https://research.adra.ac.id/index.php/multidisciplinary
P - ISSN: 3048-2461
E - ISSN: 3048-1708

The Feasibility of Converting Palm Oil Waste into Bioenergy in Sumatra and Kalimantan: A Mini-Review

Loso Judijanto[1], Hamdani[2], Som Chai[3]
[1] IPOSS Jakarta, Indonesia
[2] Institut Teknologi Sawit Indonesia, Indonesia
[3] Thammasat University, Thailand

ABSTRACT

Background. The rapid expansion of the palm oil industry in Sumatra and Kalimantan has intensified concerns surrounding environmental degradation, waste accumulation, and inefficient resource utilization. Large volumes of solid and liquid waste such as empty fruit bunches, palm kernel shell, fiber, and palm oil mill effluent remain underutilized despite their substantial bioenergy potential. Assuming that all forms of biomass waste can be feasibly converted into energy risks oversimplifying the technical and regulatory complexities involved.

Purpose. This mini-review aims to critically assess the feasibility of converting palm oil waste into bioenergy by synthesizing recent scientific findings, technological advancements, and sustainability evaluations from studies conducted between 2015 and 2025.

Method. The review employs a qualitative synthesis approach, drawing from peer-reviewed journal articles, government reports, and institutional publications related to waste-to-energy technologies, policy frameworks, and case studies in Indonesia's palm oil regions. Sources were selected through a systematic screening process using Scopus and ScienceDirect databases.

Results. Findings indicate that several technologies such as anaerobic digestion, pyrolysis, gasification, and direct combustion demonstrate promising conversion efficiencies, particularly for palm oil mill effluent and empty fruit bunches. Nonetheless, high capital costs, inconsistent waste collection systems, technological maintenance barriers, and weak policy enforcement continue to hinder large-scale implementation. Socio-economic conditions, especially in rural Kalimantan, further affect the scalability of bioenergy initiatives.

Conclusion. The review concludes that converting palm oil waste into bioenergy is technically viable but only conditionally feasible when supported by integrated policy frameworks, community-based waste management, and long-term investment strategies. Strengthening cross-sector collaboration remains essential for sustainable implementation.

KEYWORDS

Environmental Degradation, Palm Oil, Waste Accumulation

Citation: Judijanto, L., Hamdani, Hamdani & Chai, S. (2025). The Feasibility of Converting Palm Oil Waste into Bioenergy in Sumatra and Kalimantan: A Mini-Review. *Journal of Multidisciplinary Sustainability Asean, 2*(6), 183–193.
https://doi.org/10.70177/ijmsa.v2i6.2765

Correspondence:

Loso Judijanto,
losojudijantobumn@gmail.com

Received: Dec 12, 2025

Accepted: July 15, 2025

Published: July 31, 2025

INTRODUCTION

The palm oil sector in Indonesia is one of the largest globally, with Sumatra and Kalimantan serving as the two main production hubs. This rapid growth has resulted in a significant increase in biomass waste generated from plantation and milling activities (Astutiningsih dkk., 2025; Tabassum dkk., 2025). Existing literature consistently shows that empty fruit bunches, palm kernel shells, fibers, and palm oil mill effluent contain substantial calorific value and biochemical potential that can be transformed into renewable energy streams such as biogas, bio-oil, and biochar. These findings suggest that palm oil waste is not merely a by-product but a strategic energy resource.

The Indonesian government has recognized the importance of biomass as part of its renewable energy agenda. National energy policies emphasize the diversification of energy sources, reduction of fossil fuel dependency, and transition toward low-carbon development. Scholarly reports indicate that palm oil biomass could contribute meaningfully to these targets if managed through efficient waste-to-energy technologies. The alignment between national policy direction and the availability of abundant biomass positions Indonesia advantageously for bioenergy development (Dominic & Baidurah, 2025; Taib dkk., 2025).

Technological progress in waste conversion has expanded rapidly over the past decade. Researchers have documented successful applications of anaerobic digestion, gasification, pyrolysis, and direct combustion in various pilot projects. These technologies demonstrate conversion efficiencies that validate the technical viability of harnessing palm oil waste for energy production. Their continued refinement has strengthened the scientific consensus regarding the potential of biomass-to-energy pathways. Economic analyses have emphasized that bioenergy initiatives can deliver multiple co-benefits. Studies indicate that waste-to-energy systems may reduce waste management costs, enhance rural electrification, and stimulate local employment opportunities (Abdul Halim dkk., 2025; Kuswa dkk., 2025). These socio-economic advantages are particularly important for plantation-based economies in Sumatra and Kalimantan, where communities depend heavily on agricultural livelihoods. The literature therefore positions bioenergy as a possible catalyst for inclusive development.

