"BAHALAP": TRANSFORMING RATTAN AND PALM OIL WASTE INTO GREEN ECONOMIC OPPORTUNITIES

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Abstract. *The "BAHALAP" innovation addresses the environmental challenges caused by the accumulation of rattan lignocellulosic waste and massive palm oil biomass (EFB, POME) in Central Kalimantan, with the goal of optimizing this waste for efficient and eco-friendly energy production. Utilizing a mixed-methods design, the research involved field observations and interviews with farmers in Palangka Raya and Katingan, while also implementing a local biobriquette innovation from the waste. The results demonstrate that rattan waste, rich in carbon biopolymers, and palm oil waste, rich in triglycerides, possess significant energy potential that can be converted into syngas, bio-oil, and biochar through thermochemical processes like pyrolysis and gasification. Economically, "BAHALAP" creates added value from waste, provides new sources of income for farmers, generates job opportunities, and promotes a circular economy, marking a vital step toward a greener and more sustainable future. Nevertheless, current implementation is constrained by the lack of access to adequate laboratory facilities for comprehensive testing of oil and biogas production, necessitating strategic partnerships for future scientific validation.*

Keywords: *Bahalap; Circular Economy; Palm Oil; Rattan;Renewable Energy.*

1. INTRODUCTION

1.1 Background

According to the Central Kalimantan Plantation Office, the area of oil palm plantations in Central Kalimantan reached 1.7 million hectares in 2023, and the total area of rattan plantations is estimated to be 325,000 hectares. This significant potential is supported by local government programs that aim to revitalize and re-cultivate both rattan and palm oil commodities. Kalimantan Island, particularly Central Kalimantan province, is a major global production center for rattan and palm oil. The region's rattan industry, which has long been central to the local economy, produces a substantial volume of lignocellulosic waste. The processing of raw rattan into value-added products generates waste like rattan cuttings, peelings, and shavings. Due to limited technology and low economic value, this biomass waste often accumulates without further use. The accumulation of rattan waste not only reduces operational efficiency and takes up land but also increases the risk of forest and land fires, especially during the dry season, leading to transboundary haze pollution and greenhouse gas (GHG) emissions. The anaerobic decomposition of accumulated organic waste can also release methane (CH4), a GHG with a much higher global warming potential than carbon dioxide. This issue directly hinders the achievement of SDG 11 (Sustainable Cities and Communities) and SDG 13 (Climate Action).

Similarly, the palm oil sector in Central Kalimantan is a key economic pillar with expanding plantation areas. However, this industry also generates massive volumes of biomass waste, both solid (like empty fruit bunches or EFB, mesocarp fiber, and palm kernel shells or PKS) and liquid (like Palm Oil Mill Effluent or POME). Although some PKS and fiber are used as fuel for factory boilers, the surplus waste that is not properly managed remains a serious challenge. Research highlights that unmanaged EFB and POME can cause significant pollution of water and soil ecosystems, worsened by the high BOD and COD values of POME which trigger eutrophication and water quality degradation. Open burning of solid waste, despite being prohibited, still contributes to GHG and particulate matter (PM2.5) emissions, worsening regional air quality and public health. These palm oil waste problems directly conflict with SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), and SDG 15 (Life on Land).

Given the urgency and scale of the environmental impact from rattan and palm oil waste in Kalimantan, the conventional "take-use-dispose" approach is no longer sustainable. This challenge requires innovation in waste management that not only focuses on mitigating negative impacts but also on creating added value. The concept of a Circular Economy provides a transformative framework that promotes using waste as a resource. In line with this, the Waste-to-Energy (WtE) approach emerges as a strategic solution to convert biomass waste into useful energy (electricity, heat, biofuel), while simultaneously reducing waste volume and GHG emissions. This approach directly supports SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation, and Infrastructure), and strengthens SDG 12 and SDG 13 by promoting sustainable practices and reducing emissions. Therefore, this innovation aims to explore the potential and feasibility of utilizing rattan and palm oil waste in Central Kalimantan within a circular energy and WtE framework. By integrating circular economy principles, it is hoped to create a regenerative and resource-efficient system that can significantly contribute to national energy resilience and sustainable development for the Dayak Ngaju people in Central Kalimantan and Indonesia.

