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# Potential of biogas production as renewable energy in smallholder dairy farming in Enrekang District, South Sulawesi

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**Abstract.** The dairy cow in Enrekang Regency not only produces the main product of fresh milk that is processed into "Dangke" (typical food of Enrekang Regency), but it is also able to produce by-products in the form of alternative energy. The purpose of this study is to analyze the potential of renewable energy by utilizing biogas on people's dairy farms. The study was conducted in Cendana Subdistrict, Enrekang Regency in May 2018 to Juni 2019. Data were collected using observation, interviews, and documentation with dairy farmers using a purposive sampling method and analyzed using quantitative descriptive. The results show that the potential for feces production over the past five years from 570 dairy cows can produce 11.402 kg/day. Thus, the biogas produced is 456 m<sup>3</sup>/day, considering that one cow can produce biogas of 2 m<sup>3</sup>/day and 1 m<sup>3</sup> of biogas can be used equivalent to 0,62 liters of kerosene and 0,46 liters of LPG gas. Besides, the potential of biogas energy can meet the cooking needs of one family (4-5 people) for 190 hours or 8 days, considering that the energy contained in one m<sup>3</sup> of biogas is 2,000-4,000 Kcal or equivalent to 3 hours. Biogas technology has provided many benefits including improving the health of breeders' families, used to process cow's milk into dangke and saving LPG gas expenditure expenses so as to be able to provide additional income for farmers, even though the value generated is not large enough, but the reduction in costs is enough to reduce the cost burden household issued every month.

## 1. Introduction

Biogas is an environmentally friendly and renewable alternative energy source that can contribute to efforts to meet fuel needs and can be used as an energy source driving electricity generators [1,2]. The raw material for this energy source is nonfossil, generally, it is livestock waste whose production depends on the availability of grass [3]. The government has set the national energy mix in 2025 with the role of petroleum as energy, to be reduced from the current 52% to less than 20% by 2025. The main strategy set by the government for the development of national fuel is known as the Fast Track Program, namely the development of energy independent villages by the potential of each region [4].

Dairy cows become the first commodity used in the use of biogas reactors because of the availability of livestock manure. The main results of the dairy farming business are milk and calves, while feces and urine are additional products. Farmer income is selling milk, calves and organic fertilizer. Besides, feces are used as biogas technology that can break livestock feces into gas [5].



Enrekang Regency is one of the regencies in South Sulawesi that has the potential to develop dairy cows and the majority of dairy cow milk production is used to produce traditional food namely Dangka. The largest population of dairy cows in Enrekang Regency is in Cendana Subdistrict with 715 dairy cows consisting of 570 lactation and dry dairy cows, 54 male calves and 91 female calves in 2017 [6]. Cendana Subdistrict is located along the Saddang River watershed so that this area is very concerned about the level of environmental pollution, especially the level of water pollution. The large waste production indicates that people's dairy farms contribute quite a lot in terms of environmental pollution caused by the presence of such waste. Although the number of cows raised is not large, the number of dominant dairy cow farms in Cendana District is capable of producing dangke and waste with a large capacity. The purpose of this research is to analyze the potential of biogas production as renewable energy on people's dairy farms.

## 2. Methods

This research was conducted from May 2018 to Juni 2019 in Cendana District, Enrekang Regency. The deliberate selection of locations is based on the consideration of areas that have the potential for dairy cow business by utilizing cow manure as biogas. Primary data through observing farm location and making biogas, interviews with farmers and local government officials, as well as the use of farmer's documents. Secondary data through the Center for Process and Energy Industry Assessment, Central Agency for Animal Husbandry and Fisheries and Enrekang Regency. Qualitative data analysis is used in describing the use of biogas in the households of people's dairy farmers. Qualitative data analysis is divided into three main components [7], namely: data reduction, data presentation, and conclusion drawing. Quantitative analysis was carried out to calculate the potential for gas production in dangke processing and comparison of the equivalence values of four types of fuels, namely biogas, kerosene, LPG and firewood.

