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The Role of Stakeholder Engagement in Improving the Sustainability of the Biodiesel Industry

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Abstract

The Indonesian biodiesel industry faces major challenges in maintaining sustainability amidst global market dynamics and changes in international regulations. The involvement of various stakeholders, including the government, private sector, farmers, and non-governmental organizations, is a key factor in determining the direction of development of this industry. In addition, environmental issues, economic uncertainty, and technical barriers in the distribution and production of biodiesel also affect Indonesia's competitiveness at the global level. This study aims to analyze the role of stakeholder engagement in improving the sustainability of the biodiesel industry and identify strategies that can be applied to strengthen the competitiveness of this sector. The method used in this study is a qualitative approach, which analyzes data from various relevant secondary sources, such as previous studies. The data that has been collected is then processed and analyzed to find patterns of stakeholder involvement and challenges faced by the biodiesel industry. The results of the study show that the sustainability of the biodiesel industry is highly dependent on cross-sector cooperation and adaptation to international standards. Supportive regulations, transparency in the supply chain, and technological innovation are key factors in increasing the efficiency of biodiesel production and distribution. With the right strategy, the Indonesian biodiesel industry can continue to grow and compete in the global market to support a more sustainable energy transition.

Keywords: *Stakeholders, Engagement, Biodiesel Industry.*

INTRODUCTION

The biodiesel industry plays a strategic role in the sustainable energy transition in many countries, including Indonesia, which has abundant natural resources for biofuel production. With the increasing need for more environmentally friendly energy, biodiesel is a major alternative to reduce dependence on fossil fuels (Farobie & Hartulistiyoso, 2022). In addition, global policies that encourage the use of renewable energy are accelerating the development of the biodiesel industry as part of efforts to mitigate climate change and reduce greenhouse gas emissions. Amidst these initiatives, stakeholder

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engagement is one of the determining factors for the success of the biodiesel industry in achieving sustainability goals (Rial, 2024).

In the global context, the demand for biodiesel continues to increase along with policies implemented by various countries to reduce the negative impacts of fossil fuel use. Several countries have implemented mandates for blending biodiesel with conventional fuels to reduce carbon emissions and reduce environmental impacts. Indonesia, as one of the largest palm oil producers in the world, has a great opportunity to utilize these resources in biodiesel production (Yusoff et al., 2021). However, the development of this industry is not free from various challenges, including environmental sustainability, social welfare, and economic stability. To ensure that this industry develops while still considering the principles of sustainability, the involvement of stakeholders from various sectors is very important (Walker et al., 2021).

The government plays a central role in the biodiesel industry through regulatory policies, incentives, and supervision of biodiesel production and distribution. Various policies have been implemented to support this industry, such as mandatory biodiesel blending, subsidies for producers, and strengthening environmental regulations related to sustainable production practices (Jafarnejad et al., 2024). However, in its implementation, these regulations often face various obstacles, both from technical and social aspects. The biodiesel industry involves not only biofuel producers, but also oil palm farmers, local communities, non-governmental organizations, and consumers who play a role in ensuring the sustainability of this industry. Therefore, coordination and communication between stakeholders are key to creating an ecosystem that supports the sustainability of the biodiesel industry in the long term (Abideen et al., 2023).

In addition to the government, the private sector also plays an important role in ensuring the sustainability of the biodiesel industry. Companies engaged in biodiesel production are required to implement responsible business practices, including the use of raw materials from sustainably managed sources and the application of environmentally friendly technology in the production process (Sikiru et al., 2024). The main challenge faced by the industry is how to ensure that the entire supply chain, from plantations to distribution, operates following the principles of sustainability. Sustainability certification and standards have been developed to ensure that biodiesel production does not have negative impacts on the environment and society. However, in practice, there are still many obstacles to implementing these standards, especially for small-scale farmers who often have difficulty meeting certification requirements (Kshetri, 2021).

On the other hand, civil society and non-governmental organizations also have a role in supporting the sustainability of the biodiesel industry through advocacy, education, and monitoring of policies and implementation of sustainability practices. Community involvement is an aspect that cannot be ignored, considering that the

biodiesel industry has a broad impact on the socio-economic life of the community, especially those living around the raw material production area (Djatmika et al., 2023). In some areas, the expansion of oil palm plantations for biodiesel production has caused social conflicts, both related to land rights, worker welfare, and ecological impacts. Therefore, the active involvement of local communities in the decision-making process is one of the factors that can improve the sustainability of this industry (Haryati et al., 2022).