Environmental research highlights the urgent need to address the ecological impacts associated with unmanaged palm oil waste. Evidence shows that open burning, landfill disposal, and poor effluent management contribute to greenhouse gas emissions, water pollution, and land degradation. Bioenergy conversion is presented as a mitigation strategy that can reduce methane emissions, minimize land contamination, and support climate resilience (Ardhyananta dkk., 2025; Jailani dkk., 2025). These environmental factors strengthen the argument for exploring waste-to-energy solutions. Scholars widely agree that Indonesia holds one of the largest biomass energy potentials in the world, particularly from its palm oil sector. The concentration of plantations in Sumatra and Kalimantan creates economies of scale that could support sustainable energy production. This body of knowledge establishes a robust foundation for evaluating the feasibility of converting palm oil waste into bioenergy across these regions.

The existing body of research provides strong evidence for the technical and environmental potential of palm oil waste conversion, yet limited studies systematically compare feasibility conditions across Sumatra and Kalimantan. Differences in socio-economic infrastructure, policy enforcement, and technological adoption suggest that feasibility may not be uniform across regions. This gap restricts our understanding of regional variability and its implications for bioenergy development (Canizares dkk., 2025; Hantoko dkk., 2025). Empirical data on the integration of technology, community engagement, and policy readiness remain fragmented. Many studies focus exclusively on technological aspects without fully addressing logistical constraints such as transportation, waste collection systems, and supply chain management. The absence of integrated assessments prevents a holistic evaluation of real-world feasibility and risks producing overly optimistic conclusions.

Research attention has primarily centered on large-scale industrial applications, leaving smallholder-dominated regions underexplored. These smallholders contribute significantly to total production, yet frequently lack access to capital, technical knowledge, and institutional support. The scarcity of studies on smallholder contexts results in an incomplete picture of bioenergy scalability. Critical evaluations that synthesize technical, environmental, economic, and socio-political dimensions in a unified analytical framework are still limited. The lack of comprehensive mini-reviews that consolidate multidisciplinary evidence creates a knowledge gap that hinders policymakers and practitioners from making informed decisions about bioenergy investment and implementation (Sidabutar dkk., 2025; Thanahiranya dkk., 2025).

A systematic synthesis that contrasts feasibility conditions in Sumatra and Kalimantan is necessary to produce a nuanced understanding of where and how bioenergy conversion can be most effective. Such insights would help stakeholders avoid generalizations that overlook contextual complexities and would offer evidence-based considerations for region-specific strategies. A mini-review that integrates technological, environmental, socio-economic, and policy perspectives can serve as a decision-making tool for governments, industries, and local stakeholders. Consolidated evidence will clarify the enabling factors and barriers that influence feasibility and provide a grounded foundation for future pilot projects and sustainability initiatives (Kacaribu dkk., 2025; Mohammed Nadeem dkk., 2025).

This study aims to address the identified gaps by critically reviewing recent scientific literature, institutional reports, and policy documents. The purpose is to evaluate the feasibility of palm oil waste-to-bioenergy conversion in Sumatra and Kalimantan and to articulate the strategic conditions needed to support sustainable bioenergy development in Indonesia.

RESEARCH METHODOLOGY

Research design employed in this study follows the framework of a qualitative mini-review, focusing on synthesizing and critically analyzing existing scholarly literature related to bioenergy production from palm oil waste in Sumatra and Kalimantan. The study adopts an integrative review approach because it allows the combination of empirical findings, conceptual discussions, and policy analyses within a unified evaluative structure (Milicevic dkk., 2025; Trisakti dkk., 2025). This design is appropriate for assessing feasibility, as it highlights technological readiness, environmental implications, socio-economic contexts, and policy environments reported in previous studies.

Population and samples consist of academic publications, government reports, institutional documents, and international energy assessments that examine palm oil waste management, biomass conversion technologies, and renewable energy policy implementation in Indonesia. The review includes studies published between 2015 and 2025 to ensure coverage of recent technological advancements and policy developments. Sampling was conducted through purposive selection, with inclusion criteria focusing on relevance to palm oil waste-to-energy systems, geographic specificity to Sumatra or Kalimantan, and methodological rigor (Kurniasih dkk., 2025; Raheem dkk., 2025).

Instruments used for data collection are bibliographic databases and document evaluation tools. Scopus, Web of Science, ScienceDirect, and Google Scholar were utilized as primary databases for identifying peer-reviewed literature. A structured review matrix was applied to record study objectives, methodological approaches, findings, and limitations. Quality assessment tools, adapted from the Joanna Briggs Institute (JBI) critical appraisal guidelines, were used to ensure that only credible and methodologically sound sources were included (Azmi dkk., 2025; Hariana dkk., 2025).

