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Research Paper

Examining Biogas Potential from Rotting Fruits for Advanced Waste Management, Environmental Conservation, and Sustainable Energy Generation

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Abstract

This research aims to analyze the efforts of Koperasi Gemah Ripah Yogyakarta in converting rotting fruits into biogas as part of waste management at Gamping Fruit Market. The methodology involved interviews, field studies, and a comprehensive literature review from various journals. The research findings are threefold. Firstly, Koperasi Gemah Ripah employs a systematic approach to waste management comprising collection, transportation, and disposal. Secondly, the biogas produced through the processing efforts made by Koperasi Gemah Ripah serves as an alternative energy source, generating electricity. Thirdly, the collaborative partnership between Koperasi Gemah Ripah and the Waste Refinery Center at Universitas Gadjah Mada has been proven to be successful in innovatively managing waste by converting it into biogas. In conclusion, the research underscores the effective waste management strategies implemented by Koperasi Gemah Ripah, showcasing the potential of biogas as a sustainable solution to mitigate environmental damage.

Keywords: Koperasi Gemah Ripah; Waste Management; Biogas.

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1. Introduction

This study explores the role of *Koperasi* (cooperative) in waste management at Gamping fruit market, in Special Region of Yogyakarta province. In general, cooperatives play a role as an organization that aims to improve the economy (Widiyanti, 1994). However, the authors see that Koperasi Gemah Ripah has a special role in waste management at Gamping fruit market environment, making it different from most cooperatives which focus only on economic activities. The authors also want to emphasize waste management, i.e., converting waste into biogas which can produce electrical energy reserves for energy needs at Gamping fruit market environment. A huge issue found at Gamping fruit market is the accumulation of fruit waste from the purchase and sale transactions at the market. In order to reduce this waste buildup, Koperasi Gemah Ripah makes efforts to minimize waste, i.e., rotting fruits.

The word "koperasi" is derived from "co" and "operation". Cooperatives become an organization based on kinship as a people's economic movement (Anoraga & Sudantoko, 2002). In Indonesia, cooperatives are regulated in Law Number 25 of 1992; the law contains the principles of cooperatives. Overall, cooperatives are engaged in the economic sector because cooperatives are designed for economic purposes (Sitio & Tamba, 2001). In Indonesia, cooperatives are organizations that are accepted by society because cooperatives culturally represent community life based on kinship (Hadhikusuma, 2000). In 2022, in Indonesia there have been 130,354 cooperatives across various regions (Rizaty, 2023). That number shows that cooperatives are economic organizations that are accepted in Indonesian society. The authors see the uniqueness of Koperasi Gemah Ripah (KGR) in Yogyakarta, namely that KGR performs waste management at Gamping market environment. The waste management by KGR can generate a non-fossil energy source through the conversion of rotten fruits into biogas.

In Indonesia, waste has been by Law No. 18 of 2008 concerning Waste Management as the residue of human daily activities and or natural processes in solid form. Fruit waste at Gamping Market is included in a specific type, namely the type of biodegradable organic waste that can be used as compost. There are some stages in waste management including collection, transportation, and disposal (Snow, 2002). Each stage has its own system. Firstly, waste collection begins with filling a container with waste and ends with loading it to a collection vehicle (Bilitewski et al., 1997:64). Second, waste transport process is the process of unloading the waste from the collection vehicle or through a storage pit which is then brought to the final disposal site (Bilitewski et al., 1997:71). Third, the disposal process starts from collecting the waste that has previously been transferred through certain methods to be disposed of at landfills. This final process should have gone through various kinds of waste sorting, especially the selection of reusable or dangerous waste (Bilitewski et al., 1997).

The type of waste at Gamping market is biodegradable organic waste. The waste generated is rotting fruits. Unmanaged fruit waste will end up in food waste. Food waste has a negative effect on the environment. However, if managed properly, it will have an impact on reducing pollution that results from food waste (Mobaseri et al., 2021). Food waste has significant social, economic, and environmental consequences (Cosbuc et al., 2021; Stefano et al., 2021a). Most developing nations lack the technical and financial capacity to safely manage solid waste (Abdelhamid, 2014). Waste generation per capita in developed countries has nearly tripled over the last two decades, reaching a level five to six times higher than that in developing countries. Waste generation in developing countries is also rapidly increasing and may double in volume in the current decade (Katiyar, 2016). Inadequate waste management practices degrade the environment and pose health dangers (Rahman et al., 2021). Various factors influence food loss at various points of the supply chain. Wastage during processing, storage, shipping, and in the marketplace is one of these reasons (Kör et al., 2022; Żukiewicz et al., 2022). According to FAO data, food waste can amount to 1.3 billion tons per year (Devi & S, 2023). When food waste is disposed of in landfills, it decomposes and produces methane gas, which is more effective than carbon dioxide at trapping heat in the atmosphere (Sakai et al., 2012). Rotten fruits are included as food waste which can be reprocessed into useful goods. Asia Pacific accounts for 42% of fruit and vegetable waste (Tang, 2013). Based on these data, food waste, especially fruit and vegetable waste, has a large enough contribution to environmental damage. Recovery and recycling of useful components from food waste can help lessen environmental and human health problems (Ungureanu-Comanita et al., 2020).

Waste management is carried out by Koperasi Gemah Ripah to convert waste into valuable items, specifically energy reserves to supply electricity. In addition, environmental damage caused by food waste is also the focus of the SDGs, specifically number 12 with the theme "responsible consumption and production" aimed at ensuring sustainable consumption and production patterns (Hoballah & Averous, 2015a). SDGs 12 targets include reducing the amount of food waste in the world by achieving environmentally friendly management to reduce the release of hazardous chemicals such as ammonia gas into the air, water, and soil to minimize adverse impacts on the environment and human health (United Nation, 2017). SDG 12 requires fundamental adjustments in industrial processes and society as a whole (Guevara & Julián, 2019). Through green processes such as anaerobic digestion, co-digestion, composting, enzymatic treatment, ultrasonic, and hydrothermal carbonization, food waste can be used as a sustainable source of high-value energy, fuel, and nutrients (Usmani et al., 2021). Efficient waste management can reduce the cost of producing processed food (Khedkar & Singh, 2018). By implementing environmentally friendly management, the problem of food waste can be addressed better.

