Biogas from the Solid Waste of Dairy Cattle as Renewable Alternative Energy at Mowila and Konda, Konawe Selatan, Sulawesi Tenggara

Prima Endang Susilowati\textsuperscript{a}, Ahmad Zaeni\textsuperscript{a}, Darwis\textsuperscript{b},

Abstract

Utilization of fossil fuels such as lignite, hard coal, crude oil and natural gas converts carbon, stored for millions of years in the Earth's crust, and releases it as carbon dioxide (CO\textsubscript{2}) into the atmosphere. Energy diversification is one of the solutions to the energy crisis and pollution in this country. One of the main advantages of biogas production is the ability to transform waste material into a valuable resource, by using it as substrate for anaerobic digestion of animal manure and slurries. Biogas is a flexible energy carrier, suitable for many different applications. One of the simplest applications of biogas is the direct use for cooking. Production of feedstock in combination with operation of biogas plants makes biogas technologies economically attractive for farmers and provides them with additional income. The farmers get also a new and important social function as energy providers and waste treatment operators. The purpose of this project is to identify to assess biogas application at household scale. The study was undertaken by purposive method of field survey at Mowila and Konda, Konawe Selatan District. Results indicated that number of livestocks $3-4$ cattle/person. The biogas installation was donated by KKN-PPM programe (DIKTI). The use of biogas at household scale used manures from $3$ cattle have been applied for cooking.

\textsuperscript{a}Chemistry Department, FMIPA, Halu Oleo University, Kendari, Indonesia
\textsuperscript{b}Agronomy Department, FAPERTA, Halu Oleo University, Kendari, Indonesia

Corresponding author e-mail address: zaeni@yahoo.com

Introduction

Energy diversification is one of the solutions to the energy crisis. Conservation could be done through energy saving and developing renewable energy sources. Biogas has the potential to become an alternative renewable energy source in Indonesia, experiencing energy crisis, marked by the increasing scarcity and price of mineral fuel. Biogas can be produced from animal waste, tofu industry waste, organic waste from homes and traditional markets. Wahyuni\textsuperscript{[1]} stated that biogas could create fire sparks with the power of $6400-6600$ kcal/m\textsuperscript{3}. The energy content of $1$ m\textsuperscript{3} biogas equals that of $0.62$ liter paraffin, $0.46$ liter LPG, $0.52$ liter diesel fuel, $0.08$ liter gasoline, and $3.5$ kg wood. Hanif's\textsuperscript{[2]} study found that one cow could produce $25$ kg waste. Thus, $411$ animals could produce $10.275$ kg waste with dry material content of $2.055$ kg, which could produce $82.2$ m\textsuperscript{3} of biogas per day.

Hardianto et al.\textsuperscript{[3,4,5]} there are three advantages of treating cattle waste to produce biogas, namely: a) biogas can be used as alternative fuel instead of oil fuel or wood with a high heat quality; b) the fluid sludge can be used as fertilizer; and c) the solid sludge can be used as mixture of animal feed. The active biogas installation supplies energy for the farmers cooking stoves. Every day the farmers only use $2$ wheel barrows or $132$ kg of cattle waste.

Growth and concentration of the livestock create opportunities for the proper disposal of the large quantities of manures generated at dairy, swine, and poultry farms. The potential pollutants from decomposing livestock manures are biochemical oxygen demand (BOD), pathogens, nutrients, methane, and ammonia emissions. The major pollution problems associated with these wastes are surface and groundwater contamination and surface air pollution caused by odors, dust, and ammonia. There is also concern about the contribution of methane emissions to global climate change. Consequently, manure management systems that enable prevent pollution prevention and produce energy are becoming increasingly attractive.

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic material and is a type of biofuel. One type of biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure or sewage, municipal waste, green waste and energy...
crops. This type of biogas comprises primarily methane and carbon dioxide.