## 3. Results and discussion

### 3.1. History of Biogas in Enrekang Regency

In 2005 there was a kerosene crisis and the local government tried to develop biogas stoves from feces. Finally, in 2006, the Enrekang Regency Mining and Energy Office installed 10 units of plastic biogas reactors and 3 units of generator sets for biogas power plants. Dairy farmers are very enthusiastic because they do not need kerosene and LPG gas to cook milk processed into dangke. In 2007, the regional government launched the use of biogas for dairy farmers and fattening cow with the slogan "Biogas Yes Kerosene No". In 2007 through the Department of Spatial Planning and the Environment, 18 biogas units were prepared and the Regional Agriculture Office prepared 12 units. In 2008 through the Enrekang Regency Mining and Energy Office, they allocated funds to the 2008 Fiscal Year Regional Budget for 20 Biogas. In 2009 through the Department of Mining and Energy and the Department of Animal Husbandry and Fisheries, Enrekang Regency allocated funds in the 2009 Fiscal Year Regional Budget for 40 Biogas. Until 2009, Biogas in Enrekang District numbered 100 units for Biogas Stoves and 3 Units for Biogas Generators.

In 2010, the presence of a home biogas program (BIRU) which was developed using a concrete tub reactor. All funding for this program comes from the Dutch government development agency, SNV Netherlands Development Organization. Meanwhile, the Humanitarian Institute for Development Cooperation (Hivos) is implementing the program by involving local community organizations. The BIRU program believes that the use of biogas directly contributes to the increase in the level of welfare of rural households, especially for children and women. That is the forerunner to the development of biogas in Enrekang Regency.



**Figure 1.** Biogas from dairy cow

Figure 1 shows that the design of a plastic digester costing IDR 5.336.000 with a capacity of 5 m<sup>3</sup> which has an operational life of around 4 years and a concrete tub digester costs IDR 8.500.000 with a capacity of 10 m<sup>3</sup> with an operational life of around 10 years. This shows that more people use plastic digester because of lower prices, but fixed dome digester can last a long time and are sturdy. The use of concrete fixed dome digester for cooking all day while plastic digester can only be used for several hours [8].

### 3.2. Utilization of Biogas

The utilization of livestock waste is one of the most appropriate alternatives to overcome the problem of scarcity of fuel oil and rising fertilizer prices [3]. Therefore, the development of biogas is a renewable energy that can be used as an alternative fuel as described by several farmers:

*"Previously, making dangke originally using wood is now gas. Since 2011, I've been using biogas. Every week, livestock manure is collected in a planting tube resembling a septic tank. Dirt is left to settle for several months and slowly added. Since there is biogas, three kg of gas canisters only once a week. The gas produced by livestock manure, not only for cooking and making dangke, but also daily necessities such as cooking for family needs (In-depth interview with Fitri, 26 May 2019).*

*Due to the increase in the price of 12 kg LPG, most people turned to three kg subsidized LPG. Inevitably, many are worried that LPG subsidies will disappear from the market due to high demand, or even because of speculators. This concern also had circulated in several areas, including Enrekang. The practice of utilizing biogas does not only occur in Lekkong Hamlet but also spread in several other villages in Enrekang. I deliberately built a biogas reactor with a capacity of two cubic meters (2m<sup>3</sup>). The tool turns animal waste into household-scale biogas that can be used as cooking fuel or even lighting for lighting. Through a biogas stove that is directly connected to the equipment, my wife processes cow's milk into dangke, and other cooking needs. My wife no longer needs to worry about kerosene or gas from LPG. According to the count, before using biogas, we relied on LPG subsidies for three kg for a week. That is equivalent to 1.000 liters of biogas per day obtained from 30 kg of feces. Now, by utilizing the feces of two cows from just six pets, the need for cooking fuel in one day has been fulfilled (In-depth interview with Isran, 15 June 2019).*

