 1 million, are cattle farmers.

Result of the program: Biogas is a gas produced by anaerobic activity or fermentation of organic materials, including; human and animal waste, domestic (household) waste, biodegradable garbage or any biodegradable organic waste under anaerobic conditions. The main contents in biogas are methane and carbon dioxide. Biogas has the potential to be utilized as a renewable energy source. The high methane gas (CH4) content and its calorific value, which ranges from 4,800 to 6,700 kcal/m3, make it a preferred choice for combustion due to its environmentally friendly properties. Methane gas only contains one carbon in each chain, enhancing its eco-friendliness. Biogas is a colorless, odorless and very high and fast ignition gas. Biogas can be used as a vehicle fuel, generate electricity, or replace LPG gas. The use of biogas has a safer safety when compared to LPG gas. For example, if the pipe or gas container leaks, there will be no explosion because the gas that comes out will evaporate quickly and if the fire is brought closer to the gas source, there will be no burst of fire that causes a fire. So, this cow dung biogas can be said to be a safe fuel. In addition, biogas can also be utilized as an energy source to generate electricity.

Education on using biogas as an environmentally friendly, renewable energy source for electricity or LPG replacement has been successful. This program has led to converting manure waste, equivalent to the output of 2 cows, into biogas by installing a 30 cubic meter size Wastewater Treatment Plant (WWTP). Cow dung waste ± 20 kg/day (@ cow 10 Kg). Reduction of greenhouse gas emissions from livestock activities by 0.0162 CO2-eq Gg/year. Reduction of

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greenhouse gas emissions from LPG fuel by 45,377 CO2-eq Kg/year. The potential for electrical energy converted from biogas is 6.16 kWh/day, with power capable of being generated by a biogas power plant of 0.65 kW. This installation has the potential to produce 0.8 m3 of biogas/day, which can be converted into 8658 kcal/day of heat energy so that it has the potential to save the use of LPG as much as 0.19 kg/day, saving costs for the purchase of LPG gas of Rp. 1,140/day or Rp. 34,200/month, saving costs to pay for electricity Rp. 249,849/month for a house with 900 VA power. The water and soil quality around the cattle farm area in Cengkir Gading is cleaner than before the cow dung waste was converted into biogas. Systemic changes in the use of environmentally friendly renewable energy from biogas result from previously using electrical energy from PLN, which is not environmentally friendly. Community awareness in using cow dung waste for environmentally friendly renewable energy.

The process of producing biogas from cow dung is due to the anaerobic decomposition of organic matter (closed from free air). This process will produce a gas that contains predominantly methane and carbon dioxide (CO2). The gas formed is called swamp gas or biogas. The biogas formed can be used as fuel because it contains flammable methane gas (CH4), where some microorganisms, such as methane bacteria, assist the anaerobic decay process. A suitable temperature for the fermentation process is between 25-55oC. At this temperature, microorganisms can work optimally to break down organic materials. Qi et al. (2012) suggested that biogas optimization technology continues to be carried out to obtain high efficiency. Sunaryo (2014) suggested counseling related to biogas to residents, especially cattle farmers, in the form of digester maintenance management, using techniques and utilizing biogas for cooking.

Technical failure of biogas implementation is usually due to: 1) the choice of digester type is not follow the manure handling method and farm layout, so maintenance and repairs become expensive, 2) the optimum biogas technology has not been obtained, 3) the operator does not have the skills or time to make the system run well, and 4) there is no adequate counseling, training, and technical guidance (Mwirigi et al., 2014; Herriyanti, 2015).

Putro (2007) stated that the difficulties faced in the implementation of group digesters are: 1) biogas cannot be distributed to more distant places due to limited capacity and there is no technology to distribute biogas safely and cheaply, 2) limited capacity, and 3) lack of security because the digester tub and gas container are in the form of plastic bags that are at risk of being hit by sharp objects and sparks. Other barriers to group biogas development are the need to provide funds for installation to each house (Rustijarno, 2009), the difficulty of proportionally sharing electrical energy between members (Hanif, 2010), and the difficulty of dividing the work of biogas maintenance and waste treatment (Chadwick et al., 2015).

CONCLUSION

The program succeeded in converting livestock manure waste into biogas. The program also succeeded in educating the use of biogas in electricity and LPG replacement as an environmentally friendly alternative to renewable energy. Reduction of greenhouse gas emissions from livestock activities by 0.0162 CO2-eq Gg/year. Reduction of greenhouse gas emissions from LPG fuel by 45,377 CO2-eq Kg/year. The potential for electrical energy converted from biogas is 6.16 kWh/day, with power capable of being generated by a biogas power plant of 0.65 kW. This installation has the potential to produce 0.8 m3 of biogas/day, which can be converted into 8658 kcal/day of heat energy so that it has the potential to save the use of LPG as much as 0.19 kg/day, saving expenses for the purchase of LPG gas of Rp. 1,140/day or Rp. 34,200/month, which is saving expenses to pay for electricity.

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