Biogas efficiency from cow dung waste in strengthening energy security during the covid-19 pandemic through a dynamic modeling system

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Abstract. During Covid-19 pandemic, the increase in LPG types was 0.6-2.4 million BOE, while in the household sector it was 2.3-6.9 million BOE, so causes LPG import growth ratio to increase by 4.8%/year (BPPT, 2020). Therefore, it is necessary to make efforts to suppress LPG imports by increasing the supply of EBT in the household sector with biogas production. The research aims to look at the biogas production modeling system from the resulting cow dung waste. The research method that studies the literature is based on modeling data based on data obtained using Powersim 10. The results showed that LPG demand in 2020 is 2.4 million BOE that could be fulfilled by a biogas source from 9539238.75 kg ~ 0.9 metric tons cow dung waste. This cow dung waste is able to produce 381569.55 m³/kg of methane gas which is equivalent to 0.59 metric tons LPG, savings Rp 690 M; 103 million liters gasoline, savings Rp 793 M; 64.8 million liters diesel fuel, savings Rp 333.8 M; 80 million liters kerosene, savings Rp 1 T; 4.53 metric tons wood, savings Rp 4.5 T. This favorable situation must be immediately felt by the community with an estimate of future benefits.

1. Introduction
During the Covid-19 pandemic, all energy needs per type and sector decreased, except for LPG type energy and the household sector as a result of the PSBB policy. The government has pursued a biogas development program to suppress the growth of LPG imports by increasing the New Renewable Energy (NRE) mix through the BIRU (House Biogas) program [1]. Renewable energy sources can be defined as energy sources that are capable of continuously produced [2]. It is presented as an alternative to the treatment and recycling of energy from nutrients contained in animal waste, reducing the potential for pollution and sanitation risks, in addition to promoting the production of biogas and biofertilizers [3]. In 2020, the supply of NRE decreased by 9.9-15.3% (23.6-36.6 million BOE) [4]. Therefore, it is necessary to make efforts to suppress LPG imports by increasing the supply of EBT in the household sector with biogas production. It also refers to the results according to Purnomo Yusgiantoro Center.
(PYC) research, there are 10 main problems in the energy sector, including the non-optimal use of EBT and dependence on imports of fuel and LPG.

The increase in LPG types was 0.6-2.4 million BOE, while in the household sector it was 2.3-6.9 million BOE. The gap between these two variables causes the growth of the LPG import ratio to increase by an average of 4.8% per year [4], so that it can threaten domestic energy security. The production of biogas from livestock manure, especially animal manure, is one of the alternative utilization of organic waste that can be applied in Indonesia considering the large bioenergy potential in Indonesia [5]. The large production of cattle also produces a large amount of waste because by-product of the process itself. Poor management of livestock waste can cause several environmental problems such as accumulation of nutrients in soil, eutrophication of water, and air pollution [6]. Biogas originally from bacteria in the process of biological decomposition of organic matter under anaerobic conditions [7]. Biomass is a valuable alternative energy worldwide as a substitute for fossil fuels converted into various usable forms of energy such as heat, steam, electricity, biogas, and liquids biofuel transportation.

The high potential of biogas is expected to be utilized effectively and efficiently so that it can help meet the community's need for increased LPG consumption during the Covid-19 pandemic, thus having an impact on strengthening domestic energy security, by suppressing LPG imports, increasing the supply of EBT and especially to meet the energy needs of domestic LPG types during the Covid-19 pandemic. The barrier to biogas production is related to the high cost of building biogas infrastructure (Novariyanto, 2017). In addition, the community has not been able to predict the amount of savings made by biogas production. If the retail price of kerosene is Rp 3500/liter, the use of biogas can reduce household costs by Rp 2500000/year. One biogas reactor with a capacity of 2500 liters costs Rp 3500000 with a lifespan of around 10 years. Thus, the use of biogas significantly reduces the cost of farm households to buy kerosene and LPG.

By referring to the reality of this thought, it is necessary to conduct a study entitled "Biogas Efficiency from Cow Dung waste in Strengthening Energy Security during the Covid-19 Pandemic through a Dynamic Modeling System" with the aim of researching the efficiency of biogas against other energy sources, namely LPG, gasoline, diesel, kerosene and wood in meeting the national LPG type energy needs in 2020 during the Covid-19 pandemic.

2. Literature review

2.1 Energy Resistance

General Plan of National Energy in Presidential Decree No. 22 of 2017 defines that national energy security is a condition of energy availability, public access to energy at affordable prices in the long term while still paying attention to environmental protection. To measure this, a sub-index is determined, one of which is Affordability, which is an assessment of the community's ability to reach the price of energy provided based on the amount of basic daily energy needs, which considers people's purchasing power. The assessment of this condition is influenced by the efficiency of energy use as an indicator to measure the ability to save energy use while maintaining and improving the products produced.

2.2 Biogas

Biogas is a mixture of gases with the main content of methane which is flammable produced from the fermentation process of organic matter by anaerobic bacteria. Organic matter is material that can be decomposed back into soil, such as cow dung. Anaerobic bacteria are bacteria that can survive in conditions without oxygen in the air [9]. Beside biogas, waste animal manure was turned into more valuable and beneficial fertilizer or bioslurry to dress the farming fields at the end of this process [10]. Cow dung waste is harmful to the surrounding environment that produces CH4 gas and has a fairly high BOD and COD value [11]. Methane is a major constituent of biogas and although the contribution of methane (CH4) molecule to the greenhouse effect is 21 times greater than carbon dioxide molecules, consuming methane in the form of renewable energy, reducing its impact on the environment [12].
Biogas technology has the following advantages: generation of storable energy sources, stable production the residue that can be used as fertilizer, energy-saving mean manufacture of nitrogen-containing fertilizers, a process that potential for sterilization that can reduce public health hazards from: fecal pathogens, and when applied to agricultural residues, the reduction of transfer of fungi and plant pathogens from one plant to another carry on [13].

