

P-ISSN : 2337-9251  
E-ISSN : 2957-9094

# JHR

## *Jurnal Hukum Replik*

Volume 12 No. 1 Maret 2024



Published by:

**FACULTY OF LAW**

**UNIVERSITAS MUHAMMADIYAH TANGERANG**

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## **THE ROLE OF VILLAGE-OWNED ENTERPRISES (BUMDES) IN ACHIEVING A GREEN ECONOMY THROUGH WASTE BANKS IN TRANSFORMING WASTE TO DIESEL ENERGY**

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### Abstract

In the effort to manage waste, waste processing is frequently handled by larger groups or stakeholders with substantial capital. Therefore, this scholarly work proposes the independent processing of waste using financially accessible equipment. This initiative is grounded in waste mitigation efforts commencing early at the village governance level, acting as collectors and managers of waste. This concept aligns with the elevation of economy based on green economics, considering the global Sustainable Development Goals (SDGs) program. The implementation of this concept yields a dual impact, strengthening the village economy through BUMDES while simultaneously mitigating environmental pollution resulting from poorly managed waste. This research utilizes a normative method with statutory, conceptual, and field approaches. This study is tested in Balun Village, Turi Sub-district, Lamongan Regency, East Java Province, through collaboration between the Village-Owned Enterprise "Sumber Mandiri" and Bhayangkara University Surabaya. In its implementation phase, the primary objective is to create a Waste Bank as a platform for sourcing main raw materials from waste to produce alternative fuel as a substitute for diesel. The subsequent step involves waste processing through integrated distillation and pyrolysis machines.

Keywords: Bumdes, Waste Management, Green Economy

### INTRODUCTION

The latest Omnibus Law on Job Creation, Law No. 6 of 2023, Article 87 paragraph (4), emphasizes the role of Village-Owned Enterprises (BUMDES) as

# *Jurnal Hukum Replik*

## Universitas Muhammadiyah Tangerang

P-ISSN: 2337-9251 E-ISSN: 2597-9094

Vol. 12 No. 1 Maret 2024

Submit: 24-Jan-2024

Revised: 21-Feb-2024

Published: 07-Mar-2024

legally recognized entities owned by or collectively with the villages. BUMDES aims to manage businesses, optimize assets, enhance investments and productivity, provide services, and develop other types of businesses to maximize the welfare of rural communities (Bima H, 2020). As a legal entity, the role of BUMDES becomes increasingly important and strategic. It can serve as the manager of various products and services generated by the rural community, as well as a producer of diverse necessities for the community. BUMDES plays a crucial role in accelerating business growth within the community, providing public services, and fulfilling various other functions.

BUMDES plays a significant role in enhancing the village's own-source revenue and therefore serves as a means to strengthen village self-reliance. Through its contribution to the village income, BUMDES becomes a crucial tool for developing the village's capabilities towards achieving self-reliant status. Data from the Ministry of Villages, Disadvantaged Regions, and Transmigration (KEMENDES PDRT) indicates that as of December 13, 2023, the total number of BUMDES nationwide was 52,065, with 5,442 BUMDESMA, making a total of 57,507. Meanwhile, the total number of villages in Indonesia is 74,960. Thus, when averaged, the number of BUMDES spread across Indonesia has reached approximately 76.8% (<https://sid.kemendes.go.id/bumdes>). This demonstrates a positive trend, considering that village self-reliance is crucial for village governance to act as a driver for regional economic progress in each respective district (Iskandar, et.al, 2021).

In general, the existence and purpose of BUMDES as a legal entity conducting business activities for the benefit of the village have roles beyond profit-seeking. These roles are outlined in Article 5 of Government Regulation No. 11 of 2021 concerning BUMDES and include: a. Consolidating village community products and/or services, b. Producing goods and/or services, c. Acting as a collection point, buyer, and marketer of village community products, d. Incubating village community

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Revised: 21-Feb-2024

Published: 07-Mar-2024

businesses, e. Stimulating and energizing the economic activities of the village community, f. Providing basic and general needs for the village community, g. Increasing the benefit and economic value of cultural, religious, and natural resources, and h. Enhancing the added value of village assets and the village's own-source revenue. Therefore, the economic principles executed through BUMDES should not be conducted freely and actively (without guidelines). Values such as the principles of mutual cooperation (*gotong royong*) and people's economy (*ekonomi kerakyatan*) should be incorporated into managing BUMDES. This means that business concepts oriented towards capitalism and monopolies should be avoided or set aside.

Majority of BUMDES business activities conducted thus far include savings and loans, utilizing village natural tourism, producing flagship products, and providing various service offerings. Apart from these majority activities, it might be necessary to enhance and introduce additional types of businesses managed by BUMDES related to product consolidation, providing basic needs for the village community, and increasing the economic value associated with waste. Waste represents residual materials generated by households and/or industries; hence, BUMDES, as a stakeholder running village government business activities, is expected to be involved in tackling waste issues at an early stage. BUMDES is anticipated to be involved at the village level to prevent the accumulation of waste in temporary collection areas at the sub-district level and final disposal sites at the district level. Successful waste management will occur rapidly if there is synergy among governments at every level, from villages to districts. Therefore, this collaborative approach needs to be implemented at the grassroots level, i.e., the village, utilizing the BUMDES entity to transform waste into a commodity. This process involves collecting and further processing waste to generate both economic and environmental benefits.

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Published: 07-Mar-2024

In the general perspective, society often perceives waste as residue lacking value, rather than a resource (commodity) that can be utilized. The conventional approach employed in waste management primarily focuses on final actions, where waste is collected, transported, and disposed of at final waste processing sites. However, the accumulation of substantial volumes of waste at final sites (landfills) has the potential to emit methane gas (CH<sub>4</sub>), contributing to greenhouse gas emissions and causing global warming. The natural decomposition process of waste takes a long time and requires substantial costs (Ariefahnoor, et.al, 2020).

The paradigm that emphasizes an end-of-life approach in waste management should be abandoned in favor of adopting a new paradigm. This new paradigm views waste as a resource with economic value that can be utilized, such as for energy, compost, fertilizer, or as an alternative fuel replacing fossil fuels. The comprehensive waste management approach begins at its source (households, institutions, businesses) before a product becomes waste, extending to the final stage when the product is no longer useful and becomes waste, which is then safely managed back into the environment. This new paradigm of waste management involves waste reduction and handling activities. Reduction involves limiting, reusing, and recycling, while waste handling includes sorting, collection, transportation, processing, and ultimately disposal.

In order to transform waste into a commodity, this research utilizes a waste bank as a method to collect and manage waste as a raw material. It is crucial to establish regulations and operational protocols for the waste bank to ensure consistent stock of raw materials ready for processing. Subsequently, distillation and pyrolysis equipment are employed as methods to process and produce waste that has been sorted through the waste bank, thereby generating an alternative fuel to substitute for fossil fuels.