1.2 Problem Formulation:

1. How can rattan and palm oil waste be optimized as raw materials for efficient and eco-friendly energy production?
2. How the potential economic impact of implementing the conversion of rattan and palm oil waste into energy?

1.3 Research Objectives:

1. To implement the processing of rattan and palm oil waste for the efficient production of eco-friendly energy;
2. To serve as a means of economic development from the implementation of eco-friendly energy production from rattan and palm oil waste.

1.4 Research Benefits:

1. For the Environment & Community:
   Provides an innovative solution to reduce the accumulation of environmentally damaging rattan and palm oil waste, mitigate greenhouse gas (GHG) emissions, and improve air and water quality in Central Kalimantan.
2. For the Economy:
   Identifies new economic opportunities by creating added value from waste, potential savings in energy costs, new job creation for local communities, and attracting investment in the renewable energy sector.

2. LITERATURE REVIEW AND HYPOTHESIS/ES DEVELOPMENT

1. A 2024 study by Ferdinand Ngosong et al. assessed the renewable energy potential of oil palm residues (OPR) in Cameroon. It found that the palm oil industry produces about 90% biomass residue for every 10% of oil, which is often discarded and causes environmental problems. The study found that a plantation in Cameroon produced 203,666 tons of OPR annually, with a calorific value of 896 TJ and an electricity potential of 249 MWh. Utilizing this residue for clean energy is crucial to reduce dependence on fossil fuels and aligns with Cameroon's goal of reaching 25% renewable energy by 2035.

2. The 2021 research "Integrated biorefinery strategies for palm oil mill waste utilization" by Prihardi Kahar et al. discusses the significant environmental challenges from a large amount of biomass residue and effluent waste, especially from the palm oil industry, which is a major source of greenhouse gas (GHG) emissions. The review highlights that current technology is insufficient for optimal waste utilization and advocates for an integrated biorefinery strategy to convert palm oil biomass into value-added biochemical products. This approach aims to minimize environmental impact, reduce reliance on non-renewable resources, and create economic opportunities by converting waste into biofuels, biochemicals, and other commodities. The study emphasizes the importance of research and development to advance this field and the industry's responsibility in achieving global sustainability targets.
3. A study on the "Energy and economic assessment of mixed palm residue utilization" evaluated the energy and economic feasibility of using a mix of palm oil residues to produce activated carbon and ash for agricultural fertilizer. The study analyzed four process scenarios (pyrolysis, gasification, combustion, and a combination) and found that all showed a positive return on investment with varying payback periods. Palm waste ash was confirmed as a good alternative to chemical fertilizers, especially for ultisol and acidic soils, while the production of activated carbon from this waste was also a viable business option despite high initial capital investment. The findings provide technological and economic guidance for investors and policymakers in their efforts to efficiently utilize biomass.
4. A 2022 study, "Insights into key factors affecting bioconversion efficiency of rattan biomass," explored the factors influencing the bioconversion efficiency of rattan biomass, focusing on the supramolecular structural variations of cellulose. The study used rattan as a lignocellulosic model to address barriers to efficient bioconversion, applying delignification and mild alkali treatment followed by enzymatic hydrolysis. The results showed that variations in the supramolecular structure of cellulose, such as a decrease in crystallinity (50-65%) and swelling of crystallite size (4.8-5.0 nm) during allomorphic transformation, significantly improved hydrolysis, more so than the removal of lignin and hemicellulose. The separation and well-distributed fibrillation of basic cellulose fibers also contributed to increased glucose yield. This research offers new insights for efficient bioconversion strategies of lignocellulosic biomass into renewable energy.
5. A 2020 study by Dhanya et al., "Development of sustainable approaches for converting the organic waste to bioenergy," highlights the increasing dependence on fossil fuels and the importance of sustainable approaches for bioenergy production through organic waste conversion. This review focuses on the potential of organic waste sources and efficient conversion processes to produce biogas, bioethanol, biocoal, biohydrogen, and biodiesel as key renewable energy sources. It discusses various types of organic waste, biogas production via anaerobic digestion, and new techniques like photosynthetic and nano-inspired processes. Converting organic waste to bioenergy not only reduces waste accumulation and disposal hazards but also contributes to climate change action and the development of a sustainable bioenergy sector, with an in-depth analysis of the weaknesses of existing conversion methods and economic, environmental, and social considerations.
6. The 2023 research "Agricultural waste biomass for sustainable bioenergy production" highlights agricultural waste biomass as a crucial sustainable alternative energy source within the global circular economy trend. The study emphasizes that using agricultural residues can significantly reduce greenhouse gas emissions. However, agricultural waste biomass requires pretreatment, especially to remove lignin, to increase the efficiency and yield of bioenergy production. This article provides a comprehensive review of feedstocks,