Koperasi Gemah Ripah at Gamping Fruit Market in Yogyakarta converts rotting fruits into biogas to produce electricity. The electricity generated adds to the supply of electricity for activities around Gamping Fruit market. Koperasi Gemah Ripah has a role in waste management at Gamping Fruit market area. Koperasi Gemah Ripah manages food waste at Gamping Fruit market to be processed into biogas. Biogas produced from the utilization of rotten fruits is a new renewable energy alternative. The electrical energy generated from the management of rotten fruits is used for the needs of the Gamping Fruit Market community. Koperasi Gemah Ripah successfully utilizes waste to be used as electric energy. This way, rotten fruits, which are included as food waste with no selling value, can become more useful after being processed into biogas which can produce electric energy for the surrounding community.

Cooperatives carry out activities to support the economy. As researched by Arifandy et al. (2020), cooperatives seek to improve the fishermen's economy in Sumenep Regency. Cooperatives in Arifandy et al. (2020) make efforts to improve the welfare of the members. Cooperatives provide savings and loan services to support fishermen's activities in Sumenep Regency (Arifandy et al., 2020). Besides, Hanafi (2020) conducted research to explore the role of cooperatives in reducing poverty in the village of Nanggela, Cirebon Regency. The cooperative in the village has a program to market products made by the local residents. This cooperative focuses on reducing poverty by becoming a trade facilitator for the local residents. The cooperative has the opportunity to distribute goods widely (Hanafi, 2020).

Waste management problems in developing countries are open dumping and open burning which result in environmental contamination and social problems. Mismanaged waste in developing countries contributes to environmental problems such as air and water pollution, as well as health issues (Ferronato & Torretta, 2019). An article written by Spadaro et al. (2021) focuses on the issue of waste management in the European Union region by highlighting the need for new policies for port cities. Spadaro et al. (2021) emphasize the importance of sustainable waste management, especially in port cities. They also mention that waste in port cities has the potential to generate waste for coastal communities and urban waste can pollute the oceans (Spadaro et al., 2021).

The concept of Sustainable Development is a framework for the researchers to see the efforts made by Koperasi Gemah Ripah. Through this conception, the researchers see that the efforts made by this cooperative are based on the concept of sustainable development where cooperatives carry out waste management as a sustainability effort. The concept of Sustainable Development in the world of International Relations has become the basis for analyzing the problems that occur (Morán-Blanco, 2022). The definition of this concept itself is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brindtland Commission, 1987). Sustainability is the basis of many of today's international cooperations. There are three things that underlie the concept of sustainable development, namely economic, environmental, and social factors (Coghlan, 2019). With the sustainability of the three sectors in this concept, the goal is to create better conditions for the survival of human life. Sustainability is defined as providing the demands of the current generation without jeopardizing future generations' ability to meet their own needs (Church et al., 2022).

The essence of the concept of sustainable development is revolutionary, meaning that this concept makes a complete and fundamental change (Amacker, 2011). However, there are challenges to carrying out the concept, namely not only to educate a concept but also to be able to define and understand it. In its development, sustainable development is now the basis for Agenda 21. Where this agenda is a comprehensive plan of action to be taken globally, nationally, and locally by the United Nations system

organizations, Governments, and Major Groups in every field where humans impact the environment (United Nation, 1992). Now many countries have been making efforts to be aware of and understand the concept of sustainable development and make changes domestically or internationally. This regards the fact that the goals of Agenda 21 are to achieve sustainable global development as well as combat environmental degradation and poverty (Deka & Neog, 2020). These goals can be achieved by enhancing international cooperation and national policies.

2. Method

In examining the role of Koperasi Gemah Ripah at Gamping Fruit Market in Yogyakarta in terms of its effort to reduce environmental damage in the midst of technological advances, this paper uses two methods, namely the qualitative method and the library research method. Qualitative methods are used to gain in-depth understanding of the role of Koperasi Gemah Ripah in its waste management efforts, i.e., converting waste into renewable energy. The data analysis was carried out inductively from specific themes to general themes and the researchers interpreted the meaning of the collected data (Cresswell, 2009). The collected data were in the form of information related to the role of Koperasi Gemah Ripah at Gamping Fruit Market, particularly in terms of waste management and the conversion of waste into renewable energy. The data collection was conducted through interview methods with Bambang Rahardjo, the manager of Koperasi Gemah Ripah, to obtain direct insights. Additionally, the researchers also conducted a literature review to gather additional information from various relevant sources. The data validity was maintained by using qualitative methods involving direct interviews with relevant parties, carefully designing questions, focusing on the research objectives, and ensuring the data validity.

2.1 Analysis

The qualitative methodology was implemented through a comprehensive approach involving interviews with the management of Koperasi Gemah Ripah. In addition, the researchers undertook on-site observations and field studies at Gamping Fruit Market in Yogyakarta, allowing for directly observing the activities related to the management of biogas for its conversion into electric energy. This study also used thematic analysis, employing an analytical approach that involves identifying, analyzing, and recording recurring patterns within existing data (Braun & Clark, 2006 in Kiger & Varpio, 2020:2). This analytical method was used to describe the collected data, providing the researchers with a foundation for interpretation. The interpreted data comprised insights gathered from the field observations at Gamping market and interviews with the management of Koperasi Gemah Ripah. Subsequently, the researchers meticulously analyzed the data to generate meaningful discussions. The analytical process followed an inductive approach, starting with specific thematic elements and progressing towards more general themes, aligning with the methodology outlined by Cresswell (2009). The data, sourced from the interviews and literature research, were systematically categorized based on themes associated with the role of Koperasi Gemah Ripah in waste management. This categorization helped summarize information and identify relevant patterns. In the final step, the researchers interpreted the collected data, followed by drawing conclusions pertaining to the role of Koperasi Gemah Ripah in waste management at Gamping Fruit Market. This thorough and systematic approach resulted in a comprehensive understanding of the involvement of the cooperative in addressing environmental challenges within the context of the market's technological advancements.

