

Research Article

Optimization of Wood Waste Management through Reuse and Recycle Program

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Abstract

The SarKa innovation program implemented by PT Paiton Energy aims to address the issue of wood waste management by transforming waste materials into valuable products, specifically wood pellets. The program focuses on reducing the amount of wood waste sent to landfills and optimizing the economic value derived from waste materials. In 2024, 143,480.61 kg of wood waste was processed into wood pellets, resulting in significant cost savings of Rp 24,024,660.62, which increased to Rp 43,567,099.68 in 2025. Additionally, the sale of wood pellets generated substantial economic benefits for the local community, with revenue reaching Rp 344,353,468.84 in 2024 and Rp 312,230,880.95 in 2025. The program not only promotes environmental sustainability by reducing landfill waste but also fosters social empowerment by involving local communities in pellet production, creating new business opportunities. The transformation of wood waste into useful products reflects a shift toward a circular economy, optimizing value chains and reducing environmental impacts. Moreover, the program has cultivated a culture of sustainability within the company, where employees and local communities recognize the importance of resource management and waste reduction. This research highlights the economic, environmental, and social benefits of such innovative programs and suggests the potential for scaling and replicating these practices in other industries.

Keywords: Wood waste management, circular economy, wood pellets, sustainable development, cost savings, social empowerment, environmental sustainability

INTRODUCTION

The management of waste has become one of the key environmental challenges faced by industries globally. The rapid accumulation of waste, particularly from industrial activities, places a significant burden on waste disposal systems and negatively impacts environmental sustainability (Mancini et al., 2021). One of the most concerning types of waste is wood waste, which, if not managed properly, contributes to environmental degradation. Wood waste is often generated from activities such as tree pruning, packaging materials, and construction debris. Traditionally, such waste is either incinerated or sent to landfills, both of which contribute to pollution and excessive waste disposal costs (Sreenivasan, 2020). In response to these concerns, the development of innovative methods for managing wood waste is of critical importance.

The issue of wood waste management has garnered attention in both academic and industrial circles. However, many of the solutions proposed have often been either technically challenging or economically unfeasible, particularly in industries with limited resources (Ogwu & Kosoe, 2025). This gap in the existing literature, regarding scalable and economically viable solutions, highlights the need for more sustainable practices that could simultaneously address waste management, cost reduction, and environmental impact. Specifically, there is limited research on the optimization of wood waste through the reuse and recycling of wood materials to create valuable products, such as wood pellets, which can be utilized as an alternative energy source or in agriculture (Abdoli et al., 2018).

The urgency of this research stems from the global push towards sustainability and circular economy practices. As industries and businesses seek ways to reduce their environmental footprints, innovative waste management systems have become a critical part of their strategies (Geissdoerfer et al., 2017). In particular, the recycling and reuse of wood waste into valuable products aligns with the principles of circular economy, which emphasize minimizing waste and maximizing resource use. By exploring the reuse and recycling of wood waste through processes such as pelletizing, companies can both reduce waste sent to landfills and generate value-added products that contribute to environmental sustainability (Bocken et al., 2014).

Previous studies have investigated various approaches to wood waste management, but few have focused on the integration of waste materials into circular economy models for large-scale industrial use (Adami & Schiavon, 2021). Some studies have explored the production of wood pellets as an alternative energy source, while others have examined the environmental benefits of recycling wood waste (Ferreira et al., 2018). However, limited research has been conducted on the specific application of these methods within industrial settings, particularly in the context of large-scale power plants or manufacturing industries. Furthermore, studies that address both the economic benefits and social impacts of wood waste recycling remain scarce.

This research aims to fill this gap by exploring the optimization of wood waste management through a comprehensive reuse and recycle program. The novelty of this study lies in its focus on integrating wood waste management practices into a circular economy model while simultaneously evaluating the social and economic

benefits of such an innovation. Specifically, this study examines how transforming wood waste into wood pellets can not only reduce environmental impact but also create new economic opportunities for local communities.

The objectives of this study are twofold: first, to evaluate the effectiveness of wood waste recycling into wood pellets in reducing waste and minimizing disposal costs, and second, to assess the socio-economic impact of this innovation on local communities. By addressing both the environmental and social aspects of wood waste management, this research contributes to the growing body of knowledge on sustainable waste management practices. The expected benefits of this research include providing an economically feasible solution for industries facing wood waste management issues and fostering local economic development through the creation of new job opportunities in the recycling sector.

METHODS

This study employs a quantitative research approach to evaluate the effectiveness of the "SarKa" program, which focuses on optimizing wood waste management through a reuse and recycle initiative. The methodology encompasses the assessment of wood waste recycling processes, cost reduction strategies, and socio-economic impacts. Data was collected from the wood waste management operations at PT Paiton Energy, which implemented the SarKa program to transform wood waste into wood pellets, a product with potential applications in renewable energy and agriculture.

