ISSN 2549-4848
E-ISSN 2580-7749
JuTEkS, Vol. 8, No. 2, Oktober 2021
http://ejournal.uika-bogor.ac.id

Simple Methods for Observing and Utilizing Biogas as a Renewable Energy Source

Arief Goeritno
Electrical Engineering
Study Program,
Faculty of Engineering and Science,
Universitas Ibn Khaldun Bogor
Email:
arief.goeritno@uika-bogor.ac.id

Nursyamsu Mahyuddin
Pondok Pesantren Pertanian
Darul Fallah
Email:
nusagri@gmail.com

Walad Ahsani
Electrical Engineering
Study Program,
Faculty of Engineering and Science,
Universitas Ibn Khaldun Bogor
Email:
waladahsan@gmail.com

Muhammad Alif Novianto
Electrical Engineering
Study Program,
Faculty of Engineering and Science,
Universitas Ibn Khaldun Bogor
Email:
muhammadalifnovianto70@gmail.com

Inggar Ibn Albar
Electrical Engineering
Study Program,
Faculty of Engineering and Science,
Universitas Ibn Khaldun Bogor
Email:
inggaribnu@gmail.com

Felix Aditya Rachman
Electrical Engineering
Study Program,
Faculty of Engineering and Science,
Universitas Ibn Khaldun Bogor
Email:
felixadityo1234@gmail.com

Abstract – **One combustible and burnable gas that can be created through an anaerobic fermentation process is biogas. An anaerobic process occurs when organic material, like animal dung, is processed in a digester (reactor) without the presence of oxygen. This observation's objectives are to (i) disseminate knowledge about the biogas production process and (ii) acquire a generation system for producing biogas. The observation methods are based on the use of an observation algorithm in the form of a flow chart, and it includes (a) observations related to various stages of choosing the type of installation, the requirements and processes for the formation of biogas observed and utilized from readily available organic materials, and influencing factors; and (b) observations related to the generation system for the production of biogas observed and utilized, including the physical reservoir, the amount of biogas produced, and the biogas utilized for supply to the electricity generator. The results of the observations related to the generation system, including the physical reservoir, the amount of biogas produced, and the biogas used for supplying the electricity generator, while the results of the observations related to the biogas production process, including the availability of installations, requirements and processes for biogas production, and influencing factors for the formation of biogas. Based on these findings, it can be said that the best period of time for biogas production is between 14 and 16 days, with a production volume of 6.0 m^3/day. While 0.64 m^3 of biogas is needed for electric lighting, 0.30 m^3/hour of biogas at a pressure of 75 mm H_2O is needed for cooking activities. While pure methane gas has an energy content of 8,900 kcal/m^3, the resulting calorific value is relatively high, ranging from 4,800 to 6,700 kcal/m^3.**

Keywords: Simple methods, observing and utilizing, biogas, renewable energy source.

I. INTRODUCTION

This paragraph's background information is important to explain the choice of this paper's title. Anaerobic fermentation, also known as energy production in cells in a state without oxygen, with organic materials such as livestock manure, agricultural waste biomass, or a mixture of both, in a digester chamber or reactor, can produce biogas, a type of gas that can be burned and is flammable [1, 2]. The dictionary defines potential as strength, ability, or power, which is interpreted as all forms of ability with the potential to be developed [1]. This definition also includes the definition of observation, which is a way to foster the development of one's imagination, and utilization, which is a method or process of action in the form of an effort to do something for a specific use. Energy derived from non-fossil sources, such as coal, oil, and liquefied natural gas, is referred to as alternative energy. Dairy cows that frequently and continuously produce feces and pee congregate in the area used to make fresh milk. The primary ingredients used to create biogas are excrement and pee.

Several cutting-edge related studies that are presented must be explained, per the background description. According to empirical studies, it takes roughly 14 days for natural gas to become available. Methane gas (CH_4), which has a relatively high heating value of 4,800 to 6,700 kcal/m^3 and an energy content of 8,900 kcal/m^3, is the primary component of biogas as a usable fuel. Due to its high calorific value, biogas can be utilized for a variety of tasks [3], such as lighting, cooking, and as a source for prime movers in 1–5 kW micro-capacity generators. Biogas energy is a renewable resource that can be used as an alternative energy source. Alternative meanings are ways to choose between two or more options. The use of gas-based renewable energy for household needs, including all aspects of daily life in the home, has become widespread.