3. Results and Discussions

Koperasi Konsumen Pasar Induk "Gemah Ripah" or Koperasi Gemah Ripah was established in 1995. Currently there are 215 members of the cooperative, consisting of 116 traders, 41 employees, and 58 staff. This cooperative has various types of businesses including vehicle entry fees, savings and loans, procurement of crates, and waste management. In this study, the researchers focus on the waste management by Koperasi Gemah Ripah at Gamping Fruit Market in Yogyakarta. This cooperative has made efforts to manage fruit waste to be used as biogas. In the processing of biogas, the cooperative is supervised by the Waste Refinery Center of Universitas Gadjah Mada.

3.1 Waste Management by Koperasi Gemah Ripah

The problem of waste accumulation at Gamping Fruit Market in Yogyakarta was the reason for making innovations in the form of processing rotten fruits into biogas energy. In fact, the accumulation of rotten fruits have brought negative effects on the environment and social community around Gamping Fruit Market. Rotten fruits release ammonia gas, thus causing air pollution in the surrounding area which disturbs the cleanliness of the market. In addition, ammonia gas can cause respiratory problems (Utami, 2022). Thus, waste accumulation can reduce the public health index.

Based on Law No. 18 of 2008 issued by the government, waste management aims at improving public health and environmental quality as well as making waste a resource that can be utilized. Koperasi Gemah Ripah Yogyakarta strives to carry out these activities to create better conditions for the community and the environment, especially at Gamping Fruit Market in Yogyakarta. In fact, the rotten fruit waste accumulation at the market can reach 4-10 tons per day. With such a large amount, processing rotten fruits into biogas energy is seen as a great potential as a waste management measure to reduce environmental damage. The development of a biogas production pilot project managed by Koperasi Gemah Ripah is in collaboration with several domestic and international institutions, including the Sleman Regional Government, Universitas Gajah Mada, University College of Boras (Sweden), and the Boras City Government.

3.1.1 Collection, Transportation, and Disposal System

The main role of Koperasi Gemah Ripah in making biogas energy from rotting fruits is to provide raw materials, provide a site for the biogas plant, and manage the operation of the biogas pilot project. The cooperative collects waste on a daily basis. The cooperative manages waste in three stages around the market, namely first, collecting waste from market stalls; second, transporting the waste by truck to a designated location; third, sorting waste, whether it should be disposed of at landfills or processed into biogas.

The waste management process carried out by Koperasi Gemah Ripah involves the collection, transportation, and disposal of fruit waste at Gamping Fruit Market. The cooperative plays a key role in providing raw materials and a location for the biogas production as well as overseeing the operation of the biogas pilot project. The waste management process is conducted in three stages, namely waste collection from the market stalls, waste transportation to designated locations, and waste disposal, including the conversion of rotting fruits into biogas.

In the first stage, waste is collected daily from the market stalls, with cleaning crews deployed early in the morning. Sellers sort waste into non-organic and organic categories to ease later disposal. Some waste from rotting fruits is managed by the cooperative to be used for biogas production. The waste collection process involves transporting the waste from the market stalls to the final disposal site (landfill) or the biogas processing location.

"Every day starting at 6 am, the cooperative deploys cleaning crews to sweep and collect rubbish from the stalls. The cooperative also has a waste collection truck that patrols arround the market stalls" (Interview: manager of Koperasi Gemah Ripah, September 4, 2023)

Sellers sort non-organic waste from organic waste. This aims to make it easier for the cooperative to classify the types of waste because waste has two disposal methods in the final stage. The cooperative collects waste from the sellers' stalls in the morning. This waste collection is carried out by transporting the waste from the stalls to either the final disposal site or biogas processing site. Some waste from rotting fruits is managed by the cooperative to be converted into biogas. The cooperative has 11 employees who manage waste at Gamping Fruit market. First, the waste at Gamping market is sorted to determine where it should be disposed of. Waste such as plastic and wood is transported by the cooperative to the landfill, while rotting fruits are converted by the cooperative into biogas.

In the second stage, the cooperative transports waste by a garbage truck. Non-organic waste will be transported to a landfill as determined by the government. There are two destinations where the waste can be transported, namely the landfill by a truck and the biogas processing site, especially for

rotting fruits (*Figure 1*).

"The cooperative transports fruit waste using a vehicle which is a grant from Universitas Gadjah Mada. There are two people whose job is to transport certain fruit waste to be converted into biogas. The fruit waste to be converted into biogas is not collected every day, but three times a week. (Interview: manager of Koperasi Gemah Ripah, September 4, 2023)

Figure 1. Vehicle to transport rotten fruits (photographed by the author)

In the third stage, the cooperative determines the disposal site for the waste generated around the market. Non-organic waste is disposed of to the landfills determined by the government, while some of the rotting fruits is processed into biogas. The waste, specifically for processing into biogas, is collected three times a week, not every day, preventing the biogas processing site from being overloaded.