The research methodology involves several stages. First, the total volume of wood waste generated from various sources, including tree pruning, construction debris, and packaging materials, was quantified. Data on the amount of wood waste processed and converted into wood pellets was recorded for the years 2024 and 2025. The wood waste was first processed using wood shredders to produce wood chips, which were then transformed into pellets through a pelletizing machine. The production process was evaluated for efficiency and scalability, focusing on energy consumption, labor requirements, and the yield of pellets per unit of waste processed (Maj et al., 2022).

A key aspect of the methodology is the calculation of cost savings. The waste management costs associated with the disposal of wood waste at a landfill (TPA) were compared with the costs incurred in the recycling process, including labor, energy, and equipment costs. The savings from reduced transportation and landfill fees were quantified using cost per ton of waste, as outlined by previous studies on industrial waste management cost optimization (Hoang et al., 2020). Furthermore, a normalization method was used to standardize the data according to energy production, measured in gigajoules (GJ), to allow for comparisons between different periods (2024 and 2025).

Additionally, the socio-economic impact of the program was assessed by analyzing the economic benefits to the local community. The involvement of local groups in the production of wood pellets was evaluated by measuring the income generated from the sale of pellets. The price per kilogram of wood pellets was considered to estimate the total revenue generated by the community, which was

then compared to baseline figures of local economic activity prior to the program's implementation (Ebadian et al., 2021).

In line with best practices for sustainable development and circular economy initiatives, this study also used life cycle assessment (LCA) data to evaluate the environmental impact of the SarKa program. The LCA methodology enabled the research team to measure the overall reduction in carbon emissions resulting from the diversion of wood waste from landfills and the production of a renewable energy source. The LCA data was integrated into the cost-benefit analysis to provide a comprehensive evaluation of the program's environmental and economic outcomes (Bruno et al., 2023).

In conclusion, the combination of waste quantification, cost analysis, socio-economic evaluation, and environmental impact assessment allows for a thorough examination of the SarKa program's effectiveness. This methodology provides valuable insights into the potential for scaling such programs in other industrial settings, contributing to the broader goal of sustainable resource management and circular economy practices.

RESULT AND DISCUSSION

The implementation of the SarKa innovation program at PT Paiton Energy demonstrated significant impacts on both waste management practices and cost optimization. This section presents a comprehensive analysis of the program's outcomes, focusing on wood waste reduction, cost savings, and socio-economic benefits. The results also highlight the shift in the company's operational approach, moving from a traditional waste disposal system to an integrated reuse and recycle system that adds value to waste materials.

Reduction in Wood Waste Disposal and Operational Costs

One of the most noticeable results of the SarKa program is the substantial reduction in wood waste disposal. Before the innovation, wood waste, including tree branches, project material packaging, and broken pallets, was discarded in the Seboro Landfill (TPA). This practice contributed to increased waste management costs due to higher tonnage of waste being processed and transported. In 2024, PT Paiton Energy successfully processed 143,480.61 kg of wood waste, which was reduced by 9.33% in 2025, with 130,096.20 kg of wood waste being utilized for pellet production. This reduction not only alleviated pressure on the landfill but also minimized disposal-related expenses. The transition to a recycling-based approach led to significant cost savings, with a reduction in transport fees. Specifically, in 2024, the savings amounted to Rp 24,024,660.62, and in 2025, this figure increased to Rp 43,567,099.68, indicating a significant improvement in operational efficiency and waste management cost reduction (Hinden et al., 2020).



Figure 1. Scheme and Documentation of Wood Pellet Production

As shown in Figure 1, the conversion of wood waste into wood pellets follows a streamlined process, starting with the collection of wood and branch waste, which is then processed into wood chips and ultimately transformed into wood pellets through a pelletizing machine.

Economic Benefits and Value-Added Products

Another crucial finding from the SarKa program is the generation of economic benefits through the production and sale of wood pellets. The total revenue from the sale of wood pellets significantly benefited local communities. In 2024, the sale of wood pellets generated Rp 344,353,468.84, while in 2025, the revenue reached Rp 312,230,880.95. These figures indicate not only the commercial viability of the wood pellet product but also the positive economic impact on the surrounding communities, which were involved in the pellet production process through PT Paiton Energy's Corporate Social Responsibility (CSR) program (Devi, 2021). This initiative empowers local groups under the Bumdes unit of Desa Selobanteng, creating new opportunities for employment and income generation.

Moreover, the SarKa program enables PT Paiton Energy to contribute to renewable energy solutions by transforming wood waste into biomass, a potential source of alternative fuel. The value-added wood pellets can be used as an alternative energy source, helping to reduce dependence on fossil fuels, which supports the transition to cleaner energy solutions (Rimantho et al., 2023). The production of wood pellets also has the potential to replace traditional fossil fuels with a renewable energy resource, making it a sustainable option for reducing the carbon footprint of energy production and contributing to the broader efforts toward achieving energy sustainability (Abdoli et al., 2018).