The total cow dung waste is converted in m$^3$ per kilogram. Conversion from different sources, United Nations (1984) quoted by Widodo (2004) in [14] and (Hanif, nd) states that 1 kg of cow or buffalo dung waste produces 0.023–0.040 m$^3$ of biogas. In order to equalize the value of methane energy with domestic energy needs, it is necessary to convert SBM. Based on the metric conversion, it is stated that in 1 m$^3$ it is equivalent to 6.28981 BOE.

The higher the methane content, the greater the energy content (calorific value). Calculation of the energy value produced from biogas can be done by assuming 1 kg of cow dung can produce 0.03 m$^3$ of gas. The heat energy produced is around 5200-5900 kcal/m$^3$. The calorific value in 1 m$^3$ of biogas is equivalent to 6 KWh of electrical energy; 0.62 liters of kerosene; 0.52 liters of diesel oil; 0.46 kg of LPG; 3.50 kg of firewood and 0.80 liters of gasoline (Salundik, 2008). The chemical composition and biological availability of nutrients contained in material varies with species, factors affecting growth and the age of the animal or plant [16].

3. Research methods
This research uses literature study to collect relevant data. The reference obtained is processed using an analysis of the calculation of the national scale LPG type energy demand during the 2020 pandemic which is converted into the total demand for cow dung to be processed into biogas, then a modeling of the savings generated by biogas is carried out in meeting the energy needs of the LPG type and the sector. household scale nationally in 2020. Thus, the ability to save biogas is obtained in supporting energy security during the Covid-19 pandemic, especially in terms of affordability.

4. Results and Discussion
The average energy demand for LPG and the household sector on a regional scale is 2.4 million BOE based on calculations from BPPT data (2020). The conversion of LPG type energy requirement of 2,400,000 BOE to biogas production potential in units of m$^3$/kg is calculated by the following formulation.

$$\frac{2,400,000 \text{ BOE}}{6.28981} = 381,569.55 \text{ m}^3/\text{kg}$$

The total methane value above is then converted to the total cow dung in kilograms. Conversion from United Nations (1984) quoted by Widodo (2004) in [14] and (Hanif, nd) states that in 1 kg of cow dung waste produces 0.023–0.040 m$^3$ of biogas.

$$\frac{381,569.55 \text{ m}^3/\text{kg}}{0.04} = 9,539,238.75 \text{ kg} \sim 0.9 \text{ metric tons}$$

The total cow dung that is able to substitute for the energy needs of 2.4 million BOE LPG through the biogas production process is 9539238.75 kg or 0.9 metric tons. Based on this value, biogas savings are calculated using Powersim 10. Thus, this production is not only able to meet domestic demand, but also reduces imports of LPG. The following is a Causal Loop Diagram (CLD) of savings by biogas.
Based on the Causal Loop Diagram (CLD) above, then the Stock Flow Diagram (SFD) in Figure 2 below is carried out.

Table 1. Waste and Methane Conversion

| Year | Cow Dung Waste (kg) | Methane (m$^3$/kg) |
|------|----------------------|---------------------|
| 1    | 9539238.75           | 129659584.35        |
| 2    | 9539238.75           | 31488756.99         |

Table 2. Biogas Savings on LPG

| Year | Total Energy Savings (kg) | Cost Savings (Rp) |
|------|---------------------------|-------------------|
| 1    | 59643408.80               | 690849604143.82   |
| 2    | 144848278.52              | 1.68e12           |

Table 3. Biogas Savings on Gasoline

| Year | Total Energy Savings (liter) | Cost Savings (Rp) |
|------|-----------------------------|-------------------|
| 1    | 103727667.48                | 793516656224.11   |
| 2    | 251910049.59                | 1.93e12           |
Table 4. Biogas Savings on Solar

| Year | Total Energy Savings (liter) | Cost Savings (Rp) |
|------|-----------------------------|-------------------|
| 1    | 64829792.18                 | 333873429702.14   |
| 2    | 157443781.00                | 810835472133.77   |

Table 5. Biogas Savings on Kerosene

| Year | Total Energy Savings (liter) | Cost Savings (Rp) |
|------|-----------------------------|-------------------|
| 1    | 8038942.30                  | 1.5e12            |
| 2    | 195230288.44                | 2.54e12           |

Table 6. Biogas Savings on Wood

| Year | Total Energy Savings (kg)   | Cost Savings (Rp) |
|------|-----------------------------|-------------------|
| 1    | 453808545.23                | 4.54e12           |
| 2    | 1102106466.98               | 1.10e13           |

Figure 3. Savings on Total Other Energy Sources

Figure 4. Cost Savings of Other Types of Energy Sources
5. Conclusion
The results showed that the national energy demand for LPG in 2020 during the Covid-19 pandemic of 2.4 million BOE could be fulfilled by a biogas source from 95,392,387.5 kg or the equivalent of 0.9 metric tons cow dung waste. This cow dung waste is able to produce 38,156,955 m³/kg of methane gas which is equivalent to 0.59 metric tons of LPG, savings Rp 690 billion; 103 million liters of gasoline, savings Rp 793 billion; 64.8 million liters diesel fuel, savings Rp 333.8 billion; 80 million liters of kerosene, savings Rp 1 T; 4.53 metric tons of wood, savings Rp 4.5 T. This favorable situation must be immediately felt by the community with an estimate of future benefits.

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