The process of biogas production takes place in anaerobic conditions and in different temperature diapasons. There are psychrophilic (temperature 10-25 °C), mesophilic (25-40 °C) and thermophilic (50-55 °C) regimes of bioconversion. Biogas production in a thermophilic regime is much higher than for the mesophilic and psychrophilic regimes. Thermophilic bioreactors can produce 2-6 m³ per m³ of installation, which amounts to 5-15 kg of waste on a dry mass base (or 50-150 kg of wet mass). For mesophilic biogas installations, these values are 0.2-0.4 m³ per m³ of installation and 0.5-1 kg on a dry mass base (or 5-10 kg of wet mass). Series of processes in which microorganisms break down biodegradable material in the absence of oxygen. Four general stages: hydrolysis (large polymers into simpler monomers); acidogenesis (simple monomers into volatile fatty acids); acetogenesis (volatile fatty acids into acetic acid, CO₂, and H₂); and methanogenesis.

Cattle farming is an important economic activity on region Konawe Selatan, Sulawesi Tenggara. The project seeks to improve animal waste management practices through the utilization of the waste as a resource by processing manure and other organic wastes into biogas for energy use with anaerobic digestion technology and producing a mineral enriched natural fertilizer. The project will also aim: (a) to end the land spread of cattle manure on farmland, which currently causes odours and nuisance to local community; (b) to cease the substandard treatment of waste water biosludge; (c) to minimize the burying of animal waste on Mowila and Konda region; (d) to minimize the amount of animal waste transported and reduce the risk for associated environmental pollution; (e) to produce and market “green energy” from biogas; and (f) to produce and market mineral-enriched natural fertilizer.

Methodology

The study was done at the farming complex as part of Mowila and Konda regions. The cattle population consisting of dairy cows and bulls. We studied only observing the population cattle and biogas installation. Secondary data were obtained through literature study and documents related to the Mowila anda Konda Area. Biogas potential analysis was done by multiplying dairy cow waste mass and dry material content and converted to the amount of gas obtained (m³)

Biogas digester made by digging the earth (excavation site not more than 20 meters away from kitchen) to a depth of 120 cm wide, 100cm long and 4 meters. After the excavation is completed, excavation area walled with cement, and installed bricks around its open powerful. For the introduction of manure made separate holes, while the output was being placed on the contrary side. Biogas digester is made from plastic inserted and filled with manure-waer with ratio 1:1. After3-4 days of gases streamed and stored using a hose in a plastic container, and then used to light the stove.

Results and Discussion

The anaerobic digestion process breaks down volatile organic compounds, which reduces odour if due diligence is practiced for pre-storage of the feedstock, especially with non-agricultural wastes. Often, one of the main objectives of installing an on-farm anaerobic digestion system is to reduce odours, thereby facilitating good neighbour and community relations. The process also generates other environmental benefits such as the reduction of greenhouse gases, pathogens, and the viability of weed seeds. It also reduces the potential for water pollution because it decreases biological oxygen demand. Negative impacts include the potential for increased ammonia emissions and vehicle traffic. All anaerobic digestion projects should include provisions to mitigate such concerns. For example, adding a floating cover to the post-storage tank will reduce ammonia emissions and pumping manure through pipes to a digester will reduce the need to transport waste. On-farm anaerobic digestion has the potential to generate energy security for the host farm, diversify farm income, and increase rural investment and employment opportunities.
A bio-digester is a structure that facilitates the decomposition of organic materials such as manure, one example being cattle waste to produce methane gas (biogas) that can be used for cooking. While a bio-digester is normally made of concrete or metal, this manual highlights the low-cost polyethylene plastic bio-digester. A polyethylene bio-digester unit is a sealed tubular structure made of polyethylene “plastic” that may vary in size and thickness (Figure 1).