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An integrated approach between waste management and processing involving distribution and production processes is essential. Therefore, systematic governance and planning need to be considered by the Village-Owned Enterprises (BUMDES) as the business entity executing these operations. The effective handling of waste is a goal outlined in point 12 of the Sustainable Development Goals (SDGs), aiming to reduce waste production through prevention, reduction, recycling, and reuse to ensure sustainable patterns of production and consumption. By utilizing waste management methods such as through Waste Banks and processing waste through distillation or pyrolysis processes to produce an alternative fuel to replace fossil fuels, these activities also support SDGs programs related to the green economy, as articulated in point 13 concerning climate action.

In Indonesia, the green economy has been prioritized through the National Medium-Term Development Plan (RPJMN) 2020-2024, focusing on three priority programs: improving environmental quality, enhancing disaster resilience and climate change adaptation, and low-carbon development. Indonesia has also ratified the SDGs document "Transforming Our World: The 2030 Agenda for Sustainable Development" through Presidential Regulation No. 59 of 2017. Hence, Village-Owned Enterprises (BUMDES) have a normative responsibility in their role as business entities at the village government level to contribute to the success of government programs and global initiatives in achieving better economic and environmental sustainability (Ibrahim, et.al, 2021). In this context, the author presents a problem formulation related to the role of BUMDES in managing waste within the framework of the green economy, specifically in transforming waste into an alternative fuel.



## RESEARCH METHODS

In this research, a normative legal research method focusing on literature analysis was employed. The approach applied includes a statutory approach to identify the legal framework within Law No. 18 of 2008, Law No. 6 of 2014, Law No. 16 of 2016, and Law No. 6 of 2023 related to Village-Owned Enterprises (BUMDES), Waste Banks, and Green Economy. Furthermore, a conceptual approach was used to evaluate theories from various experts addressing the legal issues discussed. Meanwhile, a field approach (Brady D, 2019) was implemented to analyze the role of BUMDES in Balun Village, Turi District, Lamongan Regency, in implementing the concept of a green economy through a Waste Bank.

The legal source materials accessed encompass primary legal sources (such as relevant laws and regulations), secondary legal materials (including textbooks, scholarly journals, legal papers), and tertiary legal materials (such as legal dictionaries). The analysis process involves citing articles of legislation related to the discussed issues and opinions of scholars found in legal literature, serving as theoretical foundations to address the encountered problems. Research material collection methods include literature review or field study. With the gathered data, the aim is to produce a study that provides precise, applicable, and innovative research findings, supporting the roadmap of Village-Owned Enterprises (BUMDES) in implementing the concept of a green economy through Waste Bank management. This approach aims to generate waste processing that produces alternative energy to fossil fuels.

## RESULTS, DISCUSSION, AND ANALYSIS

The significant population size of Indonesia coupled with its high growth rate has led to a notable increase in the volume of waste. At least in 2023, the waste generated amounted to 13,073,052.01 tons per year, with waste reduction reaching

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Published: 07-Mar-2024

16.67%, equivalent to 2,179,855.72 tons per year. Waste management accounted for 51.26%, or 6,700,833.42 tons per year, while data pertaining to managed waste stood at 67.93%, approximately 8,880,689.14 tons per year. In addition, unmanaged waste comprised 32.07%, totaling 4,192,363.87 tons per year. These statistics are sourced from the Ministry of Environment and Forestry, Directorate General of Waste, Hazardous Waste, and B3 Management, Waste Handling Directorate (<https://sipsn.menlhk.go.id/sipsn/>). The increasing waste volume is exacerbated by shifting consumer patterns, resulting in diverse types of waste, particularly hazardous and/or non-biodegradable packaging waste. The surge in population and evolving consumption behaviors exacerbate waste diversity and quantity, posing a serious concern. Current waste management practices, which lack environmental consideration, adversely impact public health and the environment (Widyatmoko, et.al 2002). Waste has become a national issue requiring a comprehensive and integrated approach, from its sources to disposal, aimed at generating economic benefits, enhancing community well-being, ensuring environmental safety, and driving behavioral change.

Effective and sustainable waste management begins with understanding the types or classifications of waste to be processed, comprising household waste and similar household-related waste. Household waste originates from daily household activities, excluding specific waste like human excreta, while similar household-related waste encompasses waste from commercial, industrial, special, social, public facilities, and/or other facilities. The Ministry of Environment and Forestry, through Ministerial Regulation No. 14 of 2021 concerning Waste Management in Waste Banks, provides guidance and regulations on waste governance utilizing Waste Banks as facilities to manage waste (Bambang Suwerda, et.al, 2019) following the principles of the 3Rs (reduce, reuse, and recycle). These serve as educational tools, fostering behavioral change in waste management, and implementing a circular economy

approach. This circular economy approach entails applying a system that utilizes waste as raw materials for industries. It is stipulated that Waste Banks can be established and managed by communities, enterprises, and/or local governments.

Waste banks serve as a system or method designed to manage waste by taking actions to reduce and handle waste. The action to reduce waste is carried out through reuse activities, utilizing the entire or part of the waste for the same or different functions without undergoing prior processing (Nag A Vijayakumar, 2005). On the other hand, waste handling involves waste sorting, collection, and/or processing. Waste sorting involves categorizing waste into various types:

1. Waste containing hazardous and/or toxic materials (B3 Waste): a. Household products containing hazardous and/or toxic materials no longer in use. b. Empty packaging of products containing hazardous and/or toxic materials. c. Unused electronic devices. d. Other products and/or packaging containing hazardous and/or toxic materials no longer in use.

2. Biodegradable waste: a. Food scraps. b. Fallen leaves or foliage. c. Other waste easily biodegradable by natural processes.

3. Reusable waste: a. Plastic waste. b. Paper waste. c. Metal waste. d. Glass waste. e. Rubber waste. f. Textile waste. g. Other waste (having reusable value without undergoing prior processing).

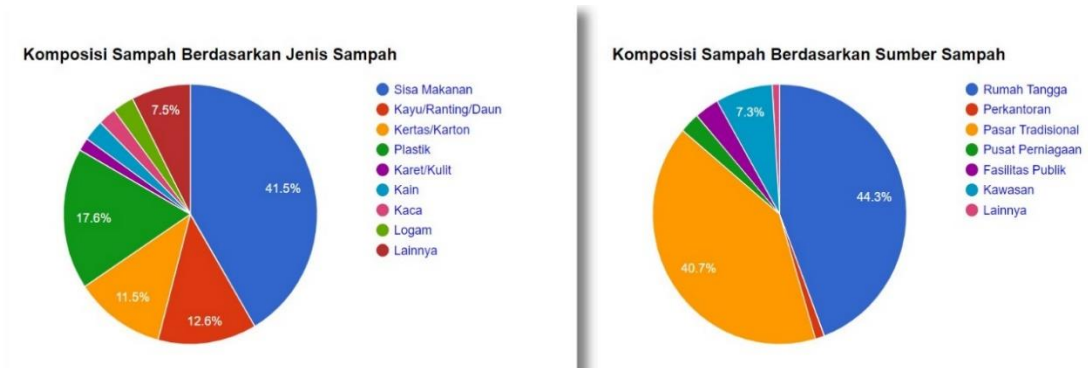
4. Recyclable waste: a. Plastic waste. b. Paper waste. c. Metal waste. d. Glass waste. e. Rubber waste. f. Textile waste. g. Other waste (having reusable value after undergoing processing).