characterization, bioconversion, and modern pretreatment procedures, and discusses future research challenges and perspectives for bioenergy production from agro-waste biomass.

3. RESEARCH METHODOLOGY

3.1 Time and Location of Research:

No.	Activity	Research Date	Research Location
1.	Field observation	July 13-15, 2025	Plantations in Tewang Sangalang Garing District, Katingan Regency, and Palangka Raya City, Central Kalimantan Province
2.	Data collection	July 16-22, 2025	Researcher's House in Palangka Raya City, Central Kalimantan Province
3.	Biobriquette production	July 23-25, 2025	Plantation in Kasongan City, Katingan Regency, Central Kalimantan Province
4.	Rattan and palm oil waste innovation	July 25-29, 2025	Researcher's House in Palangka Raya City, Central Kalimantan Province
5.	Writing research report	July 30-August 10, 2025	Researcher's House in Palangka Raya City, Central Kalimantan Province

***Table 1.1** Time and Location Research

3.2 Data Sources, Tools, and Materials

The data sources for this research are divided into two: primary and secondary.

- Primary Data Sources

  Field Observation: Researchers conducted in-depth observations at ten rattan and palm oil plantations in Tewang Sangalang Garing District and Palangka Raya City. The goal was to comprehensively analyze the growth process, local farmers' care practices, and the waste management methods used.

  Field Interviews: Researchers interviewed ten local farmers to gather detailed information on post-harvest waste management practices for rattan and palm oil. This data will be the foundation for developing sustainable innovations that benefit the environment.
- Secondary Data Sources
  1. Literature Review: Researchers conducted an extensive literature review of various research findings, journals, and books. This method aimed to gain deep insights to help answer the research questions and formulate effective solutions to the existing problems.

3.3 Research Materials

No	Material	Function
1	Rattan and palm oil waste	As research material and for making biobriquettes
2	Tapioca flour for biobriquettes	As research material and for making biobriquettes
3	HVS paper	For writing data and research reports
4	Pen and pencil	To assist in recording data during research

***Table 1.2** Research Materials

3.4 Research Tools

No	Tool	Function
1	Laptop and Handphone	For documentation and writing research reports, well as searching for research-related information
2	Used pipe	As a mold for biobriquettes
3	Iron spoon	As a tool to assist in making biobriquettes
4	Word application	For data processing and writing reports
5	Canva application	For design in research

6	Google Forms	For data collection during interviews and surveys

Table 1.3 Research Tools

3.5 Data Collection Method

The research approach uses a mixed-methods design, which integrates qualitative and quantitative research methods to gain a more in-depth, comprehensive, and holistic understanding of the complexities of rattan and palm oil waste problems in Central Kalimantan. This combination will allow the research to gather numerical and statistical data from a quantitative approach while also understanding the narratives, experiences, and social context from a qualitative approach. The specific methods used are as follows:

1. Field Observation:

In-depth field observation is a primary pillar of data collection. Researchers will observe ten plantation locations, including both rattan and oil palm plantations, in Tewang Sangalang Garing District and Palangka Raya City. The focus is not just on land area but on crucial processes like plant growth, local farmers' care practices, and how waste from both commodities is managed on the ground. This is to get a comprehensive visual and contextual picture of real-world conditions, identify waste management patterns, and see challenges and opportunities that might be missed with interviews alone.