Globally, the involvement of stakeholders in the biodiesel industry is also increasingly strengthened by demands from the international market. Countries that are the destinations for Indonesian biodiesel exports, such as the European Union and the United States, have implemented strict policies regarding sustainability standards for biofuels (Sosa-Rodriguez & Vazquez-Arenas, 2021). This encourages biodiesel producers to adapt to increasingly stringent regulations and ensure that their products meet international requirements. If domestic stakeholders do not play an active role in building a system that supports sustainability, the Indonesian biodiesel industry is at risk of losing its competitiveness in the global market (Putri et al., 2022).

The dynamics of stakeholder involvement in the biodiesel industry not only cover economic and environmental aspects but also political and social dimensions. In several countries, policies related to biofuels are often debated among various interest groups that have different views on the effectiveness of biodiesel as a sustainable energy solution (Falcone et al., 2021). Some groups consider that biodiesel development can be a positive step in reducing dependence on fossil fuels, while other groups are concerned about the negative impacts on biodiversity and food security due to the increasing allocation of land for biodiesel raw material production. Therefore, the involvement of all stakeholders in policy discussions is a very important element in balancing the various interests that exist (Oloyede et al., 2024).

With the various challenges and opportunities that exist, stakeholder involvement in the biodiesel industry needs to be strengthened through collaborative strategies that can bridge the interests of various parties. A multi-sector approach that prioritizes transparency, accountability, and a balance between economic, social, and environmental interests is key to improving the sustainability of this industry. Without optimal involvement from various stakeholders, the biodiesel industry is at risk of facing various obstacles that can hinder its growth and sustainability in the long term. Therefore, this study will explore how stakeholder engagement can contribute to improving the sustainability of the biodiesel industry, as well as identify strategies that can be implemented to strengthen their role in the ecosystem of this industry.

LITERATURE REVIEW

Stakeholder Engangement

Stakeholders are any group inside or outside the company that has a significant role in determining the success of the company. The existence of stakeholders is not only limited to individuals or groups that directly interact with the company but also includes parties that are affected by the company's policies and operations. In this context, stakeholders can consist of various elements, such as shareholders who have an interest in the company's profitability, creditors who place their trust through funding, consumers who rely on the company's products and services, suppliers who provide raw materials, and analysts who monitor the company's performance in the market (Pfajfar et al., 2022). In addition, employees are also included in the stakeholder group that has a fundamental role in the company's operations, while the government acts as a regulator that regulates and supervises business activities to comply with applicable laws. Furthermore, society as part of the social environment also becomes a stakeholder that is affected by the social, economic, and environmental impacts generated by the company. Therefore, the company cannot operate only for its internal interests, but must also consider the benefits that can be provided to various stakeholders to create balance in the business and social ecosystem (Xun & Weng, 2024).

Stakeholder engagement is an important means used by companies to build closer relationships with stakeholders. This process not only helps companies identify relevant sustainability issues but also serves as a mechanism to understand the needs and interests of stakeholders that need to be considered. Through effective engagement, companies can increase the level of trust from various parties, strengthen transparency in their operations, and affirm accountability in every business decision taken. In addition, stakeholder engagement also allows companies to create more open communication regarding business activities and the impacts they have on the environment and the wider community. Thus, companies can build more harmonious and aligned relationships with stakeholders (Attanasio et al., 2022). To manage stakeholder engagement systematically, the Project Management Institute (PMI) has developed an approach consisting of four main stages, namely identifying stakeholders involved in the company's operations, planning an effective interaction strategy, managing engagement by ensuring optimal communication and monitoring the relationships that have been formed to ensure that stakeholder expectations and needs continue to be considered. This process provides a clear structure for managing stakeholder relationships so that companies can optimize the benefits of this engagement and ensure that decisions taken are in line with stakeholder needs (Gomes et al., 2024).

To achieve success in sustainable development, companies generally document their achievements through sustainability reports that serve as the main communication tool with stakeholders. This

report not only reflects the company's commitment to implementing sustainability principles but also illustrates the extent to which the company has succeeded in integrating social and environmental aspects into its business operations. Stakeholder engagement is an integral part of the sustainability report preparation process because, through active interaction with stakeholders, companies can gain deeper insights into social and environmental issues that are considered important by various parties (Manes-Rossi & Nicolo', 2022). Therefore, collaborative action between companies and stakeholders is crucial in identifying and addressing sustainability challenges more effectively. Studies that have been conducted have proven that stakeholder engagement has a positive correlation with improving the company's social performance. In other words, the more actively a company involves stakeholders in its decision-making process and business strategy, the greater the company's potential to build an organizational culture that cares about social responsibility. In addition, stakeholder engagement also serves as an internal driver that encourages companies to continue to innovate in meeting community expectations and increasing positive social impacts (Journeault et al., 2021).