Impact on Social and Environmental Sustainability

The SarKa program goes beyond just waste management and economic optimization it also has a significant social impact. By involving local communities in the production process, the program contributes to community empowerment, social cohesion, and poverty alleviation. Local workers who engage in wood pellet

production gain valuable skills and economic benefits, enhancing their livelihoods and fostering a sense of shared responsibility for the environment. The program's success exemplifies how industrial waste management practices can be integrated with social sustainability efforts, creating a symbiotic relationship between the company and its surrounding communities (Rosado & Kalmykova, 2019).

In terms of environmental sustainability, the SarKa program demonstrates a tangible reduction in the environmental footprint of PT Paiton Energy. By diverting wood waste from landfills and using it as a resource for wood pellet production, the company reduces both the volume of waste sent to the landfill and the carbon emissions associated with landfill disposal. This aligns with the principles of circular economy, which emphasizes resource efficiency, waste reduction, and the creation of new value from waste materials (Bocken et al., 2014). Furthermore, the process of converting wood waste into wood pellets minimizes the environmental impact of waste disposal and helps preserve natural resources by reusing materials that would otherwise be discarded.



Figure 2. Process Flow of Wood Waste Recycling into Wood Pellets

As demonstrated in Figure 2, the process of converting wood waste into wood pellets not only reduces environmental costs but also enhances social value. The involvement of local communities in pellet production increases income, fosters social development, and creates a new value chain that supports sustainable economic growth.

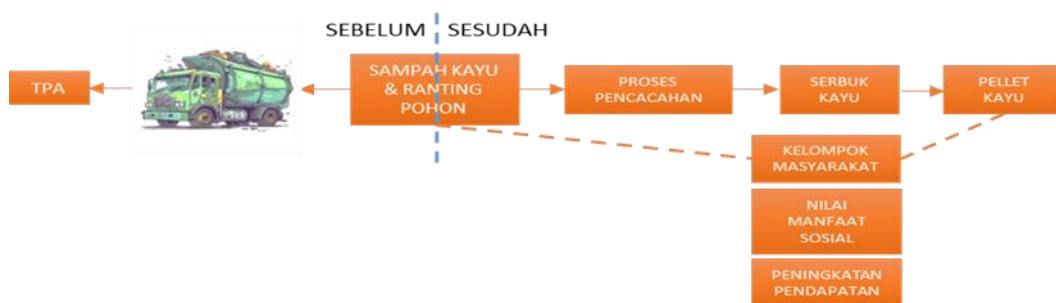


Figure 3. Schematic or Visual Representation of the Innovation Implemented

Finally, Figure 3 illustrates the overall visual innovation process implemented by PT Paiton Energy, which shows how the wood waste, initially sent to the landfill, is now being processed into valuable wood pellets while also generating positive social and economic outcomes. This visual representation emphasizes the integration of waste management with community development and economic growth.

Discussion

The results from the SarKa program at PT Paiton Energy offer compelling evidence of the effectiveness of innovative waste management practices in reducing operational costs, improving resource efficiency, and fostering social and environmental sustainability. The significant reduction in the amount of wood waste sent to landfills is a clear indicator of the potential for circular economy principles to be applied in industrial settings, specifically within the context of waste-to-resource strategies. The program's success in diverting 143,480.61 kg of wood waste in 2024, with a further reduction in 2025, directly addresses one of the most pressing challenges in industrial waste management today—the growing burden of landfill use and the associated environmental impacts (Siddiqua et al., 2022). The trend towards increasing waste diversion, particularly in developing economies, is essential to achieving global sustainability goals, as the world continues to grapple with rising waste production due to industrialization and urbanization (Abubakar et al., 2022).

One of the most notable findings from this research is the economic benefit generated by the sale of wood pellets. In 2024, PT Paiton Energy generated substantial revenue from this product, directly benefiting local communities involved in the production process. This outcome is a prime example of how industrial waste can be transformed into a profitable resource while also driving local economic growth. The involvement of local groups under the Bumdes unit of Desa Selobanteng highlights the dual role that such programs can play in both economic development and environmental sustainability (Pawitan et al., 2025). The socio-economic benefits are in line with the concept of "inclusive green growth," which emphasizes the importance of fostering sustainable industries that not only benefit the environment but also promote social equity by engaging local populations in green economy initiatives (Gupta, n.d.).

Furthermore, the cost savings resulting from reduced transportation and landfill fees are an important aspect of the program's success. These savings are indicative of a broader trend where businesses are increasingly recognizing the financial viability of sustainable practices. As companies face rising waste disposal costs, especially in countries with stringent environmental regulations, the need for effective waste management solutions becomes more urgent (Geissdoerfer et al., 2017). The SarKa program exemplifies how waste can be not only a problem to be managed but also an opportunity for cost reduction and operational efficiency.

