

Contribution of B35 Biodiesel to Indonesia's Renewable Energy Target and Challenges for B40 Implementation

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ABSTRACT

Indonesia aims for 23% renewable energy by 2025 and a 29% reduction in greenhouse gas emissions by 2030 under the Paris Agreement. B35 biodiesel, a blend of 35% palm oil-based biodiesel and 65% diesel, is a key strategic solution for this energy transition. This study, using a mixed method approach with regression analysis, analyzed data from the Ministry of Energy and Mineral Resources and Indonesian palm oil industry reports. It aimed to quantify B35's contribution to the renewable energy mix and project outcomes for a potential B40 policy. An in-depth analysis was conducted to identify the success factors and challenges of biodiesel implementation. Results show B35 biodiesel significantly contributes to Indonesia's renewable energy goals, reaching 38% in 2023 and 38.75% in 2024. Its implementation also led to substantial savings of IDR 120.54 trillion in 2023 and IDR 123 trillion in 2024 by substituting fossil fuel imports. Regression projections suggest that B40 biodiesel could further increase renewable energy contributions to 40.7% with a 15.62 million kL production target in 2025. Additionally, biodiesel usage reduces CO₂ emissions by 8-11% compared to conventional diesel. In conclusion, B35 biodiesel plays a vital role, contributing nearly 40% to Indonesia's national renewable energy. For successful B40 implementation and to optimize biodiesel's role in achieving 2025 targets, a stable Crude Palm Oil (CPO) supply, a USD 4.1 billion infrastructure investment, consistent policy frameworks, feedstock diversification, carbon tax implementation, and strong inter-ministerial collaboration are essential.

Keywords

Biodiesel B35, Renewable Energy (RE), RE Contribution, Palm Oil Biodiesel, B40 Projection, Indonesia Energy Policy, Greenhouse Gas (GHG) Emission Reduction.

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INTRODUCTION

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 parties at the UN Climate Change conference (COP21) in Paris, France, on December 12, 2015. The agreement entered into force on November 4, 2016 with the main objective of limiting global warming to 1.5°C above pre-industrial levels [1]. The Paris Agreement operates on a five-year cycle in which member states submit their national climate action plans, known as Nationally Determined Contributions (NDCs). Indonesia ratified the Paris Agreement under Law No. 16/2016 on the Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change. Indonesia's NDC outlines a target to reduce greenhouse gas (GHG) emissions by 29% unconditionally and 41% conditionally (contingent on international support) by 2030 [2].

New and Renewable Energy (NRE) has been identified as a crucial strategy to address the adverse impacts of global warming. The Indonesian government maintains confidence in reaching its target of a 23% NRE contribution to the national energy mix by 2025 [3]. To support this objective, the Electricity Supply Business Plan (ESBP) has been formulated, incorporating green energy initiatives designed to accelerate progress toward the renewable energy target.

At the global level, electricity production remains heavily reliant on coal and other carbon-based resources, which are widely recognized as major drivers of climate change [4]. In response, the adoption of renewable alternatives such as B35 biodiesel presents a promising pathway. B35 is a fuel blend composed of 35% vegetable oil-based biodiesel, primarily Fatty Acid Methyl Esters (FAME) derived from crude palm oil (CPO), combined with 65% conventional diesel [5].

The introduction of B35 was primarily motivated by economic considerations, particularly Indonesia's strategy to maximize crude palm oil (CPO) utilization for domestic energy rather than relying heavily on exports. As the main feedstock for biodiesel, CPO plays a strategic role in the government's biofuel policy, which seeks to enhance national energy security [6]. The program reflects a gradual policy trajectory, evolving from earlier mandates of B20 and B30, to progressively expand the share of renewable energy in the national mix.

Despite contributing to renewable energy targets, B35 biodiesel faces several limitations, prompting the transition toward B40. Beginning in early 2025, Indonesia raised its blending requirement from 35% to 40%, a move that has restricted exports due to limited production capacity [7]. This situation highlights the need for system optimization and expansion to meet policy objectives. The main challenges associated with B35 include its insufficient contribution to the 23% renewable energy target by 2025, limited absorption of domestic CPO production, and less-than-optimal economic outcomes from the existing blend.

A durability study on vehicle engine performance using B40 biodiesel demonstrated that a 40% biodiesel–diesel blend complies with manufacturers' