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# Management of Organic Waste Utilization into Bioenergy

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**Abstract**

Organic waste has great potential as a renewable energy source through the process of conversion into biogas. This process, which involves utilizing organic materials such as agricultural waste, food waste and livestock manure, can reduce the negative impact of waste on the environment as well as provide a more environmentally friendly energy alternative to fossil fuels. The purpose of this research is to examine the management of organic waste utilization into biogas, as well as explore the challenges and solutions faced in the application of biogas technology in Indonesia. The problem formulations to be discussed in this research include (1) how to optimally manage organic waste into biogas? (2) what are the obstacles faced in the implementation of biogas technology in Indonesia? and (3) what is the impact of organic waste management on the sustainability of renewable energy in Indonesia?

This research uses the literature study method by analyzing various relevant reference sources, including scientific journals, research reports, and publications of related institutions. The results show that although biogas technology has great potential, its implementation in Indonesia is still hampered by various factors, such as limited infrastructure, public awareness, and suboptimal economic support. The management of organic waste for biogas production, which includes anaerobic digestion, fermentation and gasification processes, shows effective results in producing renewable energy. This study also suggests the need for improved policy and technical support to accelerate the adoption of biogas technology in Indonesia to support the sustainability of renewable energy.

**Keywords:** organic waste, biogas, renewable energy, waste management, biogas technology



## Introduction

Organic waste is one of the environmental problems that is increasingly complex along with the increasing human population and industrial activities. If not managed properly, organic waste can be a source of environmental pollution, increase greenhouse gas emissions, and contribute to various public health problems. Therefore, an effective and sustainable strategy in organic waste management is needed so that the negative impacts can be minimized, while providing benefits to society and the environment. Organic waste management has become a pressing global issue along with increasing urbanization, industrialization, and consumption. Organic waste, which comes from domestic, agricultural, and industrial activities, accounts for the largest proportion of total solid waste in most countries, including Indonesia. Poorly managed organic waste can have serious impacts on the environment, such as soil, water, and air pollution (Marzuki et al., 2018), as well as increase greenhouse gas emissions such as excess methane ($CH_4$) (Rivaldi et al., 2022), and can contribute to climate change. Based on data from the Ministry of Environment and Forestry (KLHK), in 2024 there will be 8.3 million

tons of unmanaged waste, equivalent to 40.96% of all waste in Indonesia, most of which ends up in landfills without adequate processing. One solution that is now starting to be implemented is bioconversion, which is the process of utilizing organic solid waste into bioenergy, such as biogas, bioethanol, or biodiesel (Suhartawan et al., 2023).

This approach involves the process of utilizing microorganisms or other organisms to convert organic materials into more valuable products, such as biogas, bioethanol, and biodiesel. Bioconversion is not only able to reduce the volume of organic waste that is wasted into the environment, but also has great potential in providing an environmentally friendly renewable energy source. This technology is becoming increasingly relevant given the world's growing energy needs and the urgency to switch from fossil fuels to more sustainable alternative energy. Bioconversion itself is a process that uses living microorganisms such as bacteria, fungi, and insect larvae to convert organic waste into methane energy sources through fermentation (Salsabela et al., 2023). This process not only contributes to reducing the volume of waste that accumulates, but also produces renewable energy sources that can be utilized for community needs. However, the implementation of organic waste management policies through bioconversion in Indonesia still faces various challenges, including limited infrastructure, low levels of public education, and lack of incentives for environmentally friendly technologies.

However, although bioconversion has shown positive prospects, its application still faces various challenges. Some of the factors that affect the success of this technology include process efficiency, operational costs, availability of supporting infrastructure, and regulations that support implementation at the industrial and community scale. Therefore, this study aims to explore various bioconversion methods that can be applied in organic waste management, evaluate the efficiency and sustainability of the system, and identify constraints and opportunities that may be faced in its application. By examining various aspects of organic waste bioconversion, this research is expected to make a significant contribution to the development of waste management technologies that are more environmentally and economically friendly. In addition, the results of this study can also serve as a reference for policy makers and industries in designing more effective organic waste management strategies and supporting the transition to a renewable resource-based energy system. Thus, this study not only provides benefits in the academic realm, but also has practical implications in supporting environmental sustainability and climate change mitigation.