2. Field Interviews:

In-depth interviews with ten local farmers will be a vital method for obtaining primary data. The interviews are designed to uncover more subjective and nuanced information. Questions will focus on post-harvest waste management practices, including how farmers handle biomass residues, whether there are existing recycling or waste utilization practices, and the constraints they face. Researchers will also explore farmers' perceptions of the environmental and health impacts of the waste, as well as their ideas for solutions. The narrative data from these interviews will be essential for developing sustainable innovations that directly benefit the environment and the well-being of the farming community.

- Secondary Data Sources:

Literature Review:

An extensive literature review will serve as the theoretical and contextual foundation of the research. This involves analyzing sources like current scientific journals, reference books on agronomy and the environment, previous research findings, and reports from governmental or non-governmental institutions. Literature related to the environmental problems caused by the waste from these two commodities will be a main focus, including the impact of soil and water pollution, GHG emissions, and potential public health risks. The goal is to gain a deep understanding of existing theories, concepts, and empirical findings to help the researcher formulate a strong theoretical framework, identify research gaps, and ultimately propose effective and innovative solutions for the environmental problems in Central Kalimantan.

- Data Processing and Analysis Method:

- Quantitative Data:
  Quantitative data processing will involve statistical analysis to measure energy efficiency, calculate economic potential, and numerically analyze environmental impacts. This includes descriptive statistics, mass and energy balance calculations, and economic modeling.
- Qualitative Data:
  Qualitative data processing will use thematic or content analysis. Data from interviews, observations, and focused discussions will be transcribed, and then categories related

to community perceptions, cultural practices, and social challenges will be identified to gain a deep understanding of the local context.

4. RESULTS AND DISCUSSION

A. Optimizing Rattan and Palm Oil Waste as Raw Material for Efficient and Eco-friendly Energy Production

Rattan and palm oil waste have great potential to be optimized as raw materials for efficient and eco-friendly energy production, an innovation that has been implemented through the *"BAHALAP"* product in Central Kalimantan. This strategy not only reduces waste accumulation and environmental pollution but also creates added value for waste that was previously underutilized. This utilization is based on the chemical composition of rattan, which is rich in carbon biopolymers such as holocellulose, cellulose, hemicellulose, and lignin, all of which are primary energy stores. Meanwhile, palm oil waste contains lipids, especially triglycerides, which are a very efficient energy source. Through thermochemical and biochemical conversion processes, these wastes are transformed into various high-value products such as biofuels, compost, and biochar. This initiative supports the circular economy and the creation of new jobs, while also reducing dependence on fossil fuels, marking a significant step toward a greener and more sustainable future.

a). Chemical Components and Rattan Species for Energy Production

Component	Concentration (%)	Energy Significance and Conversion Mechanism
Holocellulose (Cellulose + Hemicellulose)	68% - 76%	Main energy contributor. Converted into simple sugars for fermentation (bioethanol) or broken down into syngas, bio-oil, and heat through thermochemical processes.
Cellulose	39% - 58%	A highly crystalline and stable glucose polymer. Primary source of anhydroglucose in fast pyrolysis. Energy contribution is similar to holocellulose but breaks down at higher temperatures.
α-Cellulose	39% - 43%	Pure cellulose fraction with high crystallinity. Shows uniform conversion potential but requires more intense hydrolysis conditions.
Hemicellulose	20% - 35%	An amorphous polysaccharide that is more easily degraded than cellulose. Broken down into pentose and hexose sugars for fermentation, and produces volatile compounds like furan in pyrolysis.
Lignin	18% - 30%	Aromatic biopolymer with the highest calorific value. Contributes significant combustion heat. Converted into high-quality syngas or phenolic-rich bio-oil.
Extractive Substances	5% - 15%	Non-structural compounds that contribute to the total calorific value. Easily evaporate or decompose at the beginning of the thermochemical process.
Starch	18% - 23%	A carbohydrate energy reserve that is very easily hydrolyzed into glucose. Ideal for high-yield ethanol production.

Ash (Mineral)	0.5% - 2%	An inorganic fraction with no energy value. Its presence can disrupt the conversion process (e.g., causing clinker or slagging) and affect product quality.