The usage of methane gas as a heat source dates back to the time of the ancient Egyptians, Chinese, and Romans. Alessandro Volta made the initial discovery of the fermentation method used to create methane gas in 1776. William Henry and Becham both performed the detection of combustible gases in 1806 and 1868, respectively. The microbial cause of methane production was initially identified in 1882 by Louis Pasteur and Tappeiner [4]. In 1900, the first anaerobic biogas generator was created. Germany and France conducted research towards the end of the 19th century with a focus on methane gas as biogas during World War II. Many farmers in the UK and continental Europe produced tiny amounts of biogas during World War II, which was used to power tractors. In the 1950s, fuel oil was inexpensive and easily accessible, causing the use of biogas to decline. Residents of developing nations face a variety of challenges, including a constant demand for affordable energy sources. On the basis of this, biogas generation activities have been ongoing in India since the 12th century. At that time, a number of nations, including China, the Philippines, Korea, Taiwan, and Papua New Guinea, had made progress in their varied biogas-generating equipment research and development efforts [5].

An anaerobic fermentation process (without air) takes place in a digester. There are two categories of digesters [4] based on the filling technique: batch feeding (filling once) and continuous feeding (filling continually). In a digester known as a batch feeder, organic matter (a mixture of manure and water) is filled once to capacity, and then the digester is left empty until biogas is created. The digester's contents are disassembled and then refilled with fresh organic material whenever the biogas is no longer produced or the output is very low [4]. After the biogas production starts, a set amount of organic matter is loaded into a continuous feeding digester each day in a specific amount. Wait until biogas is produced once the digester has reached its initial capacity. Following the production of biogas, an amount of organic matter is continually added each day [6]. The two types of continuous feeding digesters are the fixed-dome type and the floating-dome type.

Observations were made regarding the possibility for dairy cow's milk production sites in the vicinity of Jalan Tanjakan Cinangneng, Bojong Jengkol Village, Ciampea Subdistrict, District of Bogor, Province of Jawa Barat to be used as a source of alternative energy based on some of the preceding paragraphs. Dairy production sites are locations where it may be possible to find dairy cow excrement that can be used to make biogas, an alternative fuel that can be burned in stoves or through devices that convert it into power. This observation's goals are to (i) disseminate knowledge about the biogas production process and (ii) acquire a generation system for producing biogas.

II. LITERATURE REVIEW

A floating dome-type digester works on the premise of mixing water and animal excrement in the correct proportions after it has been collected in a tub. The liquid waste is mixed before being supplied into the input pipe of the digester. The generated gas is either contained in a dome or floats at the top of the digester. A gas outlet is included in the steel floating or floating dome. The up and down movement of the dome can preserve the stability of the generated gas pressure. The front section of the floating-dome type digester [6] is shown in Figure 1.

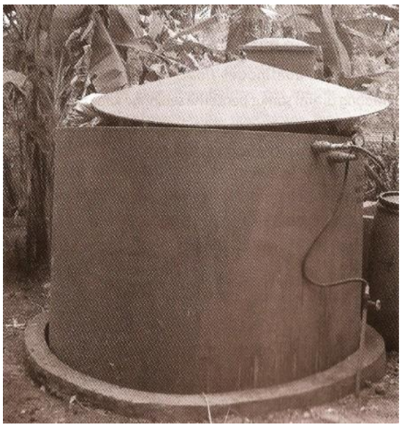


Figure 1. The front section of the floating-dome type digester

A fixed-dome type digester works on the premise of combining the digester and storage tank while continuously feeding it with organic materials. Based on the amount of livestock manure and desired output of biogas, this sort of dome can be built. Because the digester life is longer, maintenance is simpler, and operation is simpler, the permanent type does require more capital. Longitudinal cross-section of the fixed-dome digester [6] is shown in Figure 2.