In managing stakeholder engagement, four main stages must be implemented systematically so that companies can build effective and sustainable relationships with stakeholders. These four stages include the process of identification, planning, management, and monitoring which aims to ensure that each stakeholder involved receives attention following their interests and influence on the company (López-Concepción et al., 2022). By implementing these stages comprehensively, companies can not only increase stakeholder involvement in various operational aspects, but also create a business environment that is more transparent, accountable, and responsive to changes in the needs and expectations of society (Ledro et al., 2023).

The first stage in stakeholder engagement management is identification, which is the initial process of understanding who the stakeholders are that influence the company. At this stage, the company needs to conduct stakeholder mapping to identify individuals, groups, or organizations that have an interest in its business activities. This mapping is not only intended to find out who is involved but also to analyze the level of influence and interest of each stakeholder towards the company (Kujala et al., 2022). Through this in-depth analysis, the company can identify the stakeholder groups that have the most significant role and understand their dynamics and needs. This process is the basis for the company in formulating the right engagement strategy and ensuring that all relevant parties are involved in the decision-making process. Thus, the company can avoid conflicts of interest, increase support from various parties, and create more harmonious and sustainable relationships with its stakeholders (Magistretti et al., 2021).

After the identification stage is complete, the company proceeds to the planning stage, where the stakeholder engagement strategy begins

to be designed more specifically. At this stage, the company not only groups stakeholders based on their level of interest and influence but also determines the most appropriate approach for each group. Each stakeholder has different needs and expectations, so the company must develop different strategies to engage them (Shah & Guild, 2022). For example, internal stakeholders such as employees may be more likely to require open communication and human resource development programs, while external stakeholders such as local communities may be more likely to be involved in corporate social responsibility (CSR) programs. Therefore, the planning stage plays a crucial role in determining the extent to which a company can meet stakeholder expectations and build effective and constructive communication. With careful planning, a company can ensure that every step taken has a clear purpose and is aligned with the sustainability vision it wants to achieve (Adu-Gyamfi et al., 2021).

The third stage is management, which is the implementation stage of the previously designed strategy. At this stage, the company begins to implement various initiatives aimed at increasing stakeholder engagement, either through direct communication, open dialogue, or collaborative programs. The management of stakeholder engagement must be carried out systematically so that the engagement that occurs is not just a formality but truly provides benefits for both parties (Hristov & Appolloni, 2022). One important aspect in this stage is ensuring that the CSR programs implemented are in line with the needs and expectations of stakeholders that have been previously identified. By actively managing stakeholder engagement, the company can build stronger relationships, improve its reputation, and gain greater support from stakeholders in carrying out its various business and social initiatives (Kamal, 2021).

The last stage in managing stakeholder engagement is monitoring, which functions as an evaluation mechanism for the effectiveness of the engagement that has been carried out. At this stage, the company actively observes, measures, and evaluates the level of engagement and feedback provided by stakeholders. This monitoring is important because, through this process, the company can identify whether the strategy implemented is running according to expectations or whether further adjustments need to be made (Heliyon et al., 2022). In addition, monitoring also provides valuable information regarding the effectiveness of the CSR programs that have been implemented, so that the company can continue to increase its impact on society and the environment. With ongoing evaluation, companies can ensure that stakeholder engagement remains relevant to business developments and changing stakeholder needs, and can make a greater contribution to achieving long-term sustainability goals (Ghobakhloo et al., 2023).

Biodiesel

Biodiesel is a liquid fuel produced from vegetable oil and functions as an alternative to diesel in various industrial and

transportation applications. The main advantage of biodiesel lies in its more environmentally friendly nature compared to fossil fuels, as well as its potential to reduce dependence on non-renewable energy sources. According to Nelson and Watanabe, biodiesel is generally produced through the transesterification process, which is a chemical reaction involving vegetable oil and alcohol with the help of a catalyst to produce esters (biodiesel) and glycerol as a by-product. The catalyst used in this process can be a base, acid, or enzyme catalyst, depending on the type of vegetable oil and the production method applied (Das et al., 2022). Zhang stated that methanol is more commonly used in the transesterification process because of its wide availability and relatively lower production costs compared to other alcohols. The transesterification reaction takes place under less extreme operating conditions, namely a temperature of 60-70°C and a pressure of around 20 psia, with a yield ranging from 95-98 percent. In its use, biodiesel must meet several important parameters, such as cetane number, acid number, and iodine number, as explained by Soerawidjaja and Tahar, so that the quality of the fuel produced meets industry standards and is efficient in combustion (Salaheldeen et al., 2021).