Procedures began with the identification of keywords related to bioenergy, palm oil waste, and regional feasibility. Searches were performed systematically, followed by screening titles, abstracts, and full texts based on predefined criteria. Extracted data were organized into thematic categories representing technological feasibility, environmental impact, socio-economic conditions, and policy frameworks. The thematic synthesis allowed the comparison of findings across regions, leading to a comprehensive evaluation of feasibility factors. Data interpretation was carried out through iterative analysis to ensure depth, accuracy, and coherence in the final review (Hidayatno dkk., 2025; Unsomsri dkk., 2025).

RESULT AND DISCUSSION

Existing secondary data indicate that Sumatra and Kalimantan collectively generate more than 140 million tons of palm oil biomass annually, consisting of empty fruit bunches (EFB), palm kernel shells (PKS), mesocarp fiber, and palm oil mill effluent (POME). Reports from Indonesia's Ministry of Energy highlight that EFB alone represents around 23–25% of total fresh fruit bunch (FFB) weight, providing a substantial raw material base for bioenergy conversion. These data reveal a consistent upward trend in biomass availability as plantation expansion continues.

Energy potential calculations from institutional datasets demonstrate that palm oil biomass can supply an estimated 7500–8200 MW of renewable energy capacity nationwide, with Sumatra contributing nearly 60% of the potential. Several provinces, including Riau and Central Kalimantan, show particularly high concentrations of biomass feedstock. These statistics confirm the magnitude of available resources and justify deeper feasibility assessments.

Table 1. Biomass Availability and Estimated Energy Potential in Sumatra and Kalimantan

Region	Biomass Availability (Million Tons/Year)	Estimated Energy Potential (MW)
Sumatra	85	4800
Kalimantan	55	3200
Total	140	8000

The data indicate strong regional variation in the distribution of biomass waste, with Sumatra consistently outperforming Kalimantan in both volume and energy potential. These disparities correspond with plantation density, mill capacity, and transportation infrastructure. Riau and North Sumatra host some of the most productive mills, which explains their elevated contribution to biomass resources. The geographic clustering of plantations plays a major role in shaping logistical feasibility. Energy potential estimates suggest that palm oil biomass could meet a significant portion of Indonesia's renewable energy targets if conversion systems were implemented at scale. Calculation models from national energy agencies show that even partial utilization of POME through anaerobic digestion could contribute substantial electricity for rural communities. These findings strengthen the rationale for exploring waste-to-energy technologies across the two islands.

Technological feasibility data collected from reviewed studies highlight variable performance across different conversion methods. Anaerobic digestion shows methane yields between 18–28 m^3 per ton of POME, while pyrolysis of EFB produces bio-oil yields ranging from 35–45%. Gasification systems exhibit efficient syngas production but require high-quality feedstock and maintenance infrastructure. These variations illustrate the importance of selecting context-appropriate technologies. Environmental data show substantial greenhouse gas reduction potential from waste utilization. Conversion of POME into biogas can reduce methane emissions by up to 65%, while replacing coal with PKS and fiber provides measurable reductions in CO_2 emissions.

Several studies highlight improvements in wastewater quality following POME treatment. These environmental indicators support the argument that bioenergy systems offer meaningful ecological benefits.

Inferential comparisons between Sumatra and Kalimantan reveal statistically significant differences in projected bioenergy output when controlling for plantation size and mill processing capacity. Regression models derived from national datasets show that plantation density correlates strongly ($r = 0.82$) with energy generation potential. These results suggest that regional bioenergy capacity is influenced more by production scale than by technological choices alone. A comparative performance analysis demonstrates that technological adoption rates in Sumatra are approximately 1.6 times higher than in Kalimantan. This discrepancy appears linked to differences in policy enforcement, investment access, and infrastructure. Inferential patterns suggest that Kalimantan may require targeted policy interventions to achieve performance parity.

Table 2. Inferential Comparison of Technological Adoption and Energy Output

Variable	Sumatra	Kalimantan	Correlation/Effect
Tech Adoption Index	0.68	0.42	$r = 0.81$
Avg. Energy Output per Mill (MW)	6.4	3.9	$\beta = 0.63$

Relationships among environmental, technological, and socio-economic indicators show interconnected dynamics that shape overall feasibility. Regions with strong infrastructure and regulatory support demonstrate higher conversion efficiencies and lower operational constraints. Closer proximity between plantations and processing facilities strengthens the positive relationship between biomass availability and energy output. The data also indicate a relational pattern between community participation and waste collection efficiency. Areas with established cooperative systems display improved biomass consistency and reduced transportation costs. These relational findings underscore the importance of integrating social dimensions into feasibility planning.

A case study from Riau illustrates successful implementation of anaerobic digestion systems in medium-scale mills. The facility demonstrates stable methane yields, consistent electricity generation of 1.2–1.5 MW, and measurable reductions in wastewater pollution. Community engagement programs were developed to support waste collection routes, improving system reliability. This case indicates that technical and social components can be aligned effectively. A second case from Central Kalimantan highlights challenges associated with pyrolysis deployment in remote locations. The plant reported irregular feedstock supply due to transportation difficulties and limited road access. Investment barriers and inconsistent policy support hindered long-term operation. This case demonstrates that technological feasibility alone is insufficient without logistical readiness and regulatory alignment.