Table 1.4 Composition and Energy Potential of Rattan Biomass

The energy potential of rattan waste comes from its dense biomass rich in carbon-based biopolymers. Cellulose, hemicellulose, and lignin are the main energy stores, with covalent bonds that can be broken either endothermically (requiring heat) or exothermically (releasing heat), depending on the process. Extractive substances and starch also contribute to the total energy. The choice and optimization of conversion methods (direct combustion for heat/electricity, gasification for syngas, pyrolysis for bio-oil, or hydrolysis/fermentation for liquid biofuels) are based on the specific characteristics of each component and the desired energy product. A deep understanding of rattan's chemical composition is crucial for designing an efficient conversion system, reducing waste, and maximizing the use of this renewable resource.

Local Name	Species	Distribution	Growing Location	T.P Diameter (mm)
Uwei Kijang	Calamus Blumei Beccari	KL	Lowlands, Peat swamps	< 18
Rotan Getah/Minyak	Daemonorops angustifolua (Griff) Martius	KL, SM	Lowlands, Highlands	> 18

Note: KL: Kalimantan, SM: Sumatra

Table 1.5 Identification of Significant Waste-Producing Rattan Species

b). Chemical Components and Palm Oil Species for Energy Production

Component	Concentration (%)	Energy Significance and Conversion Mechanism
Triglycerides	≥95%	Hydrolyzed by lipase enzymes into glycerol and free fatty acids, which can then be metabolized for energy.
Palmitic Acid (C16:0)	35%–49%	A very dense energy source. Completely oxidized through β-oxidation, producing approximately 106 ATP molecules per molecule.
Oleic Acid (C18:1)	35%–45%	Oxidized through β-oxidation with the help of additional enzymes to handle the double bonds, producing slightly less energy than saturated fatty acids.
Linoleic Acid (C18:2)	9%–12%	Oxidized through β-oxidation, requiring more enzymes to handle the two double bonds.
Stearic Acid (C18:0)	3%6%	Similar to palmitic acid, oxidized through β-oxidation. Produces a slightly larger amount of ATP due to its longer carbon chain.
Other Chain Fatty Acids	<5%	All are oxidized via the same β-oxidation pathway. Total ATP production is directly proportional to the length of the carbon chain.

Glycerol	10%	Converted into glycerol-3-phosphate, then enters the glycolysis pathway to produce ATP. Its contribution to total energy is smaller compared to fatty acids.

***Table 1.6** Components of Palm Oil and Energy Conversion Mechanism

With its high triglyceride content (over 95%), palm oil can be a promising renewable energy source for Pertamina in the future. Through hydrogenation or transesterification, the abundant triglycerides and fatty acids, such as palmitic and oleic acid, can be converted into biofuels like biodiesel or HVO (Hydrotreated Vegetable Oil). These biofuels have properties similar to conventional fossil fuels, allowing them to be used as additives or direct substitutes in diesel engines without major modifications. Utilizing palm oil in this way allows Pertamina to reduce its dependence on fossil fuels, lower greenhouse gas emissions, and support the national energy resilience agenda, in line with global energy transition efforts.

Species	Distribution (Central Kalimantan)	Growing Location	Dura/Pisifera Type
Elaeis Guineensis	Widespread In Large Plantations	Lowlands, Mineral Soil, Flat Peat	Dura (Thick Shell)
Elaeis Guineensis	Used For Tenera Crossing	Lowlands, Mineral Soil, Flat Peat	Pisifera (Shell-Less)
Elaeis Guineensis	Dominant In All Plantations	Lowlands, Mineral Soil, Flat Peat	Tenera (Thin Shell)
Elaeis Guineensis	Some Large Plantations	Lowlands, Mineral Soil	Tenera (Thin Shell)
Elaeis Guineensis	Some Large Plantations	Lowlands, Mineral Soil	Tenera (Thin Shell)
Elaeis Guineensis	Various Plantation Locations	Lowlands, Mineral Soil, Peat	Tenera (Thin Shell)