*The use of biogas has its benefits for my family. I have used gas from feces to cook my daily needs so I no longer bothered to spend the least cost of buying LPG gas as fuel for making dangke (a kind of cheese fermented from cow's milk) (In-depth interview with Hasran, 20 June 2019).*

Based on interviews with the three informants it can be concluded that: 1) Biogas is used as a result of the scarcity of LPG gas, 2) Biogas is used for daily cooking and cooking dangke, and 3) Biogas is able to reduce the use of three kg subsidized LPG so that it is only used 1-2 times a month. Some breeders in Enrekang Regency can develop Biogas technology for 24 hours [9]. Renewable and

sustainable energy resources are biogas that plays a vital role in reducing the CO<sup>2</sup> footprint and improving the livelihoods and health of citizens thereby promoting sustainable regional development [10]. Biogas technology was mostly adopted by family members of 12-15 people and with the highest percentage of the income of US \$ 202-384 per month. The use of biogas is beneficial at the domestic household level, such as saving energy expenditure, increasing income and health, using organic fertilizers and pesticides that can maintain the ability of the soil and the balance of the ecosystem to ensure sustainable agricultural activities [11-19]. Ecological changes affect the sustainability of livestock waste treatment technology [20]. Therefore, the land is an important investment where each institution has its pattern in land management and has real rules that apply from generation to generation and cannot be changed by anyone [21].

### 3.3. Animal manure production, Gas production potential, and methane gas production in Cendana District, Enrekang

Biogas is a renewable energy source where the gas produced by livestock manure has the main content in the form of methane and carbon dioxide. Cendana District is an area that has great potential as a biogas development area. Production of livestock manure, gas and methane can be seen in table 1.

**Table 1.** Production of livestock manure, gas, and methane in Cendana District, Enrekang over the past five years.

Year	Population	Manure Production (kg/day)	Gas production potential (m <sup>3</sup> /day)	Methane gas production (m <sup>3</sup> /day)
2014	557	8.912	356	234
2015	669	10.704	428	281
2016	729	11.664	467	307
2017	715	11.440	458	301
2018	893	14.288	572	375

Table 1 shows that the production of manure, biogas and methane gas has increased during the last five years (2014-2018) with an average production of manure of 11.402 kg/day, biogas production of 456 m<sup>3</sup>/day and methane gas production of 300 m<sup>3</sup> /day. Numerical calculations refer to livestock manure production and the potential for gas production for each type of manure varies. Cow/buffalo produces gas production of 0.023-0.040 m<sup>3</sup>/kg, pig manure produces gas production of 0.040-0.059 m<sup>3</sup>/kg, and chicken manure produces gas production of 0,065-0,116 (m<sup>3</sup>/kg) [22]. Biogas is an alternative fuel that is easily obtained and at the same time preserves the environment. Greenhouse gas emissions from biogas combustion make the smallest contribution compared to GHG emissions from other sectors. The use of biogas for milk heating energy can reduce the burden of production costs for fuel purchases [23]. Also, fossil-based energy consumption is increasing, especially LPG (Liquid Petroleum Gas) which is not matched by the availability of energy reserves, demanding the development of other alternative energy which is abundant and environmentally friendly. One alternative energy source that is feasible to be developed is energy derived from biomass waste such as cow [24].

Biogas technology is influenced by the number of livestock ownership because it determines of feces produced each day. The number of family members of the farmer determines the amount of gas needed for cooking. The more family members mean the greater the capacity of the digester needed [9]. Energy diversification is one of the keys to overcoming the threat of energy scarcity in this country. Conservation can be done by saving and developing renewable energy sources, of course, must be supported by pro-environment government policies. Biogas has good prospects as alternative renewable energy that can be developed in Indonesia which is experiencing an energy crisis that is characterized by increasingly scarce and high fuel prices which have an impact on the higher costs of electricity generation [25].