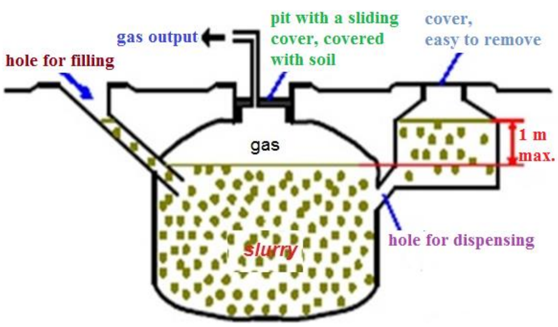


Figure 2. Longitudinal cross-section of the fixed dome digester

Additionally, compared to other livestock manures, dairy cow dung includes methane gas (CH_4) at a relatively high level. Because of this, the biogas produced can be used for cooking, lighting, and powering electric generators. Pure methane gas has a calorific value of 8,900 kcal/m^3, whereas methane gas (CH_4) has a range of 4,800 to 6,700 kcal/m^3 [6]. Dairy cow feces can be utilized for the generation of biogas, but the leftover fermentation sludge can also be used as manure since the anaerobic breakdown of organic matter takes place during the fermentation process in the digester. Sludge is also created with a range of excellent minerals that plants require, including copper (Cu), zinc (Zn), phosphorus (P), magnesium (Mg), calcium (Ca), and potassium (K).

III. MATERILAS AND METHODS OF OBSERVATION

A. *Materials of Observation*

Cow dung, a typical ingredient in the creation of biogas, serves as the primary component. As a result, with the care of 5 to 10 large dairy cows, quite a bit of waste can be created for the biogas generation process. This is related to the potential for waste from dairy cow dung more than other forms of cow dung. The comparison of the mass of manure from some livestock types [6] is shown in Table 1.

Table 1. The comparison of the mass of manure from some livestock types

Types of Livestock	Livestock Weight (kgs)	Manure Production (kgs)	Dry Ingredients (%)
Beef Cattle	520	29	12
Dairy Cow	640	50	14
Sheep	40	2	26
Pig	90	26	9

Based on Table 1 it is shown and can be explained that the balance of carbon (C) and nitrogen (N) in organic matter has a significant impact on the life and activity of microorganisms. For degrading microorganisms, a C/N balance of 25% to 30% is ideal. It is required to add additional agricultural waste [6] that has a high (C/N) balance (more than 30%) because the dung (feces and urine) of dairy cows has a (C/N) concentration of 18%. Several equations, including eqns. of (1), (2), and (3), explain the search for the ratio (C/N) in biogas.

$$\text{Ratio } N = \text{Amount of dirt (waste) x } N\ [\%] \quad (1),$$

$$\text{Ratio } C = \text{Amount of dirt (waste) x } C \quad (2),$$

$$\text{Total Ratio in biogas} = \frac{C}{N} \quad (3),$$

where: amount of dirt in kgs and N in %.

B. *Methods of Observation*

The research methods consist of an algorithm for acquiring each observation target and are constructed in the form of a flowchart, as has been done in several study findings [7-12]. Each observation objective's implementation process includes a number of stages, on which this observation's phases are based. The stages of conducting observations are related to learning more about the biogas production process, such as the type of installation to use, the conditions and procedures for producing biogas from observable and usable organic materials, and the influencing factors. The steps involved in conducting observations are related to the generation system for producing biogas, including physical storage tanks, the quantity produced, and the biogas used to supply energy generators.

The observation methods are based on the use of an algorithm in the form of a flowchart [7-12] is shown in Figure 3.

Based on Figure 3, it is clear that this observation has two objectives: producing biogas through various processes, and producing it through a generation system. The stages that relate the first objective of observation (i) a variety of installation type options, (ii) the conditions and processes for the formation of biogas that are observed and utilized from available organic matter, and (iii) influencing the factors are carried out in order to explain the biogas production processes. Regarding the second purpose of observation, various phases are carried out to explain the biogas production system. These stages include (i) the physical storage tank, (ii) the amount of biogas produced, and (iii) the use of biogas for supplying an electric generator.