5. Other waste (waste not categorized according to the types of waste in points 1-4).

In general, Waste Bank management concerning waste reduction involves recycling efforts, while waste handling involves the sorting, transportation, and

processing of waste according to its type (Sejati Kuncoro, 2009). The methods for waste reduction and handling are tailored to the waste categories managed by the Waste Bank. Waste Bank managers have the authority to determine suitable waste management methods based on the bank's capacity and typology, aiming to achieve economic benefits while preserving the environment (Rizqia Lutfi Kurnia Dewi, 2023).

**Figure 1. National Waste Composition Graph Based on Types & Sources of Waste in 2023.**



**Figure 2. Waste Composition in East Java Based on Types of Waste in 2023.**

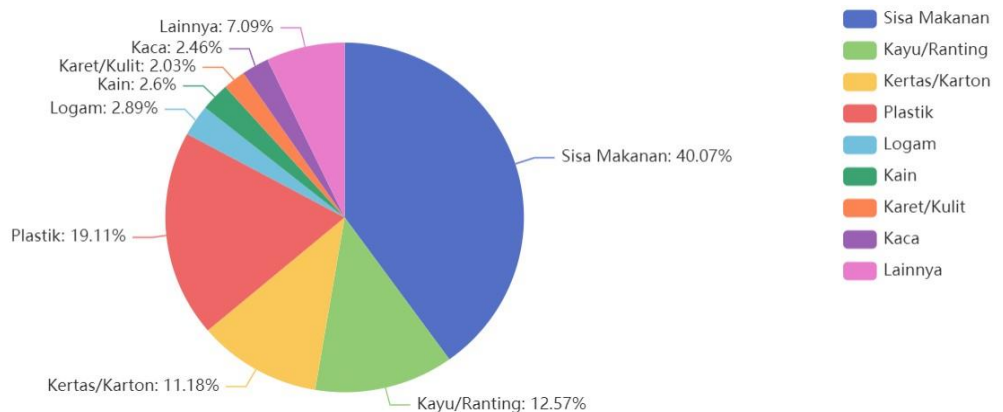
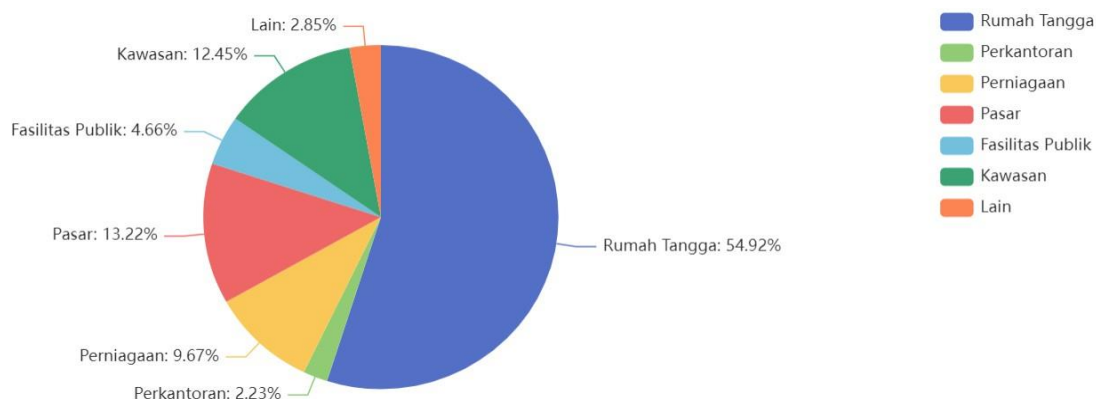


Figure 3. Waste Composition in East Java Based on Source of Waste in 2023.



### The Important Role of Village-Owned Enterprises (BUMDES) in Waste Bank Management

Balun Village, situated in the Turi District of Lamongan Regency, encompasses an area of 5.61 km<sup>2</sup>, accounting for 11.52% of the total area of the Turi District. With an elevation of 6 meters above sea level, Balun Village is bordered by Ngujunrejo Village to the north, Lamongan District to the south, Tambakploso Village to the west, and Gedongboyountung Village and Lamongan District to the east. Specifically, the distance between Balun Village and the Turi District Center and Lamongan Regency Center is 5 kilometers for each center point (Badan Pusat Statistik, 2022). Administratively, geographically, and demographically, Balun Village is divided into two hamlets, namely Dusun Balun and Dusun Ngangkrik, consisting of a total of four neighborhood associations (RW) and twenty-one community units (RT). Dusun Balun comprises three RWs and eighteen RTs, while Dusun Ngangkrik consists of

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P-ISSN: 2337-9251 E-ISSN: 2597-9094

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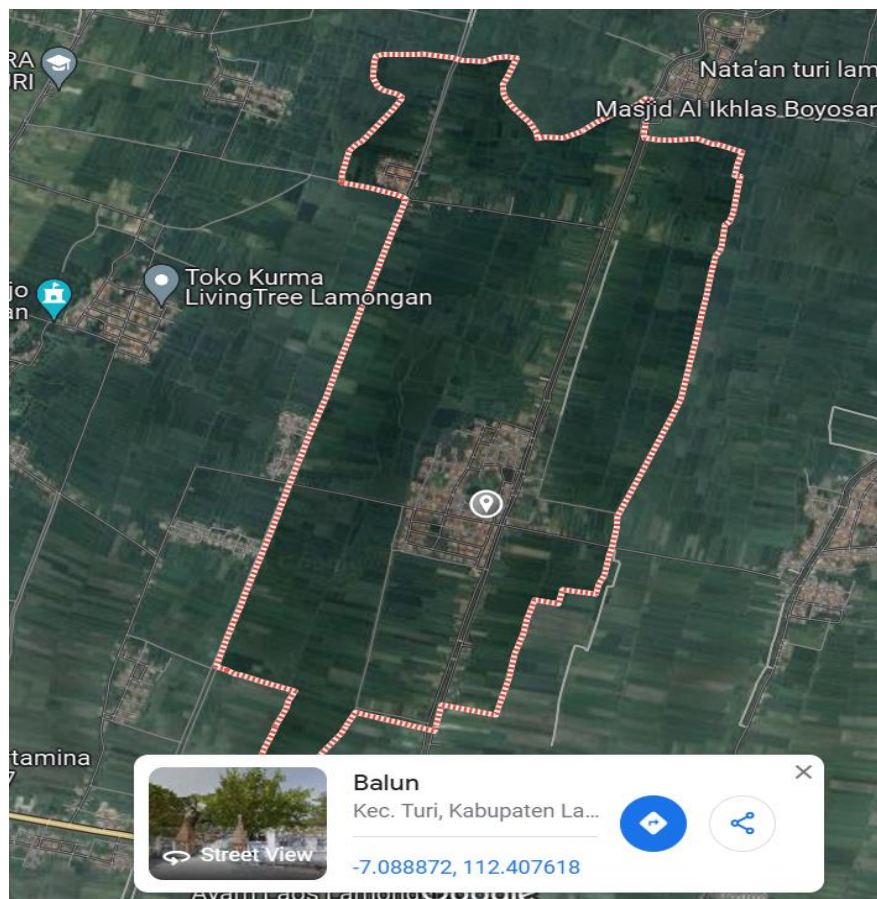
Submit: 24-Jan-2024