Farming in region Mowila and Konda Konawe Selatan has studied the biogas use obtained from cattle waste for cooking stoves. Biogas is feasible technically and economically to use as energy source[6]. The Mowila farm owns 2680 cattle and Konda farm 5038 [7], consisting of dairy cows, bulls and calves. As the cattle waste was not only treated in digester to produce biogas, but also composted to become fertilizer, so far the digester with a capacity of 2 m³ has been using only 2 wheel barrows or 65 kg of dairy cattle waste to produce gas. The produced gas was used only as fuel for cooking stoves. According the informant from the biogas section, biogas had been used to supply energy for cooking, resulting from the hard material in the feces, containing heavy copra residue that could not be removed and thus precipitated at the bottom of the digester. The number of dairy cows in the Mowila and konda farm is 7000, weighing 70,000-75,000 kg. With the number of cattle in the farm, it has the potential to produce enough biogas as a source of energy. Cattle waste is the most efficient material to produce biogas, because each 10-20 kg of waste per day can yield 2 m³ of biogas. As the energy contained in 1 m³ biogas is 2000-4000 Kkal, it is sufficient to provide cooking fuel need of a family (4-5 persons) for 3 hours [8].

Biogas is a form of energy produced by anaerobic digestion (the decomposition of constituents of biodegradable matter in an oxygen-free environment) (Figure 2). It is a mixture of gases mainly carbon dioxide and methane. Approximate biogas composition: methane (CH₄) 55 to 65%; carbon dioxide (CO₂) 30 to 35%; water vapour 1 to 5%; hydrogen sulphide (H₂S) 0 to 3%; hydrogen (H₂) 0 to 1% [9].

Production of feedstock in combination with operation of biogas plants makes biogas technologies economically attractive for farmers and provides them with additional income. The farmers get also a new and important social function as energy providers and waste treatment operators. A biogas plant is not only a supplier of energy. The digested substrate, usually named digestate, is a valuable soil fertiliser, rich in nitrogen, phosphorus, potassium and micronutrients, which can be applied on soils with the usual equipment for application of liquid manure. Compared to raw animal manure, digestate has improved fertiliser efficiency due to higher homogeneity and nutrient availability, better C/N ratio and significantly reduced odours. Biogas production can be perfectly integrated into conventional and organic farming, where digestate replaces chemical fertilisers.

Common problems and suggested solutions:

a. The bio-digester does not seem to be producing any gas:

✓ gas production may drop or cease for many reasons including the entrance of air into the bag, changes in temperature, water pH and contamination in the wastes used to charge the digester.
We would like to thank Dikti-Kemendiknas (Hibah KKN-PPM Tahun 2013 and 2014)

References


[8]. Suriawiria U (2005) Reaping Biogas from Waste (Menuai Biogas dari Limbah)


Conclusions

The installed biogas digester is very applicable and useful for farmers who have 2 or 3 cattle and could eliminate their energy requirement for cooking. Farmers can easily operate the digester without significant difficulties. The digester need to be filled every 3-4 days with 3-4 (10 litre) container.

Acknowledgments

✓ Check and be sure that no air is entering the bio-digester from the inlet or outlet bucket.
✓ Check the digester for any bag damage from foreign objects or animals that may allow gas to enter. If necessary increase the water level inside the bag.
✓ Some producers have noted a drop in bio-digester gas production during long periods of rain.

b. Soil around the bio-digester is washing onto and compressing the bag:
✓ When soil or mud falls on the bio-digester they can deflate the bag and cause sedimentation to occur inside the bag.
✓ To avoid this problem construct a barrier to keep mud, rain, and soil out. Many producers have constructed simple fences or barriers to prevent erosion from damaging the bio-digester bag. These may be constructed from wooden stakes and slats of wood. Any mud that washes onto the bag must be cleaned off daily.

c. There appears to be gas in the bag, but there is no gas coming out of the digester:
✓ Check to be sure the gas valve is open.
✓ Crack pipes can cause a leak in the gas line.
✓ Regularly inspect your gas lines for damage.
✓ Seal any damaged lines securely with glue and rubber ties.

d. Animals are damaging the digester bag
✓ Animals can quickly cause permanent damage to bio-digesters.
✓ Be sure that your bio-digester is well protected from animals.