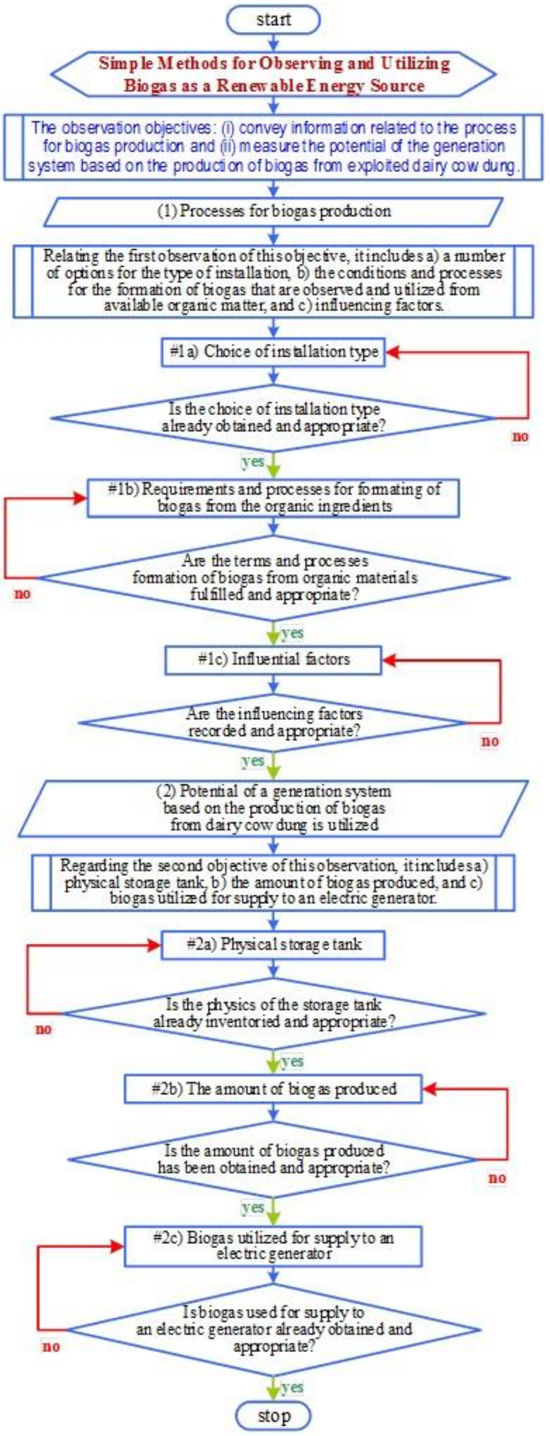


Figure 3. The observation methods are based on the use of an algorithm in the form of a flowchart

IV. RESULTS AND DISCUSSION

This chapter of results and discussion is a complete explanation related to the objectives of observation after going through a number of stages in the research methods, namely an explanation of biogas production processes and generation systems for biogas production.

A. Biogas Production Processes

An explanation regarding the biogas production process, including (a) the availability of installations, (b) the terms and production processes, and (c) the influencing factors for the formation of biogas.

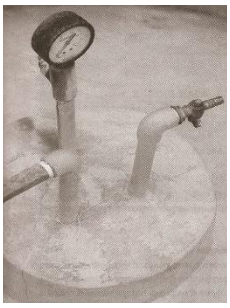
A.1. Availability of installation

In order for the dung to be directly directed into the digester, the construction site should not be too distant from the cattle pens. There are challenges that must be overcome in order to build biogas installations remote from cow pens, such as the necessity to carry animal waste from the cages to the digester site or to create a manure canal to the digester, like Setiawan accomplished in 2007. a digester serves both as a container for organic matter storage and fermentation. Livestock dung from the cage must be able to flow constantly into the digester. In order for the manure from the cage to flow straight into the digester, the digester is constructed in the excavated soil such that its location is lower than the cage. The digester may be rectangular or spherical like a well. However, as demonstrated by Setiawan in 2007, the majority of the digesters are spherical with a diameter of 3 meters and a depth of 2 meters.