A specific problem with the waste at Gamping market is fruit waste because there is too much fruit waste. Certain fruits will be processed into biogas. (Interview: manager of Koperasi Gemah Ripah, September 4, 2023)

The biogas plant is located right inside Gamping Fruit Market, making it possible for the market community to supervise the process. The operational activity carried out by the cooperative is to put rotten fruits into the biogas plant, then regulate the use of the resulting electric energy. Before carrying out the process, the cooperative first conducts a feasibility study to review the aspects of needs, technology, raw materials, and support. The first aspect is need, i.e., the basis for this activity is to minimize the impact of landfilling on public health due to an increase in the number of diseases, air pollution, and soil pollution. The second aspect is technology, i.e., in practice the technology used to convert rotting fruits into biogas energy has been standardized according to the local needs and conditions. The third aspect is raw materials, i.e., most of the waste generated at Gamping Fruit Market in Yogyakarta is rotten fruits, so instead of transporting it to *Tempat Pembuangan Sementara* (TPS) or *Tempat Pembuangan Akhir* (TPA), the waste can become a recyclable resource to create biogas energy to produce electric energy. The last aspect is support, i.e., by collaborating with many parties and improving the quality of the existing human resources, this program can be carried out properly to increase the understanding of the surrounding community about the importance of being responsible for consumption and production activities.

In the first stage, Koperasi Gemah Ripah collects waste from the market stalls at Gamping Fruit Market. Sellers typically leave their waste in front of their stalls to be picked up by the cooperative. The waste is sorted into non-organic and organic waste to ease proper disposal. Every morning, the

cooperative collects waste from the market stalls and transports it to either the landfill or the biogas processing site. Some fruit waste is processed into biogas. In the second stage, the cooperative transports non-organic waste by a garbage truck to a government-designated landfill. Some fruit waste, however, is transported to the biogas processing site. In the third stage, the cooperative continues its waste management efforts by transporting non-organic waste to government-designated landfills. In addition, the cooperative also transports fruit waste for biogas processing, typically three times a week, to prevent the biogas plant from being overloaded.

The processing rotten fruits into biogas energy that produces electricity has given a positive impact and received positive responses from the community of Gamping Fruit Market. Based on the field survey conducted by the authors, the market community greatly benefits from this activity. Reducing waste accumulation and making market conditions more comfortable are some of the positive impacts perceived by the community. The collection of rotten fruits by the cooperative also benefits the community, especially in relation to the management of waste generated from the production and consumption activities in the market. In addition to the problem of waste, electric energy produced from biogas energy also provides many benefits to the market community. This is very useful when the market experiences a power outage. With the existence of electric energy from the biogas processing, the market community still has electricity reserves and can carry out activities as usual without experiencing problems caused by power outage. The community hopes that Koperasi Gemah Ripah can continue the activities of producing biogas from rotting fruits and continue to improve the quality of its activities. The biogas plant is located within Gamping Fruit Market, enabling the community to oversee the process. Before initiating the process, the cooperative first conducts a feasibility study which covers several aspects such as needs, technology, raw materials, and support. This initiative aims to mitigate the negative impact of landfilling on public health and promote responsible consumption and production practices within the community.

3.2 Conversion of Fruit Waste into Biogas

The biogas plant is managed by Koperasi Gemah Ripah under the supervision of the Waste Refinery Center of Universitas Gadjah Mada (WRC UGM), where the installation was designed through a research scheme by UGM and Boras University (Marendra et al., 2020:2). The cooperative hires employees to manage the biogas production at the biogas plant. The cooperative handles the management of waste collection, transportation, and sorting before processed at the biogas plant. The rotten fruits produced by Gamping Fruit Market are very large in amount, with cumulative waste generation above 10 tons per day. This waste is then reprocessed to be converted into biogas which can be used as energy in the form of electricity. The fruit waste processed in the biogas plant consists of various fruits such as melons, watermelons, and bananas, excluding oranges, which make up only 1-10% of the total fruit waste processed in the biogas plant (Cahyono et al., 2018).

With the help of several sources of organic materials, rotting fruits can be used as biogas. A large amount of fruit waste is reprocessed by Koperasi Gemah Ripah to produce electric energy by utilizing gas from the rotting fruits. The rotting fruits are collected from every market stall at Gamping Fruit Market to be processed into biogas as a source of electric energy.

There are several stages of converting the rotting fruits into biogas. First, the rotting fruits will be collected from every fruit stall at Gamping Fruit Market. The cooperative is responsible for this task, followed by transporting them to a location where the rotting fruits will be ground using a grinding machine (*Figure 2*), generating liquid. The results will be channeled to a reservoir called a digester. The digester is in the form of a tube which is placed 8 meters below the ground surface, while the diameter of the digester is 8 meters (*Figure 3*). Third, the digester will store the liquid from the grinding of the rotten fruits, allowing for organism process to occur, which then results in the formation of gas. In fact, the gas that evaporates in the digester has been in the form of biogas which can be processed into electric energy. Fourth, the biogas will then be channeled to the generator (*Figure 4*), generating electric energy. Finally, the biogas becomes the power to turn on an electric generator (Marendra et al., 2018).

Figure 2. Grinding Machine (Photographed by the authors)

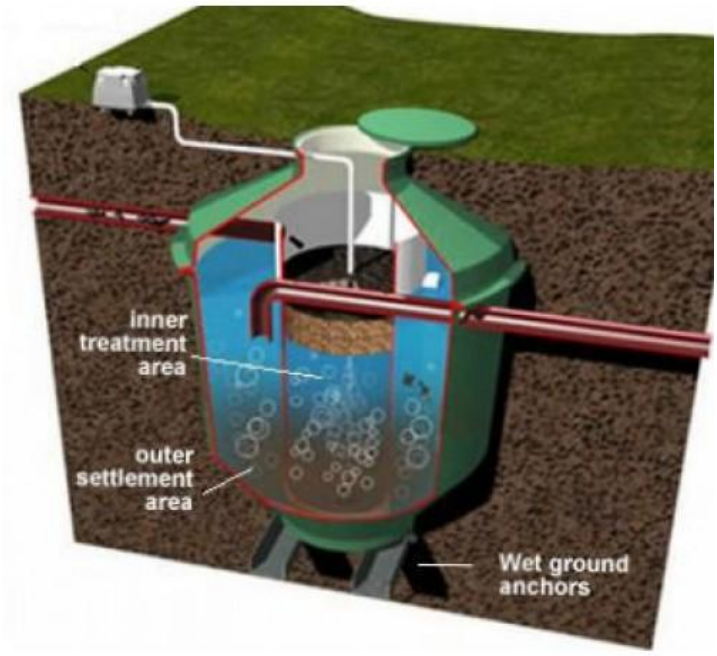

Figure 3. Example of Digester (Kencana Online, 2022)