## Methods

### 1. Study location and research time

This research was conducted in July - August 2023 with the latest literature coverage within 5 years. The data taken is literature data from various research sources obtained through Science Direct, Elsevier, Google Scholar and other websites. To find relevant literature, the keywords “biogas” and “management” were used in the search process and have undergone screening and review stages.

### 2. Data analysis procedure

In this study, the method chosen was the Descriptive Qualitative research method (Zaqinadevi & Nisrinadevi, 2024). Qualitative research deals with data analysis and interpretation of the object of study (Zaqinadevi & Yuniati, 2023). The research used qualitative techniques with a literature study approach to examine the relevance of various research sources on how biogas management is carried out in Indonesia. The author searches and collects literature data both through the internet, text books, as well as national and international scientific journals, newspapers and so on related to the utilization and problems of biogas as an alternative energy.

## Results and Discussions

### 1. Results

Bioenergy refers to energy obtained from organic materials such as plants, animals and organic waste through biological processes. In contrast to fossil energy, which is non-renewable and potentially polluting to the environment, bioenergy provides a more environmentally friendly alternative. One of the growing forms of bioenergy is organic waste processing, which includes various techniques such as fermentation, composting and gasification. These techniques allow waste such as food scraps, leaves, animal waste, and other wastes to be converted into biogas, biofuel, or thermal energy. The process is quite complex, involving several stages and technologies that aim to obtain maximum energy from organic materials. One stage that is often used is anaerobic digestion, where microorganisms break down organic matter in the absence of oxygen. The result is biogas containing methane, which can be used to generate electricity or processed into compressed natural gas (CNG) for transportation purposes. By optimizing the use of renewable resources such as waste, bioenergy can help reduce waste problems while supporting the achievement of clean and sustainable renewable energy.

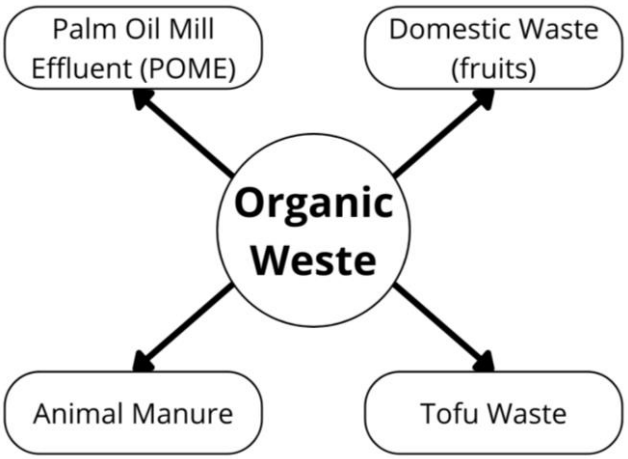


Figure 1. Organic Waste
Sources: Personal Documentation, 2025.

The results of literature analysis in the form of research on biogas utilization in Indonesia according to Salim and Kafiar (2017) with the title Making a simple biogas producing device in Hawaiian Village, Jayapura Regency Biogas technology does not seem to be popular in the Hawaiian Village community in Sentani Tengah District, Jayapura Regency. It is known that Indonesia holds a lot of potential for New Renewable Energy (EBT) resources. Maximizing the utilization of these resources can play an important role in strengthening the sustainability of Indonesia's energy supply by reducing dependence on fossil fuels (Khalil et al. 2019). Indonesia provides diverse sources of organic matter that can be utilized as a source of biogas fuel.