Red bricks are used for the walls and river stone for the foundation in the pit that has been dug. Prepared the materials' entry and exit as well. Red brick-filled holes need to have their walls plastered with a sand and cement mixture to make them tight and strong. Remember that this digester needs to be robust and airtight. As Setiawan did in 2007 [3], the plastered walls are plastered with cement to make them airtight, followed by putty and painting with a pool-specific color. The digester and gas reservoir are linked because the gas storage dome is constructed to immediately seal the digester. A wooden frame coated in plywood and an iron frame are used to build domes that are typically one meter high. After installing the iron frame as reinforcement, the dome frame is then cast to ensure that it is sturdy and tight enough to withstand gas pressure, as was done by Wibawa in 2001 [2]. A gas supply hole is constructed at the top of the dome to distribute gas to the stove. Iron pipe with a controlling valve is used to create the hole. The wooden frame and plywood in the digester hole are taken out and cleaned through the organic matter exit in cases where the dome from the casting is dry. To prevent leaks, the dome's inner and exterior walls must be covered in cement, putty, and swimming pool paint.

An inch-diameter pipe, made of polyvinyl chloride, iron, or both, is attached to the faucet above the dome to distribute gas to the kitchen's stove. To prevent gas leaks, the pipe installation must be extremely sturdy and tight. The installed stove is a gas stove that typically burns liquid petroleum gas (LPG). The gas line is initially linked to a plastic hose with a size smaller than an inch (such as an LPG hose) before the gas reaches the stove. As Wibawa demonstrated in 2001 [2], this plastic hose may be hooked to the stove directly and have a faucet attached to the connection. Installation of gas pipes and rubber hoses is shown in Figure 4.

ISSN 2549-4848
E-ISSN 2580-7749
JuTEkS, Vol. 8, No. 2, November 2021
http://ejournal.uika-bogor.ac.id


(a) installation of gas pipe


(b) installation of rubber hoses

Figure 4. Installations of gas pipes and rubber hoses

A.2. Terms and process of biogas production

Organic material, particularly livestock and/or agricultural waste, is used as digester filler. Dairy cow feces have been the waste used as a filler the most frequently so far. This is because, as determined by Wibawa in 2001 [2], there is the possibility for additional waste to be created from cow manure, such that with the upkeep of 5 to 10 cows, enough waste may be produced to produce biogas. Activities The chemical components of these organic materials have an impact on microorganisms that breakdown organic matter as well. Carbon balance (C) and nitrogen or ratio (C/N) are variables that are frequently used to assess whether or not organic matter is suitable for use as a digester filler. An ideal ratio (C/N) value for methanogenic bacteria is between 25% and 30%. According to research conducted by Wibawa in 2001, cow dung and urine are the most often used ingredients for digester filling.

As Simamora accomplished in 2006 [6], a digester with inlet and outlet holes, a gas reservoir, and a sludge reservoir make up the majority of a biogas plant. The amount of biogas produced is influenced by a variety of factors. Both internal (from the digester) and external factors affect the amount of biogas. Balance (C/N), acidity (pH), and homogeneity of the filling are internal considerations. Temperature or temperature variations are the external component that has the biggest impact on the amount of biogas. The ideal temperature range for destroyer bacteria is 25 to 280 ^{0}C. It is important to carefully plan the biogas installation building's layout to minimize exposure to direct sunlight. Many works are constructed by covering them with shade or burying them in the ground, as Simamora did in 2006 [6].

The anaerobic breakdown of organic matter in the absence of oxygen results in the production of biogas, which is mostly composed of methane (CH_4) and carbon dioxide (CO_2). Swamp gas or biogas is the name of the generated gas. Because it contains combustible methane gas (CH_4), the resulting biogas can be utilized as fuel. Numerous microorganisms, particularly methane bacteria, support the anaerobic breakdown process. Between 25 and 55 ^{0}C is a favorable temperature range for the fermentation process. As demonstrated by Simamora in 2006 [6], bacteria may efficiently break down organic compounds at that temperature. The composition of the gas contained in biogas formation is shown in Table 2.

Table 2. The composition of the gas contained in biogas formation

Types of Gas	Amount (%)
Methane (CH_4)	54-70
Carbon dioxide (CO_2)	27-45
Nitrogen (N)	0,5-3
Carbon monoxide (CO)	0.1
Oxygen (O_2)	0.1
Hydrogen sulfide (H_2S)	very little

A.3. Influential factors for the formation of biogas

The success of biogas generation is influenced by a variety of factors. The ideal environmental conditions for the growth of modified bacteria are a supportive factor for quickening the fermentation process. Simamora listed several elements that affect biogas production in 2006 [6]. Anaerobic bacteria use organic materials as a fuel source to make biogas. The equipment used to treat the biogas must be airtight. The gas created is lost and mixes with the air in situations when there is no free air, like Simamora did in 2006. Organic wastes such as livestock manure, agricultural waste, food waste, and organic waste serve as the primary raw materials for filling. Dairy cow excrement is a typical source of raw material. Inorganic substances like sand, stone, plastic, and glass must be kept away from stuffing raw ingredients in order to prevent the fermentation process from being inhibited. About 7% to 9% of the dry materials in this stuffing is ideal. A 1:1 dilution with water can be used to produce this state, as Simamora demonstrated in 2006 [6].