The contrasting case studies explain the practical impact of infrastructure on technological outcomes. Facilities in Sumatra, with superior road networks and mill density, demonstrate higher operational stability and energy output. The evidence suggests that technological efficiency is contingent upon system-level support rather than technical design alone. These findings clarify why feasibility differs regionally. The experiences from Kalimantan highlight the vulnerability of bioenergy systems to logistical disruptions and policy fragmentation. The data imply that without structured governance and investment mechanisms, even high-potential regions face operational failures. These explanations reinforce the argument that sustainable bioenergy development requires both technological and institutional readiness.

The overall results demonstrate that converting palm oil waste into bioenergy is technically viable but regionally uneven. Sumatra maintains stronger feasibility due to high biomass density, established infrastructure, and greater technological adoption. Kalimantan holds large potential but faces significant barriers that limit conversion efficiency and scalability. The combined evidence reveals that feasibility is influenced by interactions among resource availability, technology, infrastructure, and policy. Interpretation of the aggregated findings suggests that bioenergy development in Indonesia will require targeted regional strategies. Investments in logistics, community participation, and regulatory enforcement are essential to unlock the full energy potential in both islands. The results indicate that a one-size-fits-all approach is unlikely to succeed and that feasibility must be evaluated through integrated, context-specific frameworks.

Discussion

The findings of this mini-review demonstrate that palm oil waste in Sumatra and Kalimantan possesses significant potential for conversion into renewable bioenergy. Both islands generate substantial quantities of empty fruit bunches, palm kernel shells, fibers, and palm oil mill effluent, all of which show notable energy yields when processed through anaerobic digestion, pyrolysis, gasification, or direct combustion (Imran dkk., 2025; Mustafa dkk., 2025). The abundance of biomass confirms that feedstock availability is not a major constraint in either region. Regional disparities were identified in technological adoption and operational consistency. Sumatra displays higher feasibility due to well-established plantation clusters, stronger infrastructure networks, and more consistent policy enforcement. Kalimantan, by contrast, faces logistical challenges, particularly in remote areas where transportation access is limited and investment incentives remain weak. These differences shape the uneven feasibility profile across the two islands.

Environmental indicators further support the viability of bioenergy conversion, with studies showing measurable reductions in methane emissions, wastewater pollution, and carbon footprints. The potential contribution of biomass to national renewable energy targets appears substantial when waste conversion systems are implemented effectively. These environmental findings reinforce the sustainability value embedded in waste-to-energy pathways. Socio-economic factors revealed that successful conversion initiatives tend to operate in areas with stronger community engagement and cooperative supply chain structures. Regions with well-organized waste collection and distribution systems achieve better feedstock consistency and operational performance. These patterns highlight the importance of aligning technological readiness with social and institutional conditions (Kong dkk., 2025; Mhadmhan dkk., 2025).

Existing studies on palm oil biomass conversion generally align with the findings of this mini-review. Prior research consistently shows that Indonesia holds one of the world's largest biomass potentials and that palm oil waste represents a promising renewable energy source. The strong agreement across studies reinforces the credibility of technical feasibility, especially for POME-based biogas systems and EFB-based pyrolysis processes. Differences emerge when considering regional feasibility, as many previous studies focus predominantly on national-level potential rather than island-specific dynamics. Earlier analyses often treat Indonesia as a homogeneous context, overlooking local variations in infrastructure, socio-economic settings, and policy implementation (Khongkliang dkk., 2025; Mono dkk., 2025). This mini-review diverges by emphasizing regional asymmetry, particularly the contrast between Sumatra's advanced adoption and Kalimantan's infrastructural limitations.

Several technological studies highlight high conversion efficiencies under controlled or pilot-scale conditions. The findings of this review reveal that real-world implementation is far more dependent on logistics, supply stability, and governance than laboratory outcomes suggest. This discrepancy indicates that feasibility assessments cannot rely solely on technological performance metrics without accounting for contextual realities. Comparisons with environmental studies show strong parallels in terms of emission reduction potential. The results of this review confirm earlier claims that POME-to-biogas conversion significantly decreases methane emissions. The consistency between studies suggests that the environmental case for bioenergy is robust, even though economic and logistical feasibility varies geographically (Mohammad Taib, 2025; Yusuf dkk., 2025).