Compared to diesel or diesel derived from fossil fuels, biodiesel has several significant advantages, especially in terms of sustainability and environmental impact. Diesel or diesel has a high content of carbon monoxide (CO), carbon dioxide (CO_2), and various heavy metals, contributing to air pollution and global warming. In contrast, biodiesel is renewable because it comes from renewable plant resources and has cleaner exhaust emissions (Ogunkunle & Ahmed, 2021). According to Gafar, the energy produced by biodiesel is comparable to the energy obtained from diesel, so it can be used without reducing engine performance. One of the main advantages of biodiesel is its higher cetane number compared to diesel, which causes biodiesel-fueled engines to produce a smoother sound and lower vibration levels (Mustayen et al., 2022). In addition, the use of biodiesel can reduce the greenhouse effect because the carbon dioxide produced from its combustion can be reabsorbed through the photosynthesis process of vegetable oil-producing plants. Biodiesel also has lower carbon monoxide (CO) emissions, contains fewer harmful particulates, and has a relatively high flash point, making it safer to store and use. Furthermore, biodiesel has good lubricating properties, which can help extend engine life by reducing friction between engine components (Thamarai et al., 2024).

With these advantages, biodiesel is increasingly recognized as the best alternative to fossil fuels and has been used in various countries, especially in areas with strict environmental policies and high concern for sustainability issues. The selection of the type of vegetable oil used as a raw material for biodiesel is highly dependent on the availability of natural resources in a country. Some common raw materials used in biodiesel production include soybean oil, canola oil, sunflower seed oil, castor oil, coconut oil, and palm oil (Mathew et al., 2021). The main

factors that are considered in the development of the biodiesel industry in a country include the availability of raw materials, the potential for oil crops that can be cultivated locally, production capacity adjusted to domestic demand, and awareness of the limitations of fossil energy sources in the future. Thus, countries that have wide access to certain vegetable oils tend to develop biodiesel based on the most efficient resources to process (Miftah & Mutta, 2024).

In addition to fresh vegetable oil, biodiesel raw materials can also come from used oil, as stated by Zhang. The use of used oil for biodiesel production not only helps reduce domestic and industrial waste but also increases the efficiency of energy resource use. Several automotive companies have adopted biodiesel as a fuel without the need to make significant modifications to their vehicle engines. Biodiesel can be used in its pure form (B100) or a mixture with diesel at a certain ratio. For example, B20 refers to a mixture of 20% biodiesel and 80% diesel, while B5 contains only 5% biodiesel in its mixture (Singh et al., 2021). Each country has a different policy in determining the standard for biodiesel and diesel mixtures. In the United States and Europe, B20 is the general standard, while France uses more B5 mixtures. In Indonesia, the government has implemented a policy of using biodiesel with BS standards, which continues to increase along with efforts to transition to more sustainable energy (Halimatussadiah et al., 2021).

With various technological developments and increasing global awareness of energy sustainability, biodiesel is predicted to increasingly become the main solution in efforts to reduce dependence on fossil fuels. The combination of raw material availability, production efficiency, and government policies that support the use of renewable energy will be the determining factors in the success of biodiesel implementation in various countries (Babadi et al., 2022).

METHOD

This research will be conducted using a qualitative approach to understand the dynamics of the sustainability of the biodiesel industry in Indonesia. This approach allows for an in-depth analysis of the roles of various stakeholders, the challenges faced, and collaborative strategies that can be implemented to improve the competitiveness of this industry. Research data will be obtained from various sources, including previous research results, policy reports, and publications relevant to this topic. Thus, this research aims to explore comprehensive information on the factors that influence the biodiesel industry, both on a national and international scale. After the research data is collected, the next step is to process and analyze the data to produce relevant findings. In this way, this research is expected to provide broader insights into how the biodiesel industry can develop sustainably through cross-sector collaboration and adaptation to global regulatory changes.

RESULT AND DISCUSSION

Dynamics of Stakeholder Engagement in the Biodiesel Industry

The biodiesel industry is a complex sector and involves various stakeholders who have their interests, roles, and challenges in ensuring the sustainability and competitiveness of this industry. The government is the main actor in setting regulations and policies that govern the running of the biodiesel industry, both in terms of production, distribution, and consumption. Through various policies, such as mandatory blending of biodiesel with fossil fuels, incentives for biodiesel producers, and strengthening sustainability standards, the government seeks to encourage the growth of this industry in line with the targets of the energy transition and carbon emission reduction. However, the implementation of these policies often faces various obstacles, both technically and socially, which require further coordination between the government and related parties to run effectively. In addition, legal certainty in biodiesel industry regulations is also a crucial aspect, considering that policy instability can have an impact on investment certainty and business sustainability in this sector.