Revised: 21-Feb-2024

Published: 07-Mar-2024

one RW and three RTs. The population of Balun Village reaches 4,952 individuals, comprising 2,488 males and 2,464 females, distributed across 1,103 households. With an area of 5.61 km<sup>2</sup>, the majority of Balun Village, about 95%, consists of fisheries (ponds) covering an area of 495 hectares, producing approximately 3,686,185.87 tons of various fish yields (milkfish, tilapia, tombro, shrimp) annually (Ramadhani, et.al, 2020).

Figure 4. Map of Balun Village, Turi District, Lamongan Regency.



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Revised: 21-Feb-2024

Published: 07-Mar-2024

It can be assumed based on this data that each household generates around 2 kilograms of waste per day. With a total of 1,103 households, the potential waste generated solely from households is approximately 2,206 kilograms per day. This figure doesn't account for waste generated by businesses, offices, and similar establishments. This indicates an abundant availability of waste suitable for processing into solar fuel. The next challenge lies in managing the waste, from storage to processing using distillation and pyrolysis equipment (Wungo, 2020). Therefore, the subsequent focus should be on efficient waste management, encompassing storage, processing, and the use of distillation equipment to transform waste into solar fuel.

Based on the preparation for waste planning and management, the Village Chief has issued advisories and conducted socialization aiming to guide every resident of Balun **Village**. The village is divided into two areas: Dusun Balun and Dusun Ngangkrik, encompassing a total of 4 RW (administrative units) and 21 RT (neighborhood units). Dusun Balun consists of 3 RW and 18 RT, while Dusun Ngangkrik comprises 1 RW and 3 RT. The advisories mandate each household to separate waste into two different plastic bags, distinguishing between dry and wet waste. Presently, a Village Regulation is being prepared as the legal basis and roadmap for Balun Village to manage the Waste Bank, involving the Bumdes (Village-Owned Enterprises) and active participation from the community. The ongoing activity involves the collection of household waste. The community is obliged to sort waste at their homes based on types: organic, inorganic, and residual (Lisnawati, 2019). The village will provide facilities (containers) for waste sorting in every resident's home. Subsequently, waste collection will be conducted by the Waste Bank officers weekly to weigh and transport the collected waste. The weight recorded will serve as income, and the savings from waste collection will be distributed monthly to residents in the form of points through the Waste Bank concept.

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The Waste Bank management will be carried out both offline and online. The online method will involve a Waste Bank application used to record waste deposit transactions from each customer and the amount of waste (in kilograms) that can be converted into Indonesian Rupiah at the Bumdes office (Pratama, et.al, 2020). This approach enables active community involvement in waste management by starting the separation process at the waste source. The income generated from this waste management process is then calculated as earnings given back to the customers in the form of points through the Waste Bank application. This approach not only positively impacts the environment by improving waste management but also provides incentives for community members to actively participate in the waste management program.

BUMDES, as a legal entity representing the Village Government, has the task and function of making the village economically self-reliant and independent while maintaining the environmental ecosystem, especially regarding waste management. Considering the village-level governance, the phase or process of waste accumulation until it reaches the final disposal site at the district level can be intercepted and intervened at an earlier stage. Mitigation and actions related to waste management at the village level can be done by establishing Waste Banks, utilizing every BUMDES to turn waste into a commodity and raw material to be managed and processed into products with value and economic benefits. Innovation and creativity are the keys to forming and operating the Waste Bank in a systematic and sustainable manner (Bontempi, et.al, 2021).

The existing waste banks have often focused on the concept of the 3 Rs (Reduce, Reuse, & Recycle) (Todaro, et.al, 2018). Through this writing, the author offers a new concept that is more applicable in running waste banks (World Bank, 2022) namely the concept of the 5 Ps (Pick, Sort, Collect, Process, & Profit). The utilization of waste can be carried out through the activities of Selection and Sorting, including:



**a. Plastic waste**

- 1) Material for creating tablecloth from used coffee sachet packaging, or for crafting other items like pencil holders, seat mats, etc.;
- 2) Vegetable plant pots made from unused plastic buckets; or
- 3) Other functions without undergoing prior processing.

**b. Paper waste**

- 1) Crafting material for making flower vases; or
- 2) Other functions without undergoing prior processing.

**c. Metal waste, such as used beverage cans**

- 1) Writing tool containers;
- 2) Craft materials; or
- 3) Other functions without undergoing prior processing.

**d. Glass waste**

- 1) Flower vases;
- 2) Writing tool containers;
- 3) Small fish aquariums; or
- 4) Other functions without undergoing prior processing.

The next steps in managing the Waste Bank involve the activities of Collect, Process, and Profit. The collection process is carried out by Waste Bank personnel who collect the waste gathered by residents or customers. Typically, waste collection occurs after educating and socializing with customers on how to place their waste in designated areas facilitated by the Waste Bank management, which includes organic, inorganic, and residual waste. Collection is scheduled once a week and/or upon request when the waste reaches the minimum weight. Customers can contact the Waste Bank's call center (personnel) for waste pickup or directly visit the Waste Bank office to deposit their waste. Subsequently, the Waste Bank employs various methods to Process the collected waste and generate Profit. Processing activities include:

**a. Composting**

Composting is a process applied to organic waste, commonly known as wet waste, derived from living organisms such as food scraps, leaf litter, and other materials that can naturally decompose. Typically, composting involves utilizing microorganisms to produce compost fertilizer. Through this method, waste processing generates solid or liquid compost fertilizer that holds economic value, can be self-utilized, or sold.

**b. Material recycling**

The process of recycling materials involves transforming waste into products that hold functional value. For example, plastic bottles from used mineral water packaging can be processed through shredding or crushing to become plastic granules that can be reused as raw materials. Similarly, glass waste from used beverage bottles can be crushed and used as a base material to create new glass-based products.