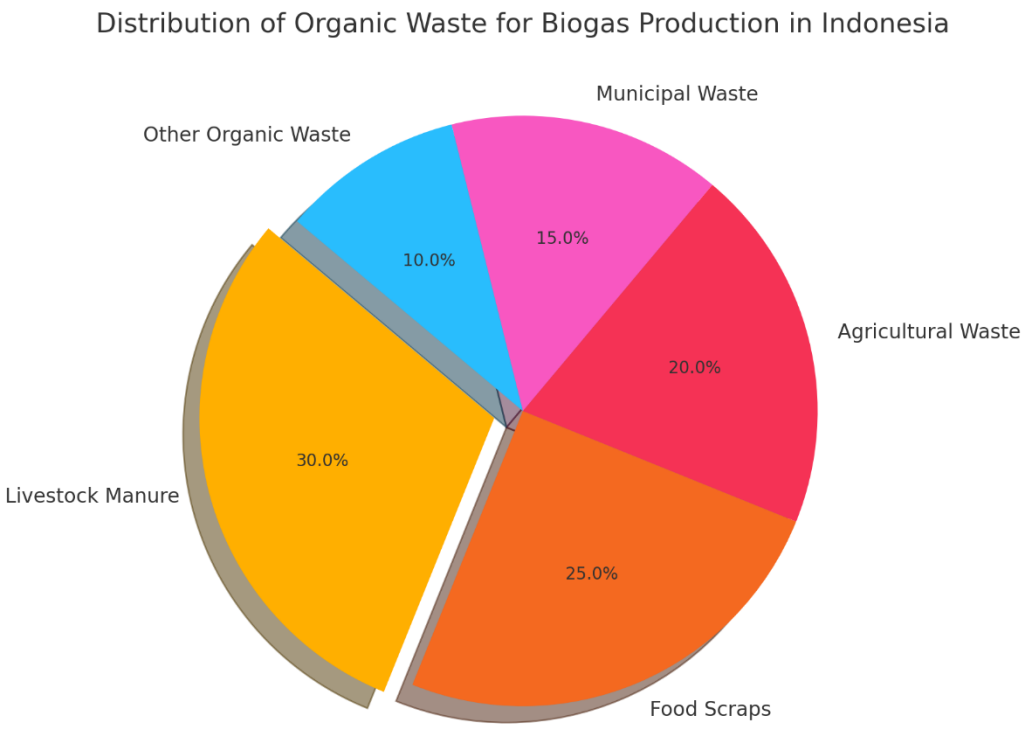


Figure 2. Distributiom of Organic Waste for Biogas Production in Indonesia
Sources: Personal Documentation, 2025.

A number of biomass feedstocks derived from organic waste feedstocks are abundantly available in Indonesia, and can be utilized to produce biogas. The availability of such organic feedstocks is increasing due to the growing economy and human population. These wastes (livestock manure, food scraps, etc.) are often left unmanaged and often thrown away, which can cause serious problems both for the environment and adversely affect human health itself.

## 2. Discussions

### a. Palm Oil Mill Effluent (POME)

Palm oil is one of the plantation commodities that plays a crucial role in Indonesia's economy, as the country is the world's largest producer and exporter of palm oil (Rajani et al., 2019). According to data from the Indonesian Palm Oil Association (GAPKI) in 2018, Indonesia's palm oil production in 2017 reached 38.17 million tons, reflecting an 18% increase compared to the 2016 production of 35.57 million tons. However, on the other hand, wastewater production from the palm oil industry is very high and has great potential to pollute the environment. The liquid residues generated mainly come from three stages in the palm oil production process, namely during bunch sterilization, after separation of the kernel from the shell using hydrocyclones, and after oil clarification. This liquid residue is known as Palm Oil Mill Effluent (POME) (Garritano et al., 2018).

POME contains residual oil that can damage aquatic organisms and cause soil degradation through infiltration, which in turn can cause nutrient imbalances that inhibit plant growth. If POME is not treated properly and discharged directly into the environment, it can have an adverse impact on the ecosystem. As a solution, the utilization of POME as biogas fuel is an alternative that can be applied by palm oil mills to reduce the negative environmental impact caused by POME. Processing POME into a biogas energy source requires proper management procedures. In some cases, the biogas produced

during the POME decomposition process through anaerobic digestion is not fully utilized. Instead, the POME is allowed to evaporate into the atmosphere, which not only wastes the full potential of biogas utilization, but also contributes to greenhouse gas emissions that can cause air pollution (Nasir et al., 2013).

Another issue associated with bio-methane production is the potential formation of highly toxic hydrogen sulfide during anaerobic digestion. In the final stages of anaerobic digestion, there is a high potential to produce this compound, so an effective biogas cleaning process is required to remove hydrogen sulfide and other toxic compounds (Li et al., 2014). Biogas technology in Indonesia is still at the development stage. In East Kalimantan, several palm oil mills already have biogas facilities, but the integration of these systems is still not optimal.