***Table 1.7** Identification of Oil-Producing Palm Oil Types

c). Innovation of Local Farmer Biobriquettes: Processing Rattan and Palm Waste

A study conducted from July 13-15, 2025, in the Tewang Sangalang Garing sub-district and Palangka Raya city, Central Kalimantan, revealed a significant, untapped potential in the region's agricultural waste. Interviews with 15 local farmers showed that the majority (13 out of 15) simply discarded rattan and palm oil waste or, at best, used it as a rudimentary fertilizer. Alarmingly, only two farmers were aware that this waste could be processed into biobriquettes, an eco-friendly and sustainable alternative fuel source. This lack of knowledge presents both a challenge and a great opportunity. Converting this waste into biobriquettes could not only provide an additional source of income for farmers but also help reduce environmental problems caused by waste accumulation. Therefore, there is a clear need for intensive education and training programs for farmers on the potential and production of biobriquettes from rattan and palm oil waste. Such initiatives would not only improve farmers' livelihoods but also promote more sustainable farming practices in the region.



***Image 1.1** Biobriquettes from Rattan and Palm Oil Waste

Local farmers now have a significant opportunity to boost their economy through biobriquette innovation, a breakthrough developed by researchers to process agricultural waste. These biobriquettes are made from rattan and palm waste that has long been discarded. This innovation not only provides a solution to the waste problem but also creates an environmentally friendly alternative energy source. Thanks to the simplified process developed by researchers, farmers can easily produce biobriquettes independently, transforming worthless waste into a product with high economic value. The collaboration between researchers and local farmers in this biobriquette innovation demonstrates a strong synergy. Biobriquettes made from rattan and palm waste have significant potential to become a leading product in agricultural regions. In addition to providing economic benefits such as additional income and job creation, this initiative also strengthens energy independence and supports environmental sustainability. With the continuous development of this innovation, biobriquettes can become a long-term, sustainable solution for farmers and the wider community.

B. Potential Economic Impact of Implementing the Conversion Rattan and Palm Oil Waste into Energy

The *"Bahalap"* product is an innovation that transforms rattan and palm oil waste into high-value products. This initiative stems from a vision to maximize the potential of waste that has been underutilized, especially in areas like Katingan Regency and Palangkaraya City, Central Kalimantan, where rattan and palm oil are abundant. By using these two types of waste, the Bahalap product not only reduces waste accumulation but also paves the way for a more sustainable use of local resources. Through research and development, Bahalap successfully converts rattan and palm oil waste into various beneficial products, such as biofuels, compost, or even eco-friendly building materials. The transformation process involves advanced technology designed to optimize the conversion of waste into high-economic-value products while minimizing negative environmental impacts. Bahalap brings new hope for waste management in Indonesia, particularly in rattan and palm oil producing regions. In addition to contributing to waste reduction and pollution control, this innovation has the potential to create new jobs and drive a circular economy at the local level. Thus, Bahalap is not just a technological innovation but a step forward toward a greener and more sustainable future, where waste is seen as a resource, not a burden**.**

a). Energy Innovation from Rattan and Palm Oil Waste

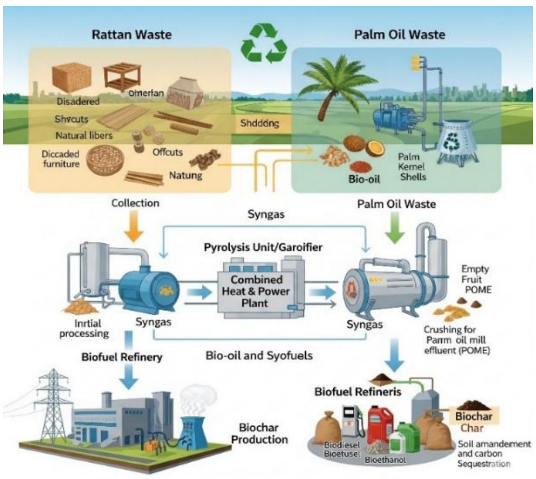

***Image 1.2** Conversion Process of Rattan and Palm Oil Waste

The image above shows the process of converting rattan and palm oil waste into various value-added products, primarily biofuel and biochar, through gasification and pyrolysis. The process is as follows:

1. Raw Material Sources (Waste):
- Rattan Waste: Includes various forms of rattan residue such as "Disadered" (irregular rattan), "Shvcuts" (short pieces), "Natural libers" (natural fibers), "Offcuts" (residual pieces), "Diccaded furniture" (discarded furniture), and "Natung" (rattan parts). This waste is collected;
- Palm Oil Waste: Consists of "Palm Kernel Shells," "Empty Fruit Bunch (EFB)," and "Palm Oil Mill Effluent (POME)".