**c. Energy recycling**

The energy recycling process involves transforming the form and characteristics of waste through biological, physical, and/or chemical processes to generate energy. In Waste Banks, energy recycling implementation often employs simple technology, such as utilizing biogas produced from the anaerobic processing of organic waste piles, where methane gas (CH<sub>4</sub>) is captured for utilization. For instance, plastic waste is used to produce an alternative fuel replacing diesel. The process involves heating at high temperatures through distillation and pyrolysis in a combustion device and vessel pipes, changing the chemical properties of plastic by depositing vapors into a fuel such as diesel.

Figure 5. Methods & Principles of Waste Processing for Benefit

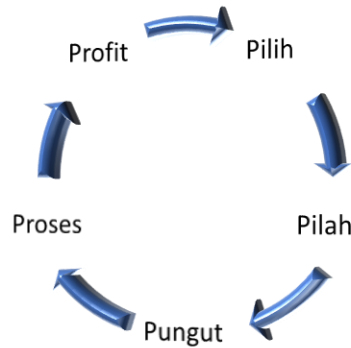
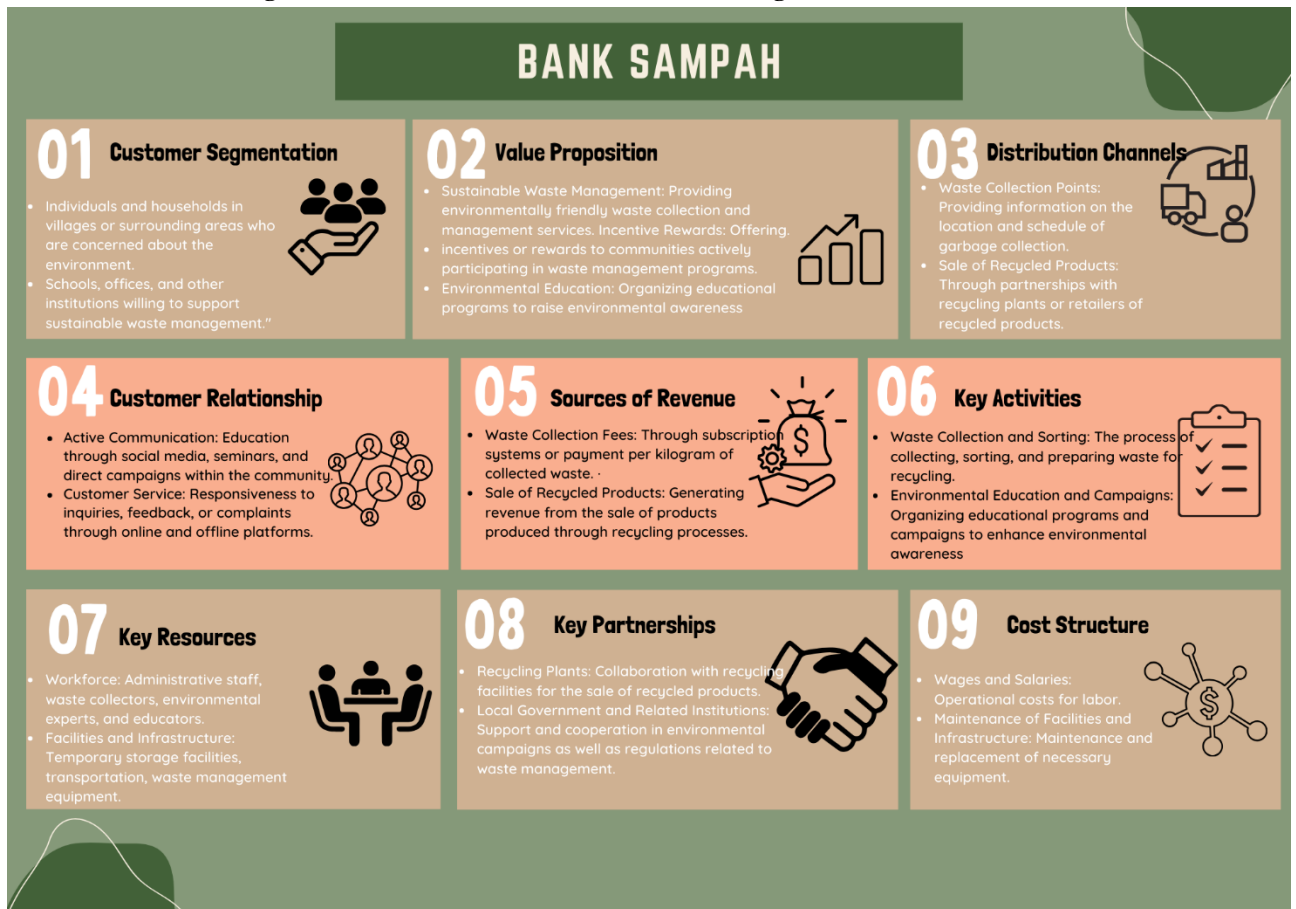


Figure 6. Business Model of Waste Bank Using the 5 P Method



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The management of a business must be based on thorough planning. The canvas business model related to the Waste Bank is designed starting from customer segmentation, value proposition, distribution channels, customer relationships, revenue streams, key activities, key resources, key partnerships, and cost structure. Each section has been detailed in Figure No. 6. Furthermore, it is necessary to address the business plan and organizational structure of the Waste Bank so that at the implementation stage, each division understands its roles, tasks, and responsibilities. The following are the steps and actions that will be taken to initiate the Waste Bank business.

<b>8 Point Business Model Canvas</b>	<b>Action Plan</b>
Segmentasi Pelanggan (Customer Segments)	<ul style="list-style-type: none"><li>• Identify the needs and preferences of each customer segment (individuals, households, schools &amp; institutions, industries &amp; businesses) through surveys and market analysis.</li><li>• Develop specific marketing strategies for each segment. For instance, specialized educational programs for schools and efficient waste management solutions for industries.</li></ul>
Nilai Proposisi (Value Propositions)	<ul style="list-style-type: none"><li>• Enhance waste collection services by creating a more flexible and easily accessible schedule for customers. Offer incentives or reward programs for top loyal contributors/customers.</li><li>• Design engaging and informative educational programs about environmental sustainability and recycling benefits. Start from brochures, seminar events, to online campaigns.</li></ul>

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P-ISSN: 2337-9251 E-ISSN: 2597-9094