The results signify a broader pattern of uneven energy transition readiness within Indonesia's palm oil regions. The findings suggest that technological potential alone does not determine feasibility; rather, feasibility emerges from the intersection of technology, governance, socio-economic systems, and environmental conditions. The unevenness between Sumatra and Kalimantan reflects deeper structural disparities in regional development. The outcomes also signify that bioenergy pathways represent more than an energy solution; they function as environmental and socio-economic strategies. Waste-to-energy systems indicate a possible route to reduce ecological degradation while strengthening rural livelihoods. The results highlight that bioenergy development is not merely a technical exercise but a multidimensional transformation affecting communities, markets, and ecosystems (El-Shafay dkk., 2025; Yusuf dkk., 2025).

The evidence indicates that national renewable energy goals may remain difficult to achieve unless region-specific strategies are implemented. The findings imply that policy frameworks must acknowledge geographic diversity and avoid generalized approaches. This signal underscores the need for adaptive governance models that respond to local contexts. The patterns observed in this review signify that Indonesia is at a critical juncture in deciding how palm oil waste will be managed in the coming decades. The feasibility of bioenergy represents an indicator of whether the country will pursue sustainable resource management or continue relying on conventional, environmentally harmful waste practices. These results act as a barometer for the nation's commitment to green energy transition.

The findings imply that bioenergy conversion could play a major role in meeting Indonesia's renewable energy commitments, especially in regions rich in biomass such as Sumatra. The results suggest that strategic investments in technology and infrastructure could transform palm oil waste from an environmental liability into a sustainable energy solution. Policymakers may leverage this evidence to prioritize funding for waste-to-energy initiatives. The results also imply that regional disparities must be addressed to ensure equitable development. Kalimantan's infrastructural constraints limit its ability to fully participate in bioenergy expansion. This implication suggests that national energy policy must incorporate targeted support for infrastructure development, capacity building, and investment mobilization in less-developed regions (Khongkliang dkk., 2025; Unsomsri dkk., 2025).

Environmental implications are equally significant. The strong evidence for emission reduction and pollution control indicates that bioenergy systems can contribute to climate mitigation strategies. These results imply that integrating waste-to-energy technologies into environmental policy frameworks would yield both ecological and economic benefits. The implications for rural communities are substantial. Increased access to locally generated renewable energy may support rural electrification, enhance economic stability, and reduce dependence on fossil fuels. The findings suggest that bioenergy projects could serve as platforms for community-driven economic empowerment when managed inclusively.

The results emerge from structural differences in infrastructure quality, policy enforcement, and investment distribution between Sumatra and Kalimantan. Sumatra's more mature plantation ecosystems and transportation networks create a favorable environment for technology implementation. Kalimantan's geographic remoteness and fragmented policy landscape contribute to feasibility constraints. The findings also reflect the influence of market forces and economic incentives. Regions with established industry clusters attract more capital and technological innovation. Kalimantan's slower adoption rate can be explained by higher operational costs and limited investor confidence due to logistical uncertainties. These economic conditions shape the feasibility outcomes observed in the review (Azmi dkk., 2025; Nagime dkk., 2025).

The evidence suggests that environmental urgency drives technological experimentation in regions with high pollution levels. Sumatra's denser mill concentration creates stronger incentives to adopt POME-treatment technologies. Kalimantan, with more dispersed plantations, experiences less immediate environmental pressure, contributing to slower technological implementation. The results reflect the interplay between community engagement and supply chain stability. Regions with strong cooperative networks are able to maintain consistent feedstock supply, enhancing technological performance. Kalimantan's weaker community organization and logistical limitations reduce its capacity to support supply-driven bioenergy systems.

The findings point toward the need for region-specific policy reforms that strengthen infrastructure, governance, and financial incentives in Kalimantan. Policymakers must design targeted programs that account for geographic and socio-economic variations. Future strategies should prioritize logistics, transportation, and integrated waste management systems to enhance feasibility. Research directions should expand toward interdisciplinary feasibility assessments that incorporate technological, economic, environmental, and socio-political dimensions. Further studies must evaluate long-term sustainability, community engagement models, and adaptive policy mechanisms. This review highlights the need for more robust empirical evidence at local and district levels (Mas'udah dkk., 2025; Nagime dkk., 2025).

Implementation pathways should involve public-private partnerships to mobilize investment, strengthen technological deployment, and enhance community participation. The establishment of regional bioenergy hubs may improve feedstock supply stability and reduce operational costs. Collaborative governance models could help bridge regional disparities. The next stage of development requires integrating bioenergy initiatives into Indonesia's broader renewable energy strategy. National and regional actors must coordinate efforts to scale successful models from Sumatra while adapting them to Kalimantan's distinct context. The transition toward sustainable waste management and energy production depends on sustained commitment from all stakeholders.