The existence of microbes is greatly influenced by the level of acidity. The range of 6.8% to 7.8% is the ideal level of acidity for the survival of microorganisms. During the first stage of fermentation, organic matter produces acid (organic acid), causing the pH to drop by between 4% and 5%. Simamora in 2006 [6] added a solution of lime ($Ca(OH)_2$) or lime ($CaCO_3$) to the mixture to get the ideal pH. One of the requirements for the generation of biogas is temperature. The ideal temperature for the production of biogas is between 30 and 50 0C. Due to abrupt temperature variations in the biogas processing facility, biogas output falls off quickly. By burying biogas installations or providing shade above the digester area, practical efforts are made to stabilize temperature. To hasten the transformation of organic matter into biogas, a starter is required. A commercially available microbe is referred to as a starter. As Simamora shown in 2006 [6], organic activated sludge or fluids from the rumen can be used as a starter.

B. Generation System for Biogas Production

The discussion relates to the generation system for the production of biogas, including (i) the physical reservoir, (ii) the amount of biogas produced, and (iii) the biogas utilized for supply to the electricity generator.

B.1. Physics of the storage tank

In the cage cleaning area, cow excrement from the cage is combined with water before being collected in a holding tank and inserted into the digester. So that the fermentation process can run smoothly, the reservoir is used to homogenize cow manure. The specifications for animal dung for stuffing include that it not be too thick, be in good shape, be well mixed with water, and be free of hard items like twigs and stones. The reservoir's size can be changed to match the digester's size. Since the reservoir and digester are close to one another, distribution from the reservoir to the digester is simpler. The cow dung that just exits a holding tank is lumpy, and it is crushed and blended with a 1:1 ratio of water to cow dung. In order to create cow dung mud, stirring must be done consistently. The sludge's shape makes it easier to put it into the digester. Additionally, using cow dung in the form of mud is excellent since it can be used to prevent scale formation in the digester, which could be a barrier to the production of biogas. The filler material's dilution affects how quickly biogas is produced. Stuffing is too dense in an attempt to speed up production since it takes less time than if it were too runny.

B.2. Amount of biogas produced

Biogas is produced over the course of around 14 days. The digester's top faucet is opened every day from the first to the eighth, allowing the created gas to escape. The initial gas that produced, which is predominately carbon dioxide (CO_2), is what causes this gas discharge. Carbon dioxide (CO_2) production decreases and methane gas (CH_4) production increases from day 10 to day fourteen. Biogas starts to occur when the ratio of methane (CH_4) to carbon dioxide (CO_2) is 54% to 27%, and it can be used to light stoves. Energy can be produced using biogas, which is always renewable, as of the fourteenth day. It has no smell, just like cow manure, is biogas. Additionally, cow dung mud is regularly added to the digester until the best biogas production is achieved. The gas discharge hose is sent to the gas stove once the ideal gas conditions have been achieved. A biogas source can be used to run any sort of gas stove. The adequacy of the biogas and air mixture must be taken into account while using gas stoves. When the ratio of biogas to air is optimal, a flame is produced that is blue and has a high calorific value, however when there is insufficient air, a flame that is yellowish in color and has less heat is produced. If there is too much air, on the other hand, the fire will go out and the biogas won't ignite.