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<p>Saluran Distribusi (Channels)</p>	<ul style="list-style-type: none"> <li>• Enhance EcoRecycle's visibility through social media and website with informative and engaging content about recycling and sustainability.</li> <li>• Expand reach by partnering with local stores, offices, and communities to facilitate waste collection at strategic locations.</li> </ul>
<p>Hubungan Pelanggan (Customer Relationships)</p>	<ul style="list-style-type: none"> <li>• Establish a feedback mechanism from customers and utilize this data to continually improve services.</li> <li>• Develop an online community for contributors/customers, enabling them to share ideas, tips, and their experiences in recycling.</li> </ul>
<p>Sumber Pendapatan (Revenue Streams)</p>	<ul style="list-style-type: none"> <li>• Streamline and tailor collection costs according to the type and quantity of waste collected, aligning with customer needs and preferences.</li> <li>• Identify the market and demand for recycled materials, and increase sales volume by seeking sustainable partnerships with recycling plants.</li> </ul>
<p>Sumber Daya Kunci (Key Resources)</p>	<ul style="list-style-type: none"> <li>• Recruit and train the operational team to enhance efficiency in waste collection, processing, and bank management.</li> <li>• Develop the necessary physical infrastructure (storage and processing facilities) and technology to improve operational capacity and efficiency.</li> </ul>
<p>Kegiatan Kunci (Key Activities)</p>	<ul style="list-style-type: none"> <li>• Increase the schedule and frequency of waste collection, along with a more efficient sorting process.</li> </ul>

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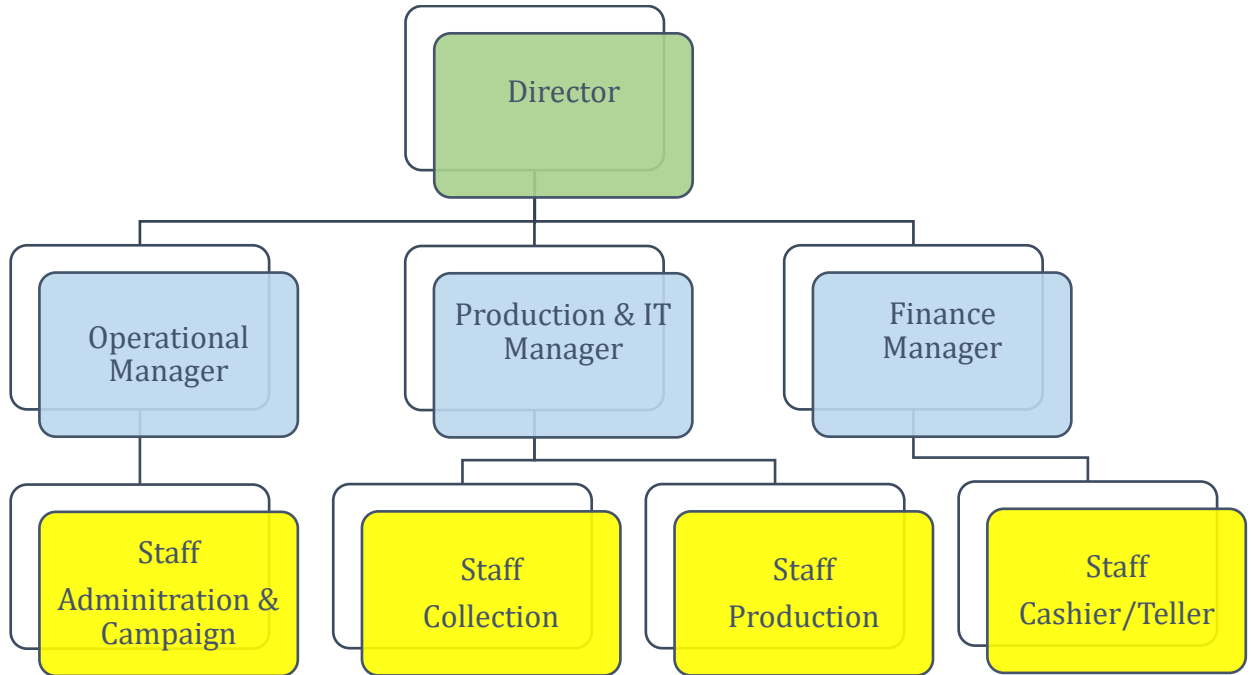
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	<ul style="list-style-type: none"><li>• Continue environmental education programs and campaigns both online and offline, and regularly hold community events.</li></ul>
Kemitraan Kunci (Key Partners)	<ul style="list-style-type: none"><li>• Conduct training and integration with partners to ensure a deep understanding of the working processes and operational standards of the waste bank.</li><li>• Start collecting and processing waste according to the established agreements, and regularly monitor the performance of partnerships.</li></ul>
Struktur Biaya (Cost Structure)	<ul style="list-style-type: none"><li>• Evaluate and improve operational efficiency to reduce transportation costs and waste management.</li><li>• Employ effective marketing strategies focusing on higher Return on Investment (ROI), such as measurable digital marketing and low-cost campaigns.</li></ul>

**Figure 7. Organizational Structure of the Waste Bank**



### **The Waste Processing Process Based on Green Economy Produces Solar Energy**

According to the journal Environmental Values in 1992, "Green Economics" (Green Economy Coalition, 2019) defines Green Economy as an economy capable of sustaining itself in a sustainable manner. An important feature of the Green Economy is the systematic separation between the rate of change in economic output and the environmental assets used in the process (Brown, et.al, 2020). The primary objective of the Green Economy is to ensure human well-being without a decrease while promoting the sustainable use of natural resources. The concept of the Green Economy was subsequently expanded by the United Nations Environment Programme (UNEP) as an effort capable of enhancing well-being and social justice while significantly reducing environmental risks and ecological scarcity. UNEP also

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highlights the importance of preserving natural capital, including ecosystems and natural resources (UNEP, 2020).

There is no global consensus on the definition of Green Economy (UNDP, 2023). In Indonesia, the Ministry of National Development Planning/ National Development Planning Agency (Bappenas) has adopted the definition of the Green Economy from the United Nations Environment Programme (UNEP). It is a model of economic development that emphasizes investment, capital, infrastructure, jobs, and skills to achieve sustainable social and environmental well-being. In Indonesia, the objective of the Green Economy is to accelerate economic growth while prioritizing environmental preservation and societal welfare. Efforts to implement the Green Economy began in 2013 through collaboration between Bappenas and the Global Green Growth Institute (GGGI) under the Green Growth Program (GGP) in Indonesia (Pemerintah Indonesia, 2023). The GGP focuses on three main sectors: sustainable energy, sustainable landscapes, and sustainable infrastructure. Participation from all stakeholders in the GGP is considered crucial for the success of Green Economy growth (Laura Loiseau, et.al, 2016).

Indonesia has taken concrete steps as a global commitment by enacting Law Number 16 of 2016, which affirms the principles of the Paris Agreement and establishes national contributions as implementation. In 2020, Indonesia submitted its NDC (Nationally Determined Contribution) to reduce CO<sub>2</sub> emissions by 29% by 2030 independently or by 41% with international support (Bappenas, 2022). In 2021, the Indonesian Government enacted Presidential Regulation Number 98 of 2021 concerning the Implementation of CEA (Carbon Economic Value) to achieve national contribution targets in controlling CO<sub>2</sub> emissions in national development. This regulation sets the foundation for the implementation of CEA. Through these commitments, Indonesia reaffirms its environmental preservation targets to achieve the Green Economy (IPCC, 2022).