In addition to the role of the government, the private sector also plays an equally important role in ensuring that the biodiesel industry runs innovatively and efficiently. Companies engaged in biodiesel production are required to apply more efficient technology, both in the process of extracting vegetable oil and in converting it into biodiesel with lower emission levels. Innovations in this industry include the use of alternative raw materials, the development of more environmentally friendly processing technologies, and the optimization of the distribution chain to be more cost-effective and sustainable. However, the challenges faced by the private sector are not few, especially related to the certainty of raw material supplies, changing regulations, and competition with fossil fuels that are still heavily subsidized in some countries. In addition, companies are also faced with demands to meet increasingly stringent sustainability standards in the global market, which require significant investment in certification and increased supply chain transparency.

The involvement of farmers and raw material producers in the biodiesel supply chain is also a very important aspect of this industry. As providers of the main raw materials, such as palm oil, jatropha, and other vegetable oils, farmers play a strategic role in determining the availability and sustainability of the supply of biodiesel raw materials. However, most farmers still face various challenges, such as limited access to sustainable agricultural technology, lack of funding for investment in environmentally friendly production, and obstacles in obtaining sustainability certification which is a primary requirement in the international market. In addition, imbalances in the supply chain often result in smallholder farmers not receiving benefits commensurate with their contributions, as the added value in this industry is mostly absorbed downstream. Therefore, strengthening the capacity of farmers, increasing access to sustainable funding programs, and fair incentive

systems are important steps in increasing their role in the sustainable biodiesel industry.

On the other hand, non-governmental organizations and civil society also play a role in ensuring that the biodiesel industry develops while still paying attention to social and environmental sustainability aspects. Various environmental and human rights organizations often play a role in advocating for the implementation of stricter sustainability standards, both for raw material producers and biodiesel processing companies. They also contribute to raising public awareness of the importance of more environmentally friendly energy consumption and monitoring the social impacts of biodiesel industry expansion, especially in areas prone to land conflicts and deforestation. In addition, these organizations often play a role in building partnerships between the public and private sectors to increase transparency and encourage the implementation of best practices in the biodiesel industry. However, the relationship between non-governmental organizations and the industry sector is often dynamic, where there are challenges in bridging the differences in interests between economic growth and environmental protection.

One of the biggest challenges in the biodiesel industry is coordination between various stakeholders who have different perspectives and objectives. Governments, the private sector, farmers, non-governmental organizations, and the general public often have interests that are not always aligned, so communication mechanisms and policies are needed that can balance the various aspects that exist. In some cases, these different interests can lead to conflict, for example between the government that wants to increase biodiesel production to meet renewable energy targets and environmental groups that are concerned about the ecological impacts of expanding raw material plantations. In addition, challenges in coordination also arise in the implementation of policies that are often not integrated between the national and regional levels, causing inconsistencies in the implementation of regulations and uncertainty for industry players. Therefore, a more inclusive and participatory approach is needed in designing policies and strategies for the sustainability of the biodiesel industry, to create a balance between industry growth, social welfare, and environmental protection.

The dynamics of stakeholder involvement in the biodiesel industry reflect the complexity of this sector which is not only oriented towards economic aspects but also involves social, political, and environmental dimensions. The success of this industry in achieving sustainability depends greatly on how stakeholders can collaborate in creating a transparent, accountable system based on the principles of justice and long-term sustainability. Without effective coordination and active involvement from all stakeholders, the biodiesel industry is at risk of facing various obstacles that could threaten its sustainability and competitiveness at the global level. Therefore, building synergy between

various actors in the biodiesel industry ecosystem is one of the key steps in creating a more sustainable and equitable energy system.

Sustainability Challenges in Biodiesel Production and Distribution

Sustainability in biodiesel production and distribution faces various challenges that include environmental, social, economic, technical, and regulatory aspects. Biodiesel production based on plant-based raw materials such as palm oil, jatropha, soybeans, and used cooking oil has significant environmental impacts, especially in the context of expanding agricultural land to meet the demand for raw materials. One of the main impacts that is often of concern is deforestation and loss of biodiversity due to the conversion of forest land into large-scale plantations. This process not only causes ecosystem degradation but also increases carbon emissions due to the release of greenhouse gases from peat soils and cleared forests. In addition, intensive production of biodiesel raw materials often requires the use of large amounts of pesticides and chemical fertilizers, which contribute to water and soil pollution and threaten the balance of local ecosystems. Meanwhile, the use of land for biodiesel raw material plantations also creates competition with the food agriculture sector, so a dilemma arises between energy production and food security which requires a more balanced management policy.