2. Pre-processing:
- Rattan Waste: Undergoes "Initial processing" after collection;
- Palm Oil Waste: POME is processed through "Crushing for Palm Oil Mill Effluent (POME)". "Shdding" is a pre-processing stage for palm oil waste and also produces "Bio-oil".

3. Main Process: Pyrolysis and/or Gasification (Pyrolysis Unit/Garoifier):
- Both types of waste (rattan and palm oil) are fed into this unit;
- Pyrolysis is the thermal decomposition of organic material without oxygen, producing bio-oil (liquid), syngas (gas), and biochar (solid);
- Gasification is the process of converting carbon-based raw materials into flammable syngas;
- The image shows that "Syngas" and "Bio-oil" are produced from this process.

4. Utilization of Syngas and Bio-oil:
- Combined Heat & Power Plant: Syngas from the pyrolysis/gasification unit is fed here to generate electricity and/or heat. The electricity generated is then distributed to the "Biofuel Refinery" and "Biofuel Refineries";
- Biofuel Refinery (for rattan waste): Bio-oil from the pyrolysis/gasification unit is further processed here for "Biochar Production";
- Biofuel Refineries (for palm oil waste): Syngas can also be directed to this plant, along with bio-oil that may be produced directly from palm oil waste. Here, bio-oil and syngas are converted into biodiesel, bioethanol, and biofuel.

***Image 1.3** Bahalap Gas and Oil Innovation

5. Final Products:

- Biochar: Produced from the Biofuel Refinery (rattan waste) and as a byproduct from the Biofuel Refineries (palm oil waste). Biochar serves as a "Soil amendment and carbon Sequestration" agent;
- Biodiesel, Bioethanol, Biofuel: Various types of renewable fuels that can be used;
- Synthetic Fuels or Syngas Fuels: Refers to fuels produced from syngas.

b). Economic Impact of the "Bahalap" Innovation on the Wider Community

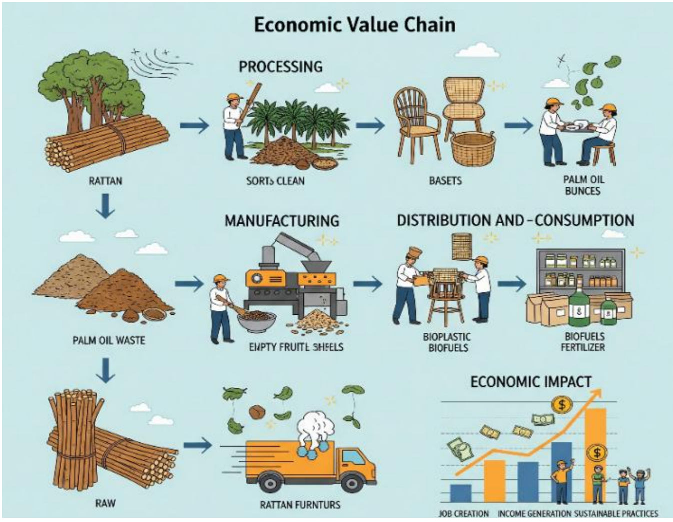

Image 1.4 Green Economic Impact for the Community

The Bahalap innovation, using rattan and palm oil waste, has the potential to create a significant economic impact, especially in raw material-producing areas like Palangkaraya. First, the product encourages the creation of added value from waste that was previously unused or even a burden. From discarding waste, rattan and palm oil farmers now have a potential new source of income by selling their waste to Bahalap's production facilities. This not only increases farmers' income but also reduces the often-expensive cost of waste management. Furthermore, the development and operation of Bahalap will create new jobs in various sectors. This includes direct jobs at the waste processing facilities and indirect jobs in logistics, transportation, and distribution of the finished products. The larger the scale of Bahalap's production, the more workers will be absorbed, for both skilled and unskilled positions. This can help reduce local unemployment and improve the welfare of the community around the production area.