The principles of the Green Economy also encompass sustainable economic recovery (green recovery) and apply to systematic (Clarke P, et.al, 2020), long-term economic reforms, supporting the transition towards a sustainable global economy. The Green Recovery Roadmap Indonesia 2021-2024 (GRRRI) is a plan aimed at restoring the Green Economy in Indonesia after experiencing a reduction in emission reduction potential of around 24.31% due to the impacts of the COVID-19 pandemic (Yudiarno, et.al, 2021). GRRRI outlines three scenarios (low, medium, and high) that depict Indonesia's capacity in efforts to revive the implementation of the Green Economy post-pandemic. GRRRI elaborates on the principles of Green Economy initiatives (Bappenas, 2021). An initiative can be considered a Green Economy initiative if it fulfills five basic principles, which are (United Nations Development Programme, 2023):

1. **Well-being**

Aims to create sustainable shared prosperity beyond mere material wealth, prioritizing human development, health, education, and community empowerment.

2. **Justice**

Emphasizes principles of equality, community solidarity, social justice, and support for human rights, particularly for marginalized groups (ensuring a fair transition for the benefit of all society and future generations).

3. **Planetary Boundaries**

Recognizes that human well-being depends on healthy natural conditions, preserving the function and limitations of natural resources like land, water, air, and various other ecosystems.

4. **Efficiency and Sufficiency**

Targets low-carbon strategies, resource diversification, and the adoption of circular economic models. The aim is to create well-being within planetary boundaries and align economic incentives with their societal impact costs.

#### 5. **Good Governance**

Involves developing institutions or bodies that integrate dynamic democratic accountability, relevant metrics, robust scientific approaches, and local knowledge in implementing Green Economy principles.

The application of a green economy system in the processing of waste into a substitute for solar fuel through a Waste Bank operated by a Village-Owned Enterprises (BUMDES) is achieved using distillation and/or pyrolysis processes. Distillation is a method used to separate a liquid from its mixture based on differences in boiling points or the capacity of substances to vaporize. In this process, the liquid is heated until it reaches its boiling point, producing vapor that is then passed through a condenser. There, the vapor condenses back into a liquid and is collected as the distillation output. Essentially, distillation is a separation technique utilizing heat as a separating agent. The distillation process occurs in a column or tray with packing material to enhance separation efficiency. This process separates mixtures into several products based on the components' ability to vaporize. Typically, distillation methods are used to separate components within a solution (Wang H, et.al, 2020).

Various distillation methods are commonly used in industries, including flash distillation, simple distillation, steam distillation, and flash distillation with partial condensation. Flash distillation involves the partial evaporation of a liquid so that the resulting vapor reaches equilibrium with the remaining liquid (Aisa Rosa, 2019). This vapor is then separated from the liquid and condensed. Equipment used in flash distillation includes a heat exchanger or sometimes a pipe still for components with high boiling points, as well as a flash drum. The flashing process involves volatile feed passing through a heater and then entering the flash drum through a pressure-

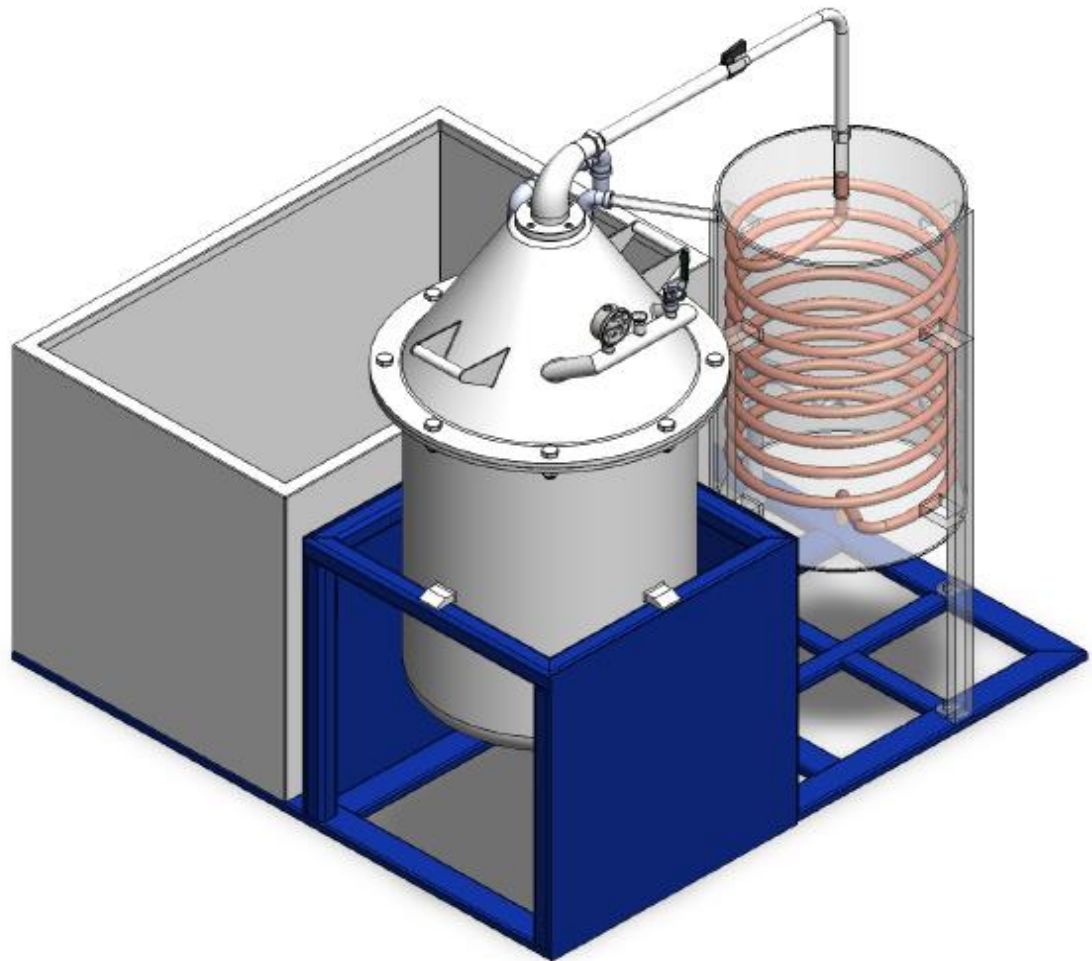
reducing valve (choke valve). The vapor and liquid phases leaving the flash drum are considered to be in equilibrium (Affandi R.A,et.,al, 2020).

The other process is carried out using the pyrolysis method, derived from the combination of the words "Pyro," meaning fire, and "Lysis," meaning separation. It is the thermal decomposition of organic material (Effendy L, et.,al, 2020). This process involves heating organic material without or with minimal oxygen or other reagents to break down chemically. Pyrolysis or devolatilization is a process in which organic material or plastics are thermally decomposed at high temperatures, typically starting around 230°C. Plastic pyrolysis involves three decomposition mechanisms:

1. Polymer Chain Scission; Random cutting of polymer chains occurs, resulting in shorter chains.
2. End Chain Cutting: Cutting occurs at the end of the chain, forming smaller molecules and longer polymer chains.
3. Polymer Chain Separation: Polymer chains break into smaller molecules.