Biogas energy from the processing of rotten fruits at Gamping Fruit Market in Yogyakarta is a breakthrough and at the same time solves the problem of many rotten fruits. The biogas plant potentially generates up to 162 Nm3 biogas, which can generate electricity up to 150 kWh/day (Marendra et al., 2018:87). The electric energy generated can meet the needs of 500 families. In addition to being a breakthrough for electric energy, converting rotten fruits into biogas serves as alternative energy to fossil energy that is not environmentally friendly. Koperasi Gemah Ripah, supervised by WRC UGM, can convert rotten fruits, which initially have no value, into electric energy that can benefit the Gamping market community. Apart from converting rotting fruits into biogas to generate electric energy, the end products of rotten fruits at this market are also in the form of fertilizer and gas for the cooking needs of the Gamping Fruit Market community (Marendra et al., 2020:3).

Figure 4. Generator (Photopgraphed by the authors)

Fertilizer is generated from the liquid that remains in the digester, while gas is generated from the vapor in the digester. This way, all rotten fruits are processed by Koperasi Gemah Ripah into products with benefits, instead of wasted. Environmental damage can be reduced by not using fossils as the main source of power generation; alternative energy can be used to reduce environmental damage. Rotten fruits processed into biogas can be a source of energy that is more environmentally friendly compared to the use of fossil energy which can have negative effects on the atmosphere.

Koperasi Gemah Ripah has successfully reduced its waste after converting it into biogas. There are at least two problems solved by this cooperative, including (1) the conversion of rotting fruits into biogas can reduce food waste problems, (2) energy reserves generated from biogas can be alternative electric energy supply. The activities of Koperasi Gemah Ripah are regularly monitored by the Waste Refinery Center of Universitas Gadjah Mada (WRC UGM). Universitas Gadjah Mada created the concept for the biogas system as technically supervised by Sweden. Universitas Gadjah Mada, the Sleman Regional Government, and Koperasi Gemah Ripah Market make a collaboration to build the Biogas Power Plant Gamping (BPG). The University of Boras, Boras Municipality, and Boras Energy and Environment also work together to develop this project (Marendra et al., 2018:87).

Koperasi Gemah Ripah at Gamping Fruit Market in Yogyakarta has shown the potential for sustainable development as an innovative concept at the local level, so it is possible to encourage the government to take similar actions at the national and international levels. The breakthrough demonstrated by Koperasi Gemah Ripah in converting rotting fruits into biogas energy that can generate electricity is the result of combining the three aspects as outlined in the concept of sustainable development. Each of these aspects is a form of sustainable development efforts.

The implication of waste management carried out by Koperasi Gemah Ripah is to convert rotten fruits into electric energy. The electric energy generated from the renewable energy at Gamping Market provides benefits for the surrounding community. The energy can be used as gas for cooking and electricity to power up electronic devices. The community should play a role in collecting rotten fruits as the raw materials to generate renewable energy.

The effort made by Koperasi Gemah Ripah is to create a community that can contribute to renewable energy. This effort is important because people must also be prepared for the transition from fossil energy to fulfill their daily needs towards renewable energy. Koperasi Gemah Ripah acts as a

facilitator, allowing the community at Gamping market to utilize rotten fruits as the raw material to produce biogas to generate electric energy.

The important role of the community in the energy transition is to familiarize people with the use of renewable energy. Local communities play an essential role in promoting localized renewable energy (Yamamoto, 2016). National commitment to energy transition will be more easily achieved when there are interventions that consider the psychological, social, cultural, and organizational factors that influence energy choices. In addition, there are also efforts to involve the community to see how social and community behavior are important to reduce consumption of fossil fuels (Stern et al., 2016). The program created by Koperasi Gemah Ripah at Gamping market at least serves as an intervention to the surrounding community to utilize rotten fruits to be processed into renewable energy. The communities can gain better understanding of how to use renewable energy in their daily life, especially around the market, such as using electricity and gas for cooking resulting from the conversion of rotten fruits.

3.3 Cooperatives and the Sustainable Development Goals (SDGs)

The SDGs are global goals aiming at eradicating poverty and inequality, protecting the environment, and guaranteeing that all people have access to health, justice, and prosperity (Howard-Grenville et al., 2019). It is vital to set integrated targets for food, energy, and ecological services (Griggs et al., 2014). Koperasi Gemah Ripah carries out waste management efforts related to SDG 12 "Responsible Consumption and Production". Goal 12 aims at maintaining long-term consumption and production trends (Hoballah & Averous, 2015b). SDG 12 has a target to reduce food waste at the retail and consumer level throughout the world (Gasper et al., 2019:86). Koperasi Gemah Ripah is re-processing the remaining fruit waste. This cooperative does not allow fruit waste to be disposed of, but it makes effort to make use of the food waste. Every day, Gamping market has the potential to produce significant amounts of food waste. Every year, Indonesia contributes 20.93 million tons of food waste, accounting for 8-10% of global greenhouse gas emissions (Naurah, 2022). Gamping market is a specialized fruit market that generates 4-10 tons of fruit waste every day. As a consequence, Koperasi Gemah Ripah, as a market business unit, tries to manage the fruit waste generated by market activity. The cooperative's management has reduced food waste in the retail sector by re-processing food waste, instead of disposing it at the landfill.