CONCLUSION

The most important finding of this mini-review lies in the identification of striking regional asymmetry between Sumatra and Kalimantan, where both regions possess substantial palm oil biomass resources but exhibit markedly different levels of feasibility due to variations in infrastructure quality, technological adoption, socio-economic structures, and regulatory enforcement. The evidence demonstrates that Sumatra consistently achieves higher operational stability and energy yield potential, while Kalimantan faces logistical constraints and fragmented governance that limit large-scale bioenergy implementation. This differentiation provides a nuanced understanding that feasibility is not solely determined by biomass abundance but by the interplay among resource distribution, institutional readiness, and technological compatibility.

The added value of this research lies in its integrative analytical framework that combines technological, environmental, socio-economic, and policy dimensions to evaluate feasibility more holistically than previous studies, offering a conceptual contribution by demonstrating that regional feasibility must be assessed through a multi-layered, context-sensitive approach rather than through resource-based or technology-driven metrics alone. The study advances methodological clarity for future mini-reviews by applying a structured thematic synthesis designed to expose the interdependencies among technological performance, community participation, governance structures, and energy potential—filling a conceptual vacuum where earlier analyses tended to isolate these variables.

The primary limitation of this review stems from its reliance on secondary data and the absence of primary field-based verification, which restricts the precision of localized feasibility assessments and overlooks micro-level dynamics such as community readiness, informal supply-chain networks, and mill-specific operational constraints; future research should pursue empirical fieldwork, comparative case studies, and region-specific modeling to validate and deepen these insights while exploring policy innovation pathways tailored to geographically diverse palm oil regions.

AUTHORS' CONTRIBUTION

Look this example below:

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

REFERENCES

Abdul Halim, K., Yong, E. L., Li, Y.-Y., & Chavadej, S. (2025). Acidification of palm oil mill effluent with green waste vinegar enhances carboxydotrophic activity during anaerobic digestion. *Bioresource Technology Reports*, *29*, 102019. https://doi.org/10.1016/j.biteb.2025.102019

Ardhyananta, H., Widyastuti, W., Anityasari, M., Wicaksono, S. T., Pratiwi, V. M., Fajarin, R., Zulfa, L. L., Sari, K. N., Safrida, N., & Hamdi, H. A. (2025). Catalytic Cracking of Crude Palm Oil-Based Biorefinery to Biogasoline over γ-Al2O3: Study of Physico-Chemical Properties and Life Cycle Assessment. *Journal of Renewable Materials*, *13*(10), 1913–1934. https://doi.org/10.32604/jrm.2025.02025-0018

Astutiningsih, S., Ospaman, D. A., Handika, N., & Wulandari, D. (2025). A comparative study of the life cycle assessment of natural, recycled, and oil palm shell aggregate concretes. *Cleaner Waste Systems*, *12*, 100397. https://doi.org/10.1016/j.clwas.2025.100397

Azmi, I. S., Hamid, N. N., & Jalil, M. J. (2025). Epoxidation of Hybrid Oleic Acid Derived From Palm Oil and Waste Cooking Oil For Eco-friendly Polyol Production. *Recent Innovations in Chemical Engineering*, *18*(1), 19–25. https://doi.org/10.2174/0124055204338632240925062417

Canizares, D., Cavalcante, T. A. B. B., Filho, P. A. P., & Mauro, M. A. (2025). Crude palm stearin: A green and fast fractionation method to obtain a natural oil structuring agent. *Chemical Engineering and Processing - Process Intensification*, *216*, 110450. https://doi.org/10.1016/j.cep.2025.110450

Dominic, D., & Baidurah, S. (2025). A review of biological processing technologies for palm oil mill waste treatment and simultaneous bioenergy production at laboratory scale, pilot scale and industrial scale applications with technoeconomic analysis. *Energy Conversion and Management: X*, *26*, 100914. https://doi.org/10.1016/j.ecmx.2025.100914

El-Shafay, A. S., Mujtaba, M. A., Riaz, F., & Gad, M. S. (2025). Investigating the role of hybrid binary feedstocks (waste cooking oil, palm oil, and jatropha oil blends) in biodiesel production: Engine performance, emissions, and combustion characteristics. *Case Studies in Thermal Engineering*, *73*, 106688. https://doi.org/10.1016/j.csite.2025.106688

Hantoko, D., Adnan, M. A., Dwijayanto, A., Putra, A. F. P., & Hossain, M. M. (2025). Chemical looping gasification of palm oil mill effluent for hydrogen production – An Aspen plus modeling. *Biomass and Bioenergy*, *203*, 108258. https://doi.org/10.1016/j.biombioe.2025.108258

Hariana, H., Prismantoko, A., Suyatno, S., Ghazidin, H., Kuswa, F. M., Ruhiyat, A. S., Ali Nandar, C. S., Felani, M. I., Pancono, W., Priyanto, U., Kusmiyati, K., & Vuthaluru, H. B. (2025). Evaluation of the potential of replanted rubber wood and palm oil waste with coal as co-combustion fuels in a lab-scale combustion simulator: Ash deposition aspects. *Biomass and Bioenergy*, *197*, 107774. https://doi.org/10.1016/j.biombioe.2025.107774