The social impact of biodiesel production is also a complex issue, especially for communities living around the raw material production area. In many cases, the expansion of the biodiesel industry has caused social and economic shifts in local communities, with some people losing access to land that previously served as their livelihood. Land conflicts often arise from large-scale land conversion without adequate consultation with local communities. In addition, although the biodiesel industry promises to create jobs, the reality on the ground shows that many workers in plantations and processing plants still face inadequate working conditions, including low wages, long working hours, and a lack of social and occupational health protection. The gap in the distribution of economic benefits from this industry is also a concern, as the largest profits tend to be enjoyed by large companies, while smallholders are often in a vulnerable position due to unstable raw material prices and dependence on distribution chains controlled by intermediaries.

Economic uncertainty in the biodiesel supply chain is another challenge that affects the sustainability of this industry. Fluctuations in the prices of biodiesel raw materials, such as palm oil and soybeans, are greatly influenced by global market dynamics, trade policies, and supply and demand that are not always predictable. When raw material prices soar, biodiesel production costs become more expensive, which ultimately reduces its competitiveness compared to fossil fuels that are still subsidized in many countries. Conversely, when raw material prices drop drastically, farmers and small producers often suffer losses due to shrinking profit margins. In addition, uncertainty in government

incentive policies, such as subsidies or biodiesel blending schemes with conventional fuels, also creates instability in business planning for industry players. The lack of certainty about future regulations makes many investors hesitant to invest in the development of more efficient and sustainable biodiesel technologies, thus hampering innovation in this sector.

From a technical perspective, the biodiesel industry also faces several challenges in processing and distribution that affect the efficiency and quality of the final product. One of the main obstacles is the difference in chemical characteristics between biodiesel and conventional diesel fuel, which often requires modifications to engines and distribution systems to be used optimally. The oxidative stability of biodiesel is also an important issue, as biodiesel tends to degrade more quickly than fossil fuels, which can cause deposits and blockages in vehicle fuel systems if not managed properly. In addition, the infrastructure for storing and distributing biodiesel is still not evenly developed, especially in developing countries that do not yet have adequate renewable fuel distribution networks. This challenge is further exacerbated by the lack of investment in research and development to increase production efficiency and improve biodiesel characteristics to be more compatible with existing engine standards.

Difficulties in implementing sustainability standards and certification are another challenge that hampers efforts to make the biodiesel industry more environmentally and socially friendly. Currently, there are various sustainability certification schemes, such as the Roundtable on Sustainable Palm Oil (RSPO) and the International Sustainability and Carbon Certification (ISCC), which aim to ensure that biodiesel production meets certain standards in environmental, social, and economic aspects. However, the implementation of these certifications often faces obstacles, especially for smallholders who have difficulty meeting administrative requirements and relatively high certification costs. In addition, the differences in standards between various certification schemes also create confusion at the industry and consumer levels, where not all certifications are universally recognized in the global market. Meanwhile, monitoring and enforcement of sustainability standards still face obstacles, especially in areas with weak institutional capacity and a lack of transparency in the supply chain.

In facing these sustainability challenges, a more holistic and integrated approach is needed that involves all stakeholders in the biodiesel industry. The government needs to ensure that the regulations implemented can provide legal and economic certainty for industry players while balancing environmental and social sustainability aspects. The private sector needs to increase investment in more efficient technologies and build fairer supply chains for farmers and raw material producers. Civil society and environmental organizations also have a role in overseeing the implementation of sustainability standards and encouraging transparency in the industry. With closer collaboration

between various parties, it is hoped that the biodiesel industry can develop more sustainably, not only in economic aspects but also in maintaining social and ecological balance in the long term.

Collaborative Strategy to Enhance Sustainability of the Biodiesel Industry

The sustainability of the biodiesel industry requires a collaborative strategy involving various stakeholders to ensure that its production and distribution can meet better environmental, social, and economic standards. In this context, stricter regulations and incentives for producers who implement sustainable practices are one of the main steps that can accelerate the transformation of this industry. The government has an important role in creating policies that encourage the use of environmentally friendly technologies, reduce the negative impacts of raw material production, and provide legal certainty for industry players. Policies such as carbon taxes, subsidies for green technology, and mandatory blending of biodiesel in fossil fuels can help create a more supportive ecosystem for the growth of a sustainable biodiesel industry. However, the effectiveness of these policies depends heavily on consistent implementation and the existence of transparent monitoring mechanisms to ensure that the incentives provided are truly utilized to increase efficiency and reduce environmental impacts.