The cooperative manages fruit waste, which generates biogas that can be used as a reserve of electric energy for the market community. The cooperative's efforts to use biogas as a material to generate electric energy are part of the company's efforts to encourage sustainable energy. The contribution made by Koperasi Gemah Ripah in generating electric energy from biogas is related to the Sustainable Development Goal (SDG) 7. SDG7 aims to prepare affordable energy and clean energy (Miskiewicz, 2022). Improvements in energy efficiency are made to accelerate the climate goal of reducing greenhouse gas emissions (Puig et al., 2018; United Nation, 2022). Gamping Market possesses a valuable resource in the form of biogas generated from food waste processing. This biogas is harnessed by the cooperative to generate electric energy, thus contributing to the utilization of renewable energy sources. Effforts made by Koperasi Gemah Ripah that is in line with clean energy are to generate electric energy from biogas. Koperasi Gemah Ripah executes energy transition by innovatively managing fruit waste at Gamping Fruit Market. Through daily collection and sorting, the cooperative utilizes a garbage truck for the waste transportation to transport non-organic waste to a landfill and certain fruit waste to a biogas plant. The biogas production involves grinding the rotting fruits that results in liquid, channeling the liquid to a digester for gas formation, and subsequently channeling the biogas to a generator to generate electric energy. This energy is crucial for powering up activities in the market, emphasizing a sustainable energy source. The cooperative conducts feasibility studies by collaborating with some institutions like Universitas Gadjah Mada and actively involves the community in waste management. This initiative not only addresses waste issues but it also in line with Sustainable Development Goals, offering multiple benefits such as reduced food waste, fertilizer production, and cooking gas utilization.

Furthermore, the effort made by Koperasi Gemah Ripah of converting fruit waste into biogas, followed by the utilization of biogas as a source of electric energy meets SDG 7, which seeks to ensure affordable and clean energy (Miskiewicz, 2022). By improving energy efficiency and transitioning away from fossil fuels, the cooperative contributes to the broader climate objective of reducing greenhouse gas

emissions. The biogas produced from food waste at Gamping Market represents a valuable resource that is useful for the promotion of renewable energy sources.

Conclusions

The research introduces an innovative waste-to-energy model implemented by the cooperative, shedding light on sustainable practices that can contribute to renewable energy generation. Additionally, it emphasizes the active engagement of the local community in waste management and energy transition, fostering awareness and a collaborative approach to addressing environmental challenges. The study illustrates how the biogas generated from fruit waste aligns with Sustainable Development Goal 7, emphasizing affordable and clean energy. The findings present a potential blueprint for addressing waste management challenges in other markets or communities, serving as a case study for sustainable practices and promoting environmental responsibility and clean energy adoption. The research provides valuable academic insights into sustainable practices and waste-to-energy models while offering practical guidance for policymakers, environmentalists, and community leaders interested in implementing similar initiatives. By emphasizing the alignment of the cooperative's actions with Sustainable Development Goals, the research underscores the broader implications of local initiatives in contributing to global sustainability objectives.

The waste management carried out by Koperasi Gemah Ripah is an important contribution to reducing food waste. Koperasi Gemah Ripah has successfully turned waste into more valuable goods. The application of renewable energy technology carried out at Gamping Fruit Market in Yogyakarta by Koperasi Gemah Ripah is to convert rotting fruits into biogas energy that can generate electricity. This activity is in line with the concept of sustainable development about clean energy. Waste management is carried out by Koperasi Gemah Ripah in three stages, including collection, transportation, and disposal. The cooperative carries out waste management from start to finish. In the final stage, the cooperative sorts fruit waste to be converted into biogas. These efforts are indirectly related to Sustainable Development Goals 7 and 12. Koperasi Gemah Ripah is in partnership with the Waste Refinery Center in waste processing around Gamping market. In this case, the fruit waste processing efforts are not solely the responsibility of the cooperative; there is also a contribution from WRC UGM in managing waste in the Gamping market area.

The Sustainable Development Goals (SDGs) represent a global commitment to combat poverty, inequality, and environmental degradation, as well as ensure access to essential resources and services for all (Moyo, 2016). To achieve these goals effectively, it is imperative to establish integrated targets for food, energy, and ecological services (Griggs et al., 2014). Koperasi Gemah Ripah plays a crucial role in waste management aligned with SDG 12, which focuses on Responsible Consumption and Production (Hoballah & Averous, 2015a). Specifically, Goal 12 aims to maintain sustainable consumption and production patterns, including reducing food waste at the retail and consumer levels worldwide (Gasper et al., 2019:86). The waste management efforts by Koperasi Gemah Ripah within the Gamping market environment are fully in line with SDG 7 and 12. These endeavors include reducing food waste and transitioning to renewable energy sources, indirectly supporting the broader SDGs in achieving their objectives. The commitment of the cooperative to responsible consumption, waste reduction, and clean energy demonstrates a significant contribution to the global pursuit of sustainable development.

The inclusion of three aspects, namely economic, environmental, and social aspects, makes the processing of rotten fruits an activity that makes fundamental and comprehensive changes. The role of Koperasi Gemah Ripah in the management of rotten fruits shows that there is awareness in the community of the importance of preserving the environment for the common good. The good impact of the processing of rotting fruits has been felt by the market community and its surrounding. The reduced waste and the availability of electricity reserves are benefits that greatly affect the social environment of the market. Koperasi Gemah Ripah in Yogyakarta continues to improve its quality in the development of biogas energy generated from rotting fruits to generate electric energy.

Reference

Abdelhamid, M. S. (2014). Assessment of different construction and demolition waste management approaches. *HBRC Journal*, *10*(3), 317–326. https://doi.org/10.1016/j.hbrcj.2014.01.003

Amacker, C. (2011, July 27). *The Concept of Sustainable Development*. https://www.e-ir.info/2011/07/27/the-concept-of-sustainable-development/

Anoraga, P., & Sudantoko, D. (2002). *Koperasi Kewirausahaan dan Usaha Kecil.* Rineka Cipta.