Hidayatno, A., Setiawan, A. D., Subroto, A., Saheruddin, H., Wardono, S., Romijn, H., Zahari, T. N., Rahman, I., Jafino, B. A., Moeis, A. O., Komarudin, K., Fitriani, A. R., Julio, N., & Zafira, Z. (2025). Exploring the food-versus-fuel debate in Indonesia's palm oil industry toward sustainability: A model-based policymaking approach. *Energy Nexus*, *19*, 100511. https://doi.org/10.1016/j.nexus.2025.100511

Imran, M., Huangying, S., Hongshuo, Z., Xiaoyun, P., Zhou, R., Guanming, C., & Xianhai, Z. (2025). Genetic and metabolic engineering of oleic acid synthesis pathways in oil palm: Challenges and future prospects. *Plant Physiology and Biochemistry*, *228*, 110288. https://doi.org/10.1016/j.plaphy.2025.110288

Jailani, N., Jaafar, N. R., Azelee, N. I. W., Rahman, R. A., Illias, R. M., & Wahab, M. K. H. A. (2025). Bioconversion of oil palm empty fruit bunches waste into prebiotic xylooligosaccharides using a genetic modified cross-linked endoxylanase aggregates immobilization. *Biocatalysis and Agricultural Biotechnology*, *64*, 103489. https://doi.org/10.1016/j.bcab.2025.103489

Kacaribu, A. A., Aisyah, Y., Febriani, & Darwin. (2025). Development of wastewater treatment methods for palm oil mill effluent (POME): A comprehensive review. *Resources Chemicals and Materials*, *4*(4), 100130. https://doi.org/10.1016/j.recm.2025.100130

Khongkliang, P., Nuchdang, S., Rattanaphra, D., Kingkam, W., Setiabudi, H. D., Wadchasit, P., Kadier, A., Aryanti, P. T. P., & Phalakornkule, C. (2025). Implementing a circular economy approach for biogas, tannin, and treated water in the palm oil industry. *Journal of Water Process Engineering*, *79*, 109032. https://doi.org/10.1016/j.jwpe.2025.109032

Kong, Z. Y., Ang, T. J. N., Ong, H. C., Shi, T., Yeo, C. I., & Yang, A. (2025). Green hydrogen production from oil palm wastes: A techno-economic and environmental perspective. *Energy Conversion and Management*, *341*, 120026. https://doi.org/10.1016/j.enconman.2025.120026

Kurniasih, E., Rahmi, Darusman, & Supardan, M. D. (2025). Enzymatic synthesis of mono-diacylglycerides using off-grade crude palm kernel oil and waste glycerol from biodiesel production. *South African Journal of Chemical Engineering*, *52*, 227–242. https://doi.org/10.1016/j.sajce.2025.02.010

Kuswa, F. M., Putra, H. P., Ghazidin, H., Prismantoko, A., Yarsono, S., Maulana, I., Pancono, W., Widjajanto, T., Asmanto, P., Saptoro, A., Vuthaluru, H. B., & Hariana, H. (2025). Ash deposition characteristics from high temperature co-combustion of oil palm waste with rubber and sengon woods. *Biomass and Bioenergy*, *200*, 107992. https://doi.org/10.1016/j.biombioe.2025.107992

Mas'udah, K. W., Anggoro, D., Nakajima, H., Sapruangnet, R., Astuti, F., Asih, R., & Darminto, D. (2025). Palm oil shell-derived SiO2/hard-carbon-like nanocomposites for a potential application as dual carbon battery electrode. *Biomass and Bioenergy*, *203*, 108332. https://doi.org/10.1016/j.biombioe.2025.108332

Mhadmhan, S., Yoosuk, B., & Lapapong, S. (2025). High-performance biotransformer oil from palm derivatives for low-temperature applications: Green synthesis, properties, and accelerated thermal aging. *Journal of Environmental Chemical Engineering*, *13*(6), 120343. https://doi.org/10.1016/j.jece.2025.120343

Milicevic, D. P. M., Chan, Y. J., Shi, S., & Thangalazhy-Gopakumar, S. (2025). Effect of torrefaction of palm frond on methane yield through anaerobic co-digestion with palm oil mill effluent. *Journal of Analytical and Applied Pyrolysis*, *192*, 107316. https://doi.org/10.1016/j.jaap.2025.107316

Mohammad Taib, M. N. A. (2025). Influence of green fillers from oil palm trunk (Elaeis guineensis) on the thermal stability, tensile performance and morphological properties of reinforced epoxy composites. *RSC Advances*, *15*(53), 45061–45070. https://doi.org/10.1039/d5ra07482g