In addition to regulations, transparency in the biodiesel supply chain is also a key factor in ensuring the sustainability of this industry. One of the main challenges in the biodiesel industry is the lack of transparency regarding raw material sources, production methods, and distribution of the final product. In many cases, environmentally unfriendly production practices still occur due to weak monitoring systems and a lack of access to information for consumers. Therefore, the implementation of a traceable sustainability certification system with digital technology is a solution that can increase transparency in the supply chain. By utilizing blockchain technology, for example, every stage in biodiesel production can be recorded permanently, allowing consumers and regulators to ensure that the biodiesel products used come from responsible sources. This system can also help companies increase their credibility in the global market, considering the increasing demand for products with a lower environmental footprint in various countries.

The importance of a partnership approach between the government, the private sector, and local communities cannot be ignored in efforts to improve the sustainability of the biodiesel industry. The government can act as a facilitator connecting various actors in the biodiesel ecosystem, while the private sector is responsible for providing technological innovation and investment needed to increase production efficiency. On the other hand, local communities, especially farmers and raw material producers, must also be involved in the planning and implementation process of biodiesel policies so that they can feel more equitable economic benefits. Partnership models based on social

inclusion, such as farmer cooperative schemes or micro-business development programs in the biodiesel supply chain, can be an effective strategy to improve community welfare while ensuring the sustainability of raw material supplies. Through this approach, the biodiesel industry not only focuses on economic benefits alone but also contributes to more sustainable social development.

In terms of technology, developing innovations to increase the efficiency of biodiesel production is a priority that must continue to be developed. Currently, the main challenges in biodiesel production are high production costs and limited raw materials that can be used sustainably. Therefore, investment in research and development is a crucial factor in driving the progress of this industry. Technologies such as enzyme-based catalysts to increase the conversion of vegetable oil into biodiesel, the use of agricultural waste as an alternative source of raw materials, and the integration of renewable energy in the production process can be solutions to increase efficiency and reduce environmental impacts. In addition, efforts to develop biodiesel blending technology with fossil fuels that are more compatible with vehicle engines must also be a priority so that the use of biodiesel can be more widely applied in various transportation and industrial sectors.

In addition to technical and policy aspects, the role of education and public campaigns in increasing awareness of sustainability is also an equally important element. Public awareness of the environmental impact of energy consumption still needs to be increased so that demand for more sustainable biodiesel can continue to grow. Public campaigns that educate the public about the benefits of biodiesel as a more environmentally friendly fuel, as well as how to choose certified biodiesel products, can encourage wider adoption of biodiesel. In addition, education also needs to be focused on industry players and local governments so that they understand the importance of implementing sustainability principles in their business policies and practices. Through training programs, seminars, and collaboration with academic institutions, various parties can gain a better understanding of how to integrate sustainability into the biodiesel value chain.

A collaborative strategy in improving the sustainability of the biodiesel industry requires synergy between various stakeholders with a comprehensive and sustainable approach. By strengthening regulations, increasing transparency in the supply chain, encouraging multi-sectoral partnerships, developing innovative technologies, and strengthening public education and awareness, the biodiesel industry can transform into a more environmentally and socially responsible sector. These steps will not only ensure that biodiesel remains a competitive alternative energy source, but also contribute to global efforts to reduce carbon emissions and strengthen energy security in the long term.

Global Implications and Competitiveness of the Indonesian Biodiesel Industry

Indonesia's biodiesel industry plays a strategic role in the global energy market, especially as one of the main producers of palm oil-based biofuels. However, the dynamics of international policies are a factor that greatly influences the competitiveness of Indonesian biodiesel exports. Several major importing countries, such as the European Union and the United States, have implemented strict regulations related to sustainability and carbon footprint in biodiesel production, which often become obstacles for Indonesian exports. Policies such as the Renewable Energy Directive (RED) II in the European Union restrict imports of palm oil-based biodiesel on the grounds of deforestation and environmental impacts, thereby reducing market access for Indonesian producers. In addition, protectionist policies in several export destination countries are increasingly tightening competition, where they are encouraging the use of biofuels from domestic sources. As a result, Indonesian biodiesel exports often face trade tariffs, additional import duties, or even political import bans. In this context, a strong economic diplomacy strategy is needed to fight for Indonesia's biodiesel position in the global market and ensure that international policies not only benefit developed countries but also provide space for developing countries to participate in the global energy transition.

Another challenge faced by the Indonesian biodiesel industry is meeting increasingly complex global market standards and regulations. Many countries require sustainability certification as a prerequisite for biodiesel products to enter their markets. Certifications such as ISCC (International Sustainability & Carbon Certification) and RSPO (Roundtable on Sustainable Palm Oil) are the main benchmarks in assessing the sustainability of palm oil-based biodiesel production. Although several Indonesian producers have obtained this certification, there are still many challenges in implementation at the upstream level, especially related to supply chain transparency and smallholder compliance with the standards set. In addition, differences in sustainability standards in various export destination countries often make it difficult for producers to adjust their production to meet applicable requirements. Adapting to these global regulations requires significant investment in clean production technology, digital supply chain tracking, and capacity building for local farmers and producers to meet the requirements set by the international market.