The findings also reflect a growing global trend in industries adopting circular economy practices to reduce their environmental footprint. By transforming wood waste into wood pellets, PT Paiton Energy contributes to the renewable energy sector, aligning with the global push for cleaner energy sources. Biomass, such as wood pellets, plays a pivotal role in reducing dependence on fossil fuels and mitigating climate change (Haregu et al., 2023). However, it is essential to consider the full environmental impact, including the energy consumed in the pelletizing process and the lifecycle emissions. While the overall environmental impact appears positive, future studies could explore the carbon footprint of wood pellet production to ensure that the process itself is as sustainable as the end product (Bocken et al., 2014).

In addition, the SarKa program represents a shift in the way industrial waste is perceived. Traditionally, waste was seen as a burden—a cost that businesses had to bear. However, this program shows that with innovation and the right processes in place, waste can become a resource, generating both economic and social value. This reflects a broader shift in industry toward recognizing the value of waste as part of the circular economy (Geissdoerfer et al., 2017). Such shifts are essential for advancing global sustainability efforts, as industries contribute significantly to both resource consumption and environmental degradation. The SarKa program, by engaging in waste reduction and promoting the reuse and recycling of materials, serves as a model for other industries looking to adopt sustainable practices.

Despite the positive results, the program also highlights challenges that need to be addressed to maximize its potential. For example, while the conversion of wood waste into wood pellets has clear benefits, further efforts could be made to scale up production and increase the efficiency of the pelletizing process. Additionally, local communities involved in pellet production need continuous training and support to ensure that the economic benefits are sustained in the long term. Ensuring that the pellet production process remains cost-effective and environmentally sound will require ongoing innovation and investment in technology.

In conclusion, the SarKa program has proven to be an effective waste management solution that brings multiple benefits: reducing waste disposal costs, promoting economic development through local community involvement, and contributing to environmental sustainability. As industries worldwide seek to meet sustainability goals, programs like SarKa provide a blueprint for integrating waste management with economic and social benefits. Future studies should continue to explore ways to optimize such programs and examine their long-term impact on both the environment and local communities.

CONCLUSION

The SarKa innovation program implemented by PT Paiton Energy has demonstrated significant advancements in the sustainable management of wood waste. The program successfully reduced the volume of wood waste sent to landfills by processing it into valuable wood pellets, aligning with the principles of circular economy. In 2024, 143,480.61 kg of wood waste was processed, resulting in cost savings of Rp 24,024,660.62, which increased to Rp 43,567,099.68 in 2025. This indicates not only a reduction in waste management costs but also a positive contribution to economic and environmental sustainability.

Furthermore, the program has generated substantial socio-economic benefits, particularly for the local community. The sale of wood pellets provided local groups with new economic opportunities, generating Rp 344,353,468.84 in 2024 and Rp 312,230,880.95 in 2025. This economic activity is a clear example of how waste can be transformed into a resource that benefits both businesses and local communities, creating new value chains and fostering social empowerment.

The program's impact extends beyond just cost savings and economic value. The transformation of wood waste into wood pellets represents a significant change in the company's value chain, where previously discarded waste now holds economic

value. This shift also reflects a broader trend toward sustainable business practices, where companies not only optimize their resource use but also contribute to broader societal goals such as waste reduction, energy sustainability, and social equity.

The program has also contributed to a cultural shift within the company, instilling a sustainability culture where employees and local communities alike recognize the value of waste and are encouraged to adopt more sustainable practices. This change in behavior is an essential step in fostering long-term environmental responsibility and creating a more sustainable industrial ecosystem.

Recommendations for Future Research

While the SarKa program has shown promising results, future research could explore several avenues for further optimization. First, studies could focus on improving the efficiency of the wood pellet production process, including energy use and cost-effectiveness, to ensure that the production remains environmentally and economically sustainable. Additionally, future research could assess the carbon footprint of the entire wood pellet production process to ensure that the environmental benefits outweigh any potential emissions generated during production.

Moreover, a more extensive evaluation of the socio-economic impact on the local community over the long term would provide a deeper understanding of the sustainability of these benefits. Research could explore how such initiatives can be scaled up and replicated in other regions or industries, and the potential for integrating additional waste streams into the circular economy model. Finally, studying the potential for expanding the use of wood pellets as a renewable energy source could provide further insights into the role of biomass in reducing reliance on fossil fuels and contributing to global energy sustainability goals.

In conclusion, the SarKa program serves as a successful model for integrating waste management with sustainable business practices, economic growth, and community empowerment. Further research will continue to refine these practices, enhancing the overall impact and scalability of such innovative programs.

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