The gas output regulating valve can be adjusted to properly control the mixture. While the measurement without load reveals a gas flow rate of 1.5 m3/hour with a pressure of 490 mm H_2O, the gas production produced at Darul Fallah is 6 m3/day (with an average biogas production of 30 liters of gas per kg of cow dung mass). Electric and gas stoves can both be lit with the biogas that is produced. There are several uses for biogas, including (i) cooking in the kitchen, which requires 0.30 m^3/hour at a pressure of 75 mm H_2O, (ii) lighting with petromax lamps, which requires 0.23 m^3/hour at a pressure of 45 mm H_2O, and (iii) an electric generator, which requires 0.64 m^3. The biogas production process also yields leftover sludge, which can be used as organic fertilizer in addition to creating biogas. To create solid and liquid organic fertilizers, the leftover sludge can be divided into its solid and liquid components.

B.3. Biogas is utilized for supply to an electric generator

According to Zuhal in 2000 [13], an electric generator is a device that uses a magnet to transform mechanical energy into electrical energy. A synchronous generator's operation is based on electromagnetic induction. As explained by Petruzzela in 1996 [14], once the rotor has been rotated by the prime mover, causing the poles on the rotor to rotate, if the pole coil is given direct current, a magnetic field (lines of flux force) will arise on the surface of the pole that rotates at a speed equal to that of the pole. The installed generator is a Chinese-made CC 500 gas generator. The front section of the gas generator CC 500 type is shown in Figure 5.

Figure 5. The front section of the gas generator CC 500 type

Technical specifications of the synchronous generator CC 500 type, namely:
Generator Type: Brushless single-phase synchronous generator
Frequency (hertz): 50
Rated Output Voltage (volts): 220
Running Power (watts): 400
Peak Power (watts): 500
Displacement (cc): 80
Gas Consumption: 0.7 to 0.8 m^3/kilo-Watt-hour (kWh)
Starting Method: Recoil Start
Length x Width x Height (mm): 490 x 385 x 445
Gross Weight (kg): 22
Engine Model: CC 152F-MG-A
Engine Type: Single Cylinder, 4-stroke, Overhead Valve (OHV), Forced Air-cooled
Bore Stroke (mm): 52 x 38
Ignition System: Transistor Coil Ignition (TCI)
Oil Capacity (liter): 0.35
Temperature (^{0}C): -50 to 400
Gas Pressure: 3-6 kPa
Biogas: 65% Methane (CH_4)
Type of Fuel: LPG or Biogas
Fuel Consumption per kWh: 0.32 kg (LPG) or 0.64 m^3 (biogas).

The generator can operate after meeting the necessary requirements. The comparison between machine operating conditions and measurement results are shown in Table 3.

Tabel 3. The comparison between machine operating conditions and measurement results

Parameters	Terms of Condition for Operating the Machine	Measurement results*)
Temperature	-5^0-40^0 C	25^0-27^0 C
Gas pressure	3- 6 kPa	4 kPa
Biogas	65% Methane (CH_4)	77% Methane (CH_4)

*) at the Darul Fallah, Ciampea, Bogor.

The gas pipe is first linked to a plastic hose less than an inch in diameter before the gas flows into the stove or generator. Plastic hoses can be linked directly to a stove or generator, but the connection part needs to have a faucet attached. The generator can be used once the plastic hose has been attached to it and all necessary requirements have been met for operation. When the load is installed, the first measurement is made. The type of load on the measurement of the operation of the electric generator with biogas model of CC 500 is shown in Table 4.

Tabel 4. The type of load on the measurement of the operation of the electric generator with biogas model of CC 500

Types of Load	Amount of lamps	Power per Lamp (watts)	Total Power (watts)
Incandescent lamp	4	75	300
	4	15	60
Tubular lamp	4	10	40
Installed Load:			400

In order for the electric generator to run and give electricity to the load, the total installed load must not exceed the power installed on the generator. When the generator is running, the measurement is done within an hour (without attaching the gas hose from the digester). Because a gas hose connects the generator to the digester, the electric generator's operation depends on whether gas is present in the digester. The cross-section of the observation of the generator loading is shown in Figure 6.