Despite facing various challenges, Indonesia still has a strong position in the global biodiesel industry. As the world's largest palm oil producer, Indonesia has the advantage of abundant raw material availability compared to competing countries such as Malaysia, Argentina, and Brazil. Domestic policies such as the mandatory B35 biodiesel program and the planned upgrade to B40 provide certainty of domestic demand, which not only reduces dependence on exports but also increases the competitiveness of the national biodiesel industry. In

addition, production efficiency continues to be improved through investment in palm oil conversion technology into biodiesel with lower emission levels. With increasing global awareness of renewable energy and the need to reduce dependence on fossil fuels, Indonesia has a great opportunity to expand its market share in developing countries that are still looking for alternative energy sources at competitive prices. However, to truly strengthen its competitiveness, Indonesia needs to increase the added value of biodiesel products through product innovation and differentiation, such as the development of second-generation biofuels that have lower emission levels and are more in line with global sustainability standards.

International cooperation opportunities in biodiesel research and development can also be an important strategy for Indonesia to strengthen its competitiveness. Partnerships with global research institutions, multinational companies, and environmental organizations can help Indonesia develop more environmentally friendly production technologies and increase the efficiency of converting vegetable oil into biodiesel. Several countries such as Japan and Germany have shown interest in bioenergy technology collaboration, which can be used to accelerate the development of biodiesel based on alternative raw materials, such as used cooking oil or agricultural waste. In addition, cooperation with importing countries can open up opportunities for Indonesia to negotiate more realistic sustainability standards that do not discriminate against palm oil-based biodiesel. In this context, international forums such as the G20 and ASEAN can be platforms to fight for Indonesia's interests in biodiesel trade and encourage harmonization of international regulations to be more inclusive for developing countries.

On the other hand, global geopolitical dynamics also affect the stability of Indonesia's biodiesel industry. Trade tensions between major countries such as the United States and China, as well as geopolitical conflicts in the Middle East, can have implications for global crude oil prices which indirectly impact the competitiveness of biodiesel. When crude oil prices are low, biodiesel becomes less competitive as an alternative fuel, which can reduce demand in the global market. In addition, changes in energy policies in major countries, such as the European Union's push to switch to green hydrogen as a future energy source, can threaten the long-term prospects of biodiesel as a primary fuel in the energy transition. Therefore, Indonesia needs to anticipate geopolitical changes with a strategy of market and product diversification, as well as strengthening bilateral cooperation with countries that still have a high dependence on biofuels. These steps will ensure that the Indonesian biodiesel industry continues to have a stable market, despite the ever-changing dynamics of the global economy and politics.

Considering the various challenges and opportunities that exist, the Indonesian biodiesel industry needs to adopt an adaptive and innovative strategy to maintain its competitiveness at the global level. In

addition to strengthening domestic policies that support sustainability, Indonesia must be more proactive in trade diplomacy to ensure that international policies do not harm national biodiesel exports. Investment in green technology, increasing supply chain transparency, and strengthening international cooperation in research and development are key steps that can improve the competitiveness of the Indonesian biodiesel industry in the long term. With the right strategy, Indonesian biodiesel can not only become a major pillar in national energy security but also play a bigger role in the global energy transition towards a greener and more sustainable economy.

CONCLUSION

Indonesia's biodiesel industry is at the crossroads of global challenges and strategic opportunities that could determine its future sustainability. Increasingly stringent international policies on sustainability standards, fluctuating raw material prices, and global geopolitical dynamics are the main factors affecting the competitiveness of Indonesian biodiesel exports. Despite facing various obstacles in meeting global market regulations, Indonesia remains in a strong position as a major producer of palm oil-based biodiesel with the support of domestic policies that encourage increased domestic consumption. Therefore, efforts to adapt to international standards, transparency in the supply chain, and product diversification are important steps to maintain the stability and growth of this industry. The sustainability of Indonesia's biodiesel industry depends not only on economic and trade aspects but also on collaborative strategies involving various stakeholders. Strengthening more environmentally friendly regulations, technological innovation in production, and international cooperation in research and development can be the main drivers in increasing the competitiveness of Indonesian biodiesel at the global level. With a more strategic approach to trade diplomacy and market diversification, Indonesia can ensure that its biodiesel industry remains relevant in the global energy transition towards a greener and more sustainable economy.

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