“Bahalap” innovation also has the potential to reduce dependence on fossil fuels or other conventional materials. If Bahalap's products are biofuels or eco-friendly construction materials, this could reduce the import of certain fuels or materials, which in turn would save foreign exchange. These savings can be allocated to other more productive sectors, supporting overall economic growth. Additionally, by reducing operational costs for industries that switch to Bahalap's more affordable and sustainable products, the region's economic competitiveness can also increase. Finally, the Bahalap innovation can drive a circular economy and investment in the bio-economy sector. By demonstrating that waste can be turned into high-value products, Bahalap becomes a successful example that can attract more investors to develop similar technologies or downstream industries that use Bahalap products as raw materials. This will trigger the growth of a green industrial cluster, attracting new capital and expertise to the region, and strengthening Palangkaraya's position as a center for sustainable innovation in Central Kalimantan.

CONCLUSIONS

5.1 Conclusion:

The *"Bahalap"* innovation offers a transformative solution for managing rattan and palm oil waste in Central Kalimantan by converting it into high-value products. Rattan waste, rich in carbon biopolymers, and palm oil waste, which primarily consists of triglycerides, have significant energy potential that can be optimized. Through thermochemical processes like pyrolysis and gasification, both types of waste are converted into syngas, bio-oil, and biochar. The economic impact of this innovation is substantial. Bahalap creates added value from waste, provides new sources of income for farmers, and opens up new job opportunities. Furthermore, the project promotes a circular economy, attracts investment, and reduces dependence on fossil fuels. Overall, Bahalap is a step forward toward a greener and more sustainable future for Indonesia.

5.2. Limitation

The primary limitation of the "Bahalap" study is the current absence of comprehensive laboratory testing necessary for the production of oil and biogas from rattan and palm oil waste. This constraint is solely due to the lack of access to adequate laboratory facilities. Such access is critical for performing the necessary extraction processes, analyzing the biomass content, and effectively converting these components into the final energy products: vegetable oil and biogas. Despite this technical hurdle, the research team has developed a mitigation plan and strategic roadmap for the future. The next focus is to establish strategic partnerships with educational institutions or research centers that possess the requisite laboratory infrastructure for biomass testing and energy conversion. This effort is vital for scientifically validating the initial findings and proving the economic potential and sustainability of this waste recycling process. With the necessary laboratory support, this research can transition from the conceptual phase to the applied experimental stage, ultimately yielding the optimal formulation for producing both oil and biogas from rattan and palm oil waste.

5.3 Suggestion:

The viability of the large-scale *"Bahalap"* biofuel facility investment in Central Kalimantan, research must be centered on three main pillars: Technology, Logistics, and Socio-Economics. Technically, deep optimization studies, particularly through co-pyrolysis and gasification experiments, are required to determine the optimal blending ratio of rattan waste and palm oil residue that efficiently yields SNI-quality liquid biofuels (biodiesel/bioethanol) and syngas. Logistically, research must map the long-term biomass availability and design the most economical and reliable supply chain model for the region. Finally, socio-economic studies must be conducted to establish an inclusive partnership model that ensures equitable economic benefits for local entities and rattan farmers, along with a comprehensive Life Cycle Assessment (LCA) to validate the project's overall sustainability claims.

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BAHALAP

GUIDE TO MAKING BRIQUETTES FROM RATTAN AND PALM WASTE

4. Mixing with a Binder:
   - Combine the charcoal powder with a natural binder, such as tapioca or cassava starch mixed with hot water;
   - Maintain a common ratio of approximately 1:10 (1 part binder to 10 parts charcoal powder). Mix until a consistent and pliable dough is formed.

5. Molding and Drying:
   - Mold the mixture into briquettes using either a manual press or a machine;
   - Dry the briquettes completely under direct sunlight for several days. The duration of this process depends on weather conditions.

BIOBRIQUETTE PRODUCTS

Photo source : *Wikimedia.org,* (2016) *Photo of Rattan.*

Photo source: *Diskominfo Kaltim. (2025). Photo of oil palm fruit.*