Arifandy, F. P., Norsain, N., & Firmansyah, I. D. (2020). PERAN KOPERASI DALAM MENINGKATKAN PEREKONOMIAN MASYARAKAT NELAYAN: PERSPEKTIF MODAL KERJA. *Jurnal Akademi Akuntansi*, *3*(1), 118. https://doi.org/10.22219/jaa.v3i1.11665

Bilitewski, B., Härdtle, G., & Marek, K. (1997). *Waste Management*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-03382-1

Brindtland Commission. (1987). *Our Common Future*. Oxford University Press.

Cahyono, R. B., Wikandari, R., Millati, R., Wulandari, C., Ariyanto, T., Marendra, F., Wardhani, A. T. R., & Rimbawan, H. J. (2018). *KOMPOSISI BAHAN BAKU BIOGAS DARI CAMPURAN LIMBAH BUAH JERUK DENGAN LIMBAH BUAH ORGANIK LAINNYA* (Patent IDP000086360). Direktorat Penelitian Universitas Gadjah Mada.

Church, J. M., Tirrell, A., Moomaw, W. R., & Ragueneau, O. (2022). Sustainability. In *Routledge Handbook of Global Environmental Politics* (pp. 217–227). Routledge. https://doi.org/10.4324/9781003008873-20

Coghlan, A. (2019). Introduction. In *An Introduction to Sustainable Tourism*. Goodfellow Publishers. https://doi.org/10.23912/9781911396734-4257

Cosbuc, E. L., Ungureanu-Comanita, E.-D., & Gavrilescu, M. (2021). Identification of the Risks Generated in the Environment by Food Waste. *2021 International Conference on E-Health and Bioengineering (EHB)*, 1–4. https://doi.org/10.1109/EHB52898.2021.9657709

Cresswell, J. W. (2009). *Research design : qualitative, quantitative, and mixed methods approaches* (3rd ed.). SAGE Publication.

Deka, D. C., & Neog, S. R. (2020). Glossary. In M. C. Jacob & W. W. Mijnhardt (Eds.), *The Dutch Republic in the Eighteenth-Century* (pp. 339–348). Cornell University Press. https://doi.org/10.7591/9781501736773-019

Devi, Ms. K. S., & S, Sundareshwar. (2023). Food Waste Management System. *International Journal for Research in Applied Science and Engineering Technology*, *11*(5), 2462–2466. https://doi.org/10.22214/ijraset.2023.52028

Di Stefano, V., Durazzo, A., & Lucarini, M. (2021). Food Waste: Treatments, Environmental Impacts, Current and Potential Uses. *Sustainability*, *14*(1), 234. https://doi.org/10.3390/su14010234

Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *International Journal of Environmental Research and Public Health*, *16*(6), 1060. https://doi.org/10.3390/ijerph16061060

Gasper, D., Shah, A., & Tankha, S. (2019). The Framing of Sustainable Consumption and Production in <scp>SDG</scp> 12. *Global Policy*, *10*(S1), 83–95. https://doi.org/10.1111/1758-5899.12592

Griggs, D., Stafford Smith, M., Rockström, J., Öhman, M. C., Gaffney, O., Glaser, G., Kanie, N., Noble, I., Steffen, W., & Shyamsundar, P. (2014). An integrated framework for sustainable development goals. *Ecology and Society*, *19*(4), art49. https://doi.org/10.5751/ES-07082-190449

Guevara, S., & Julián, I. P. (2019). Sustainable Consumption and Production: A Crucial Goal for Sustainable Development—Reflections on the Spanish SDG Implementation Report. *Journal of Sustainability Research*, *1*(2). https://doi.org/10.20900/jsr20190019

Hadhikusuma, S. R. (2000). *Hukum Koperasi Indonesia*. Raja Grafindo Persada.

Hanafi, A. (2020). View of Pemberdayaan Ekonomi Anggota Koperasi Harapan Keluarga Sejahtera Sebagai Alternatif Mengurangi Tingkat Kemiskinan Di Desa Nanggela Kec. Greged Kabupaten Cirebon. *Jurnal Indonesia Sosial Teknologi*. https://jist.publikasiindonesia.id/index.php/jist/article/view/8/3

Hoballah, A., & Averous, S. (2015a). Ensure sustainable consumption and production patterns. *UN Chronicle*, *51*(4), 28–29. https://doi.org/10.18356/4bd7f86c-en

Hoballah, A., & Averous, S. (2015b). Ensure sustainable consumption and production patterns. *UN Chronicle*, *51*(4), 28–29. https://doi.org/10.18356/4bd7f86c-en

Howard-Grenville, J., Davis, G. F., Dyllick, T., Miller, C. C., Thau, S., & Tsui, A. S. (2019). Sustainable Development for a Better World: Contributions of Leadership, Management, and Organizations. *Academy of Management Discoveries*, *5*(4), 355–366. https://doi.org/10.5465/amd.2019.0275

Katiyar, M. (2016). Solid Waste Management. *RIET-IJSET: International Journal of Science, Engineering and Technology*, *3*(2), 117. https://doi.org/10.5958/2395-3381.2016.00015.0

Kencana Online. (2022). *Digester Biogas BD 5000L*.