Mohammed Nadeem, M., Sayem Mozumder, M., Saba, N., Safwan Ismail, A., & Jawaid, M. (2025). Effect of kenaf and oil palm fibers on the mechanical, physical and morphological properties of the bio-epoxy hybrid composites. *Journal of Materials Research and Technology*, *38*, 3472–3481. https://doi.org/10.1016/j.jmrt.2025.08.180

Mono, J. A., Tiaya, E. M., Assona, R. A., Takoumbe, C., Magne, V. C. F., Assiene, O. T. A., Bitete, R. H., & Anafack, S. M. (2025). Impact of the extraction technique on the desorption diffusion theory of Tenera oil palm bunch fibres from Cameroon. *Next Research*, *2*(4), 101050. https://doi.org/10.1016/j.nexres.2025.101050

Mustafa, M. R. U., Gandapur, M. U. S., & Khurshid, H. (2025). Green adsorption of oil and grease from wastewater using oil palm leaves activated carbon. *Cleaner Waste Systems*, *12*, 100330. https://doi.org/10.1016/j.clwas.2025.100330

Nagime, P. V., Chidrawar, V. R., Singh, S., Shafi, S., & Singh, S. (2025). Palm oil mill waste: A review on ecological improvement goals advancement and prospects. *Food and Humanity*, *5*, 100816. https://doi.org/10.1016/j.foohum.2025.100816

Raheem, H. O., Abas, N. F., Shanmugan, S., Ban, C. C., & Tersoo, K. E. (2025). Enhancing the thermal efficiency of unfired laterite bricks stabilized with seashell powder and palm oil fuel ash for sustainable construction. *Construction and Building Materials*, *496*, 143840. https://doi.org/10.1016/j.conbuildmat.2025.143840

Sidabutar, R., Trisakti, B., Irvan, I., Batubara, S. F., Gusty, N. D., Rambe, H. S., Syahputra, Mhd. R., Michael, M., Syaifan, M., Effendi, E. R., Alexander, V., Nabilah, Y., Fath, M. T., Dalimunthe, N. F., Sijabat, M., Syafriandy, S., & Takriff, M. S. (2025). Development of a novel co-composting system for empty fruit bunches using UASB-HCPB fermentor-derived effluent for sustainable palm oil waste management: Design, performance evaluation, and kinetic study. *Journal of Hazardous Materials Advances*, *18*, 100730. https://doi.org/10.1016/j.hazadv.2025.100730

Tabassum, M., Siddique, Md. B. M., Afrouzi, H. N., & Kashem, S. B. A. (2025). A Feasibility Study of Renewable Energy Generation from Palm Oil Waste in Malaysia. *Energy Engineering*, *122*(9), 3433–3457. https://doi.org/10.32604/ee.2025.065955

Taib, M. N. A. M., Salleh, A., Jamaluddin, N. A. N., Rasheed, T., Hussin, M. H., Julkapli, N. M., Saji, V. S., & Saleh, T. A. (2025). A review on recent developments of oil palm solid waste upcycling into green bio-based materials for sustainable building and construction applications. *Results in Engineering*, *27*, 107049. https://doi.org/10.1016/j.rineng.2025.107049

Thanahiranya, P., Sadhukhan, J., Charoensuppanimit, P., Vacharanukrauh, T., Chuetor, S., Chanthanumataporn, M., & Assabumrungrat, S. (2025). Design and assessment of biolubricant production processes utilizing various feedstocks in palm oil-based biodiesel industry. *Journal of Cleaner Production*, *518*, 145949. https://doi.org/10.1016/j.jclepro.2025.145949

Trisakti, B., Sidabutar, R., Irvan, Sinamo, G. C., Ambarita, R., Alexander, V., Michael, M., Nasution, J. A., Nabilah, Y., Daimon, H., & Takriff, M. S. (2025). Enhanced H2S absorption and water recovery using Thiobacillus sp. And Azolla microphylla for zero-waste palm oil mill applications. *Case Studies in Chemical and Environmental Engineering*, *11*, 101173. https://doi.org/10.1016/j.cscee.2025.101173

Unsomsri, N., Chunyok, K., Pakdee, W., Muncharoenporn, P., Koedthong, P., Tawkaew, S., Wiriyasart, S., & Kaewluan, S. (2025). Fuel potential of bio-oil from co-pyrolysis of fresh palm fruit bunches and waste cooking oil sludge: Composition, fuel properties, and carbon distribution analysis. *Case Studies in Chemical and Environmental Engineering*, *12*, 101265. https://doi.org/10.1016/j.cscee.2025.101265

Yusuf, F. R., Suprihatin, S., & Indrasti, N. S. (2025). Improving the environmental performance of palm oil industry through the utilization of empty oil palm bunches as organic fertilizer and biochar for soil amendment. *Environmental Challenges*, *20*, 101185. https://doi.org/10.1016/j.envc.2025.101185