**b. Domestic Waste (fruits)**

According to data from BPS (2017), fruit and vegetable production in Indonesia in 2016 was recorded at 17.5 million tons. The volume of waste generated from fruits and vegetables is proportional to the population and the level of economic activity. Along with this development, it is expected that the amount of food waste will continue to increase. To reduce this impact, the waste generated can be utilized as a source of biogas energy. A study shows that a fruit waste-based biogas plant in Yogyakarta provides significant social, economic and environmental benefits for workers, consumers and the local community. The plant also provides employment opportunities for local residents. Such positive impacts are crucial to support the sustainability of biogas plants, given that social factors play an important role in waste management and renewable energy implementation in Indonesia.

**c. Tofu Waste**

Liquid waste generated from the tofu processing process can cause water pollution if discharged into rivers or lakes, potentially negatively impacting the health of communities around these water sources. However, tofu liquid waste, which is considered useless, contains organic materials such as amino acids and proteins. In addition, tofu liquid waste has the potential to be used as biogas fuel because it contains various types of gases such as hydrogen sulfide (H2S), oxygen (O2), carbon dioxide (CO2), ammonia (NH3), and methane (CH4) (Ridhuan, 2012). Tofu factories, whether small, medium or large scale, are spread across Indonesia and produce liquid waste and solid waste. Tofu liquid waste comes from soaking, washing, draining, and separating solids in the tofu making process, which produces a large amount of waste from the total raw materials (Anwar, 2020). The management of biogas from tofu liquid waste is still rarely done and needs to be introduced so that it can be widely applied by tofu producers in Indonesia. This step also supports the achievement of the 7th point in the Sustainable Development Goals (SDGs), namely the provision of affordable and clean energy. To produce biogas from tofu liquid waste, a minimum processing capacity of about 600 kg is required.

**d. ` Animal Manure**

Some regions in Indonesia are mostly farmers (Fauziah & Hidayatullah, 2023). Various types of livestock have been cultivated for various purposes, including beef cattle, dairy cattle, horses, goats, buffaloes, sheep, pigs, rabbits, chickens, and ducks. According to the results of the Inter-Census Agricultural Survey conducted by the Central Bureau of Statistics (2013), the number of households engaged in the livestock sector in Indonesia reached 13.56 million. This figure is expected to continue to increase along with the increasing demand for livestock. In addition, each type of livestock waste has a different potential to produce gas, depending on its biological characteristics and composition. The use of biogas as an alternative to LPG, for example, requires manure from 2 to 3 cows. This is equivalent to the manure produced by 400 chickens or 6 pigs to produce 4 $m^3$ of biogas per day. This volume can meet cooking needs equivalent to the use of 2.5 liters of kerosene per day (Wahyuni, 2011).

The quality and quantity of biogas produced from animal manure is greatly influenced by various factors, such as the design of the biodigester reactor, the type of feedstock, temperature, pH,

and the content of other substances. In addition, biogas production also depends on the ratio of total solids and waste feedstock. Despite its great potential as a renewable energy source and a solution in animal waste management, the adoption of this technology in Indonesia is still relatively low (Khalil et al., 2019). In some areas, the design of digesters as biogas processing equipment is quite advanced and meets the standards, while in other areas it is still very simple and inadequate. This is due to various obstacles faced in the operationalization of biogas, both on a small and large scale, which include economic, technical and infrastructure aspects. In addition, although some farmers who have used biogas made from livestock manure find this alternative energy source helpful, they also complain about the odor caused by pipe leaks and manual management, which requires extra effort to transport the manure into the digester. These issues are the main challenges in the effort to improve biogas management with more sophisticated technology.

## Conclusion

Indonesia has a very large and diverse potential source of biogas energy, especially from livestock manure and palm oil waste. Several regions in Indonesia have successfully utilized biogas derived from livestock manure as a substitute for fossil energy for cooking and power generation. As a country with a growing agricultural sector, Indonesia also has palm oil waste that has great potential to be converted into alternative energy. However, the management and utilization of biogas as a source of New Renewable Energy (EBT) in Indonesia is still far from optimal and uneven. Various challenges and obstacles, both in terms of economic, technical, and infrastructure, still hinder the progress of this sector.

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