### 3.4. Comparison of Expenditures of Three Types of Fuel

Biogas is a technology that supports breeders' activities in Cendana District, Enrekang. The value of equality of biogas that can be produced from dairy cow waste compared to other energy can be seen in table 2.

**Table 2.** Equality of Biogas with Kerosene, LPG and Firewood.

Year	Gas production potential (m <sup>3</sup> /day)	Gas production potential (m <sup>3</sup> /year)	Equivalent to kerosene (liters)	Equivalent to gas LPG (kg)	Equivalent to firewood (kg)
2014	356	128,333	79,566	59,033	449,165
2015	428	154,138	95,565	70,903	539,482
2016	467	167,962	104,136	77,262	587,866
2017	458	164,736	102,136	75,779	576,576
2018	572	205,747	127,563	94,644	720,115

Table 2 shows that Cendana District has biogas energy potential which is able to be an alternative energy source as a companion to other energy that has been used by the community. Based on the research results obtained biogas equality compared to other energy. Based on the results of calculations in Table 2, it is known that there has been an increase in biogas potential over the past five years with an average of 164.183 m<sup>3</sup> / year or equal to 101.793 liters/year of kerosene, equivalent to LPG gas requirements of 75.524 kg/year and equivalent to fuelwood requirements of 574.461 kg/year year. Therefore, the need for fuel oil can be substituted by biogas produced from livestock manure, such as for cooking daily needs, cooking dangke, lighting cages, and electricity. The caloric value of 1 cubic meter of biogas is around 6.000 Kcal/m<sup>3</sup> which is equivalent to half a liter of diesel oil. Therefore, biogas is very suitable to be used as an environmentally friendly alternative fuel to substitute kerosene, LPG, coal, and other materials derived from fossils [22].

**Table 3.** Energy Conversion Based on the Potential of Animal Waste (m<sup>3</sup> biogas) in dairy cow maintenance activities in Cendana District, Enrekang.

1 m <sup>3</sup> biogas application is equivalent to	Dairy farming
Daily biogas potential (m <sup>3</sup> /day)	571
Lighting (lamps 60-100 watts) for 6 hours	3.426
Cook 3 types of food for 5-6 people	100-103 servings
Electricity ( 1,25 kWh)	714

Table 3 shows dairy farms that have a very large waste potential compared to other farms. Adult dairy cows produce 25 kg of feces per day. Biogas potential produced by 571 m<sup>3</sup>/day can be used as an electrical energy source for lighting and gas stove fuel sources. The biogas produced can be used as lighting lamps 60-100 watts for 3.426 hours, produces 714 kWh of electrical energy and can produce 3 types of dishes for 100-103 servings. The implementation of waste technology into energy such as biogas production from animal waste is considered as one of the best ways to achieve the goal of sustainable energy development in many developing countries including Indonesia. It is estimated that the potential for biogas around 9597.4 mm<sup>3</sup>/year can be used to produce electricity up to 1.7 × 10<sup>6</sup> kWh/year [26]. On the other hand, the depletion of fossil fuel resources and fluctuations in oil prices lead to an upward trend in green energy alternatives and cost savings [27].

#### 4. Conclusion

The conclusion obtained in this study is that the use of dairy cow manure into biogas is very suitable to be developed in people's dairy farms because in addition to reducing environmental impacts it also adds to the benefits and savings in the use of fuel or electrical energy sources. The potential of biogas produced from 570 dairy cows is 456 m<sup>3</sup>/day. The biogas produced can be used as a 60-100 watt cage lighting for 3.426 hours, produces 714 kWh of electrical energy and can cook 3 types of cuisine for 100-103 servings. Amid the increasing prices of crude oil and fuel oil, biogas can be an alternative to fuel oil for daily use. In the Cendana District area, biogas production has another urgency because it supports the development of a home-based milk processing industry from dairy cows, namely dangke.

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