Khedkar, R., & Singh, K. (2018). *Food Industry Waste: A Panacea or Pollution Hazard?* (pp. 35–47). https://doi.org/10.1007/978-3-319-58415-7_3

Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher*, *42*(8), 846–854. https://doi.org/10.1080/0142159X.2020.1755030

Kör, B., Krawczyk, A., & Wakkee, I. (2022). Addressing food loss and waste prevention. *British Food Journal*, *124*(8). https://doi.org/10.1108/BFJ-05-2021-0571

Marendra, F., Pramudikto, D. A., Rahmada, A., Rimbawan, H. J., Cahyono, R. B., & Ariyanto, T. (2020). Biogas production for electricity from fruit waste: a case study of Gemah Ripah biogas plant, Yogyakarta. *IOP Conference Series: Materials Science and Engineering*, *736*(2), 022058. https://doi.org/10.1088/1757-899X/736/2/022058

Marendra, F., Rahmada, A., Prasetya, A., Cahyono, R. B., & Ariyanto, T. (2018). Kajian Dampak Lingkungan pada Sistem Produksi Listrik dari Limbah Buah Menggunakan Life Cycle Assessment. *Jurnal Rekayasa Proses*, *12*(2), 27. https://doi.org/10.22146/jrekpros.36425

Miskiewicz, R. (2022). Clean and Affordable Energy within Sustainable Development Goals: The Role of Governance Digitalization. *Energies*, *15*(24), 9571. https://doi.org/10.3390/en15249571

Mobaseri, M., Mousavi, S. N., & Haghighi, M. H. M. (2021). Environmental effects of food waste reduction using system dynamics approach. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1–19. https://doi.org/10.1080/15567036.2021.2000066

Morán-Blanco, S. (2022). Sustainable Development in international relations theory: its presence or abscence A proposal for a new paradigm. *Revista Iberoamericana de Estudios de Desarrollo = Iberoamerican Journal of Development Studies*, *11*(2), 78–100. https://doi.org/10.26754/ojs_ried/ijds.682

Moyo, D. (2016). Implementing the Sustainable Development Goals is an imperative. *OECD Observer*. https://doi.org/10.1787/23127425-en

Naurah, N. (2022, July 25). *Food Waste Index 2021: Indonesia Jadi Penghasil Sampah Makanan Terbesar Se-ASEAN*. https://goodstats.id/article/food-waste-index-2021-indonesia-jadi-penghasil-sampah-makanan-terbesar-se-asean-7FgZ2

Puig, D., Farrell, T. C., & Moner-Girona, M. (2018). A Quantum Leap in Energy Efficiency to Put the Sustainable Development Goals in Closer Reach. *Global Policy*, *9*(3), 429–431. https://doi.org/10.1111/1758-5899.12574

Rahman, M. M., Bohara, A. K., & Vazquez, J. E. (2021). Geospatial analysis of health risks and solid waste management behaviour. *Journal of Environmental Economics and Policy*, *10*(4), 400–427. https://doi.org/10.1080/21606544.2021.1903560

Rizaty, M. A. (2023, March 2). *Jumlah Koperasi Aktif Meningkat Jadi 130.354 Unit pada 2022*. https://dataindonesia.id/bursa-keuangan/detail/jumlah-koperasi-aktif-meningkat-jadi-130354-unit-pada-2022

Sakai, K., Poudel, P., & Shirai, Y. (2012). Total Recycle System of Food Waste for Poly-L-Lactic Acid Output. In *Advances in Applied Biotechnology*. InTech. https://doi.org/10.5772/32858

Sitio, A., & Tamba, H. (2001). *Koperasi: Teori dan Praktek*. Erlangga.

Snow, D. A. (2002). Waste management. In *Plant Engineer's Reference Book* (pp. 47-1-47–7). Elsevier. https://doi.org/10.1016/B978-075064452-5/50102-4

Spadaro, I., Pirlone, F., & Candia, S. (2021). Waste management: new policies for EU port cities. *International Planning Studies*, *26*(4), 413–425. https://doi.org/10.1080/13563475.2021.1883421

Stern, P. C., Janda, K. B., Brown, M. A., Steg, L., Vine, E. L., & Lutzenhiser, L. (2016). Opportunities and insights for reducing fossil fuel consumption by households and organizations. *Nature Energy*, *1*(5), 16043. https://doi.org/10.1038/nenergy.2016.43

Tang, A. (2013, August 17). *As millions go hungry, Asia battles food waste*. https://news.trust.org/item/20130829154039-47okt/

Ungureanu-Comanita, E.-D., Cosbuc, E. L., Cozma, P., Smaranda, C., & Gavrilescu, M. (2020). Human Health Risks Concerning Food Waste Management. *2020 International Conference on E-Health and Bioengineering (EHB)*, 1–4. https://doi.org/10.1109/EHB50910.2020.9280256

United Nation. (1992). *United Nations Conference on Environment & Development*. http://www.un.org/esa/sustdev/agenda21.htm.

United Nation. (2017). *Ensure access to affordable, reliable, sustainable and modern energy for all.* . https://sdgs.un.org/goals/goal7: https://sdgs.un.org/goals/goal7

United Nation. (2022). *The Sustainable Development Goals Report 2022*. https://unstats.un.org/sdgs/report/2022/The-Sustainable-Development-Goals-Report-2022.pdf

Usmani, Z., Sharma, M., Awasthi, A. K., Sharma, G. D., Cysneiros, D., Nayak, S. C., Thakur, V. K., Naidu, R., Pandey, A., & Gupta, V. K. (2021). Minimizing hazardous impact of food waste in a circular economy – Advances in resource recovery through green strategies. *Journal of Hazardous Materials*, *416*, 126154. https://doi.org/10.1016/j.jhazmat.2021.126154

Utami, H. J. (2022). *ANALISIS KADAR GAS AMONIA (NH3) TERHADAP FAKTOR LINGKUNGAN DI TEMPAT PEMROSESAN AKHIR (TPA) PIYUNGAN YOGYAKARTA*. UNIVERSITAS ISLAM INDONESIA.

Widiyanti, N. (1994). *Manajemen Koperasi*. Rineka Cipta.

Yamamoto, Y. (2016). The role of community energy in renewable energy use and development. *Renewable Energy and Environmental Sustainability*, *1*, 18. https://doi.org/10.1051/rees/2016040

Żukiewicz, K., Dudziak, A., Słowik, T., Mazur, J., & Łusiak, P. (2022). Analysis of the Problem of Waste in Relation to Food Consumers. *Sustainability (Switzerland)*, *14*(18). https://doi.org/10.3390/su141811126