Figure 6. The cross-section of the observation of the generator loading

V. CONCLUSION

Conclusions that are in line with the observation objectives can be made based on the findings and discussion. Under ideal circumstances, it takes around 14 days to produce gas. Around 6 m3/day of biogas are produced at the Darul Fallah. Through the use of an electric generator, this biogas can be used to power gas stoves and electric lighting. With a pressure of 75 mm H_2O, it needs 0.30 m^3/hour for cooking activities whereas 0.64 m^3 of biogas is needed for electric lighting. While pure methane gas has an energy content of 8,900 kcal/m^3, the resulting calorific value is relatively high, ranging from 4,800 to 6,700 kcal/m^3. A gas-fired electric generator with a 500 VA capacity is the one that is currently installed. The electric generator's measuring time while the load is running is one hour (60 minutes). The amount of biogas present in the digester determines how well the electric generator performs when it is running in situations where it is linked to the digester's gas pipe.

VI. REFERENCES

[1] Pusat Pembinaan dan Pengembangan Bahasa, Kamus Bahasa Indonesia, Jakrata: Balai Pustaka, 2010. https://kbbi.kemdikbud.go.id/entri/

[2] U. Wibawa. *Sumber Daya Energi Alternatif*, Universitas Brawijaya, Fakultas Teknik, Jurusan Teknik Elektro, Malang, 2001.

[3] I. Setiawan. *Memanfaatkan Kotoran Ternak*, Penebar Swadaya, Jakarta, 2007.

[4] S. Pamuji dan A. Wiji, "*Potensi Produksi dan Pemanfaatan Biogas dari Berbagai Sumber Bahan Organik*," *Jurnal Media Komunikasi Masyrakat Energi Terbarukan Indonesia*, Edisi 04/November, ITB, 2006.

[5] H. Berahim. *Penghantar Teknik Tenaga Listrik*, Elektronik Industri, Yogyakarta, 1991.

[6] S. Simamora. *Membuat Biogas Pengganti Bahan Bakar Minyak dan Gas Dari Kotoran Ternak*, Agromedia Pustaka, Jakarta, 2006.

[7] A. Goeritno, D. Nurmansyah, Maswan, "Safety Instrumented Systems to Investigate the System of Instrumentation and Process Control on the Steam Purification System," International Journal of Safety and Security Engineering, vol. 10, no. 05, pp. 609-616, Oct. 2020 https://dx.doi.org/10.18280/ijsse.100504

[8] A. Goeritno, I. Nugraha, S. Rasiman, and A. Johan, "Injection Current into the Power Transformer as an Internal Fault Phenomena for Measuring the Differential Relay Performance," Instrumentation Mesure (I2M), vol. 10, no. 06, pp. 443-451, Dec. 2020. https://dx.doi.org/10.18280/i2m.190605

[9] A.F. Nasyarudin, Ritzkal, and A. Goeritno, "Prototipe Perangkat untuk Pemantauan dan Pengendalian Berbasis Web Diiintegrasikan ke Smarthome System," *Indonesian Journal of Eletronics and Instrumentation Systems*, vol. 10, no. 2, pp. 167-178, Oct. 2020. https://dx.doi.org/10.22146/ijeis.58316

[10] A. Goeritno, and S. Pratama, "Rancang-Bangun Prototipe Sistem Kontrol Berbasis Programmable Logic Controller untuk Pengoperasian Miniatur Penyortiran Material," *Jurnal Rekayasa Elektrika*, vol. 16, no. 3, pp. 198-206, Des. 2020. http://dx.doi.org/10.17529/jre.v16i3.14905

[11] S. Tirta, and A. Goeritno, "Simulator Berbasis PLC untuk Pengaturan Lalu-lintas Jalan Raya pada Perlintasan Jalur Kapal," *Jurnal RESTI* (*Rekayasa Sistem dan Teknologi Informasi*), vol. 4, no. 6, pp. 1007-1016, Des. 2020.https://dx.doi.org/10.29207/resti.v4i6.2668

[12] L. Hardian, and A. Goeritno, "Pabrikasi Unit Kontrol Berbasis Web pada Smarthome System untuk Pengoperasian Pintu Gerbang," *Jurnal RESTI* (*Rekayasa Sistem dan Teknologi Informasi*), vol. 5, no. 1, pp. 163-173, Februari 2021. https://dx.doi.org/10.29207/resti.v5i1.2879

[13] ZUHAL, *Dasar Teknik Tenaga Listrik dan Elektronika Daya*, Gramedia Pustaka Utama, Jakarta, 2000.

[14] F.D. Petruzzela. *Elektronik Industri*, Andi Offset, Yogyakarta, 1996.