These mechanisms depend on the energy required to break the bonds, the degree of aromatization, and the presence of halogens and other heteroatoms in the chain. Pyrolysis is a thermal cracking process where polymer chains are broken down into simpler compounds through heating or combustion, with little or no oxygen. The pyrolysis process is endothermic, meaning it only occurs when heat energy is introduced into the system.

Figure 8. Design of Distillation and Pyrolysis Equipment for Processing Waste into Solar Fuel



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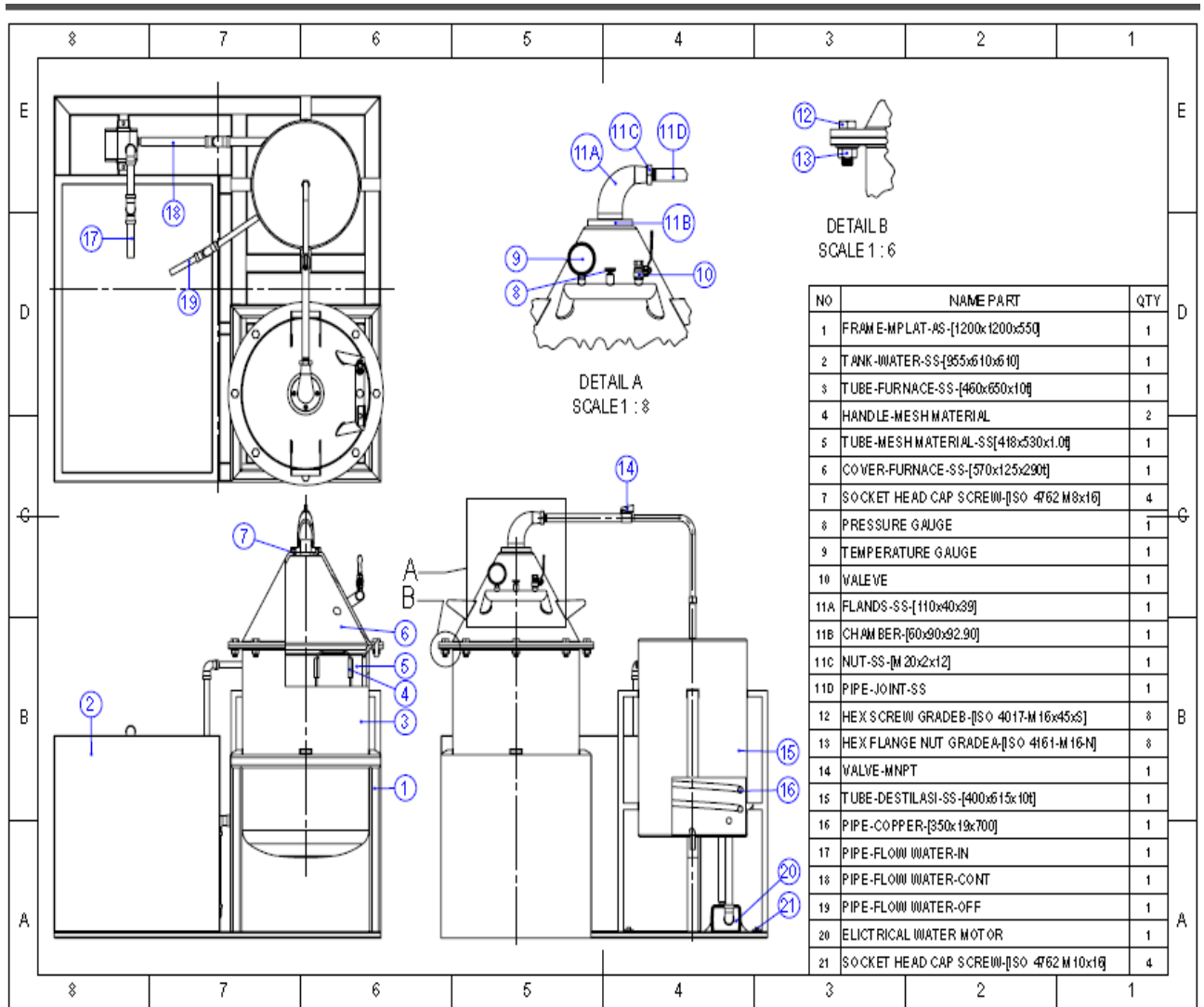
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**Figure 9. Work flow of Distillation and Pyrolysis Equipment for Processing Waste into Solar Fuel**



### CONCLUSIONS

Bumdes plays a strategic role in managing Waste Banks due to the latest Omnibus Law on Job Creation, Law No. 6 of 2023, Article 87 paragraph (4), which allows Village Governments to establish business entities to generate village own-source revenue, enhance village fund receipts, thereby enabling the village to become self-sufficient as per the goals of Village SDGs, not solely reliant on the National Budget. Villages can achieve economic, social, and environmental self-reliance, transforming into regions that promote local governments and support the development of national civilization towards an advanced state. Principles of mutual cooperation (*gotong royong*) and people's economy (*ekonomi kerakyatan*) are fundamental in governing Bumdes. Besides seeking profits, Bumdes also plays a role in empowering functions, as regulated in Article 5 of Government Regulation No. 11 of 2021, including enhancing the benefit and economic value of cultural wealth, religious aspects, and natural resources. As a legitimate juridical basis and source of authority, the Village Government should establish Village Regulations concerning Bumdes and Waste Banks. This ensures that future actions are measured, directed, and based on valid and clear legal grounds.

Waste, originally considered a nuisance (as refuse), is transformed into a resource and positioned as a commodity processed through a Waste Bank, following the 5P principle (Pick, Sort, Collect, Process, & Profit) as an extension of the 3R principle (Reduce, Reuse, & Recycle). The Waste Bank implements its business based on previously structured plans via the business model canvas (BMC) and operates according to a pre-planned action plan. Guided by the concept of a green economy as ratified through Law No. 16 of 2016 and Presidential Regulation No. 98 of 2021, waste management and processing oriented towards environmental sustainability are projected to not only yield economic profits but also align with the principles of the Green Recovery Roadmap Indonesia 2021-2024: well-being, justice, Planetary

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Boundaries, efficiency and sufficiency, and good governance. The transformation process of converting waste into an alternative fossil fuel energy source is conducted through distillation and pyrolysis mechanisms, altering chemical compounds from plastics to produce an alternative fuel to replace traditional solar energy. Ultimately, achieving the SDGs program, particularly in point 12 concerning responsible consumption and production, and point 13 concerning climate action, becomes an inevitability rather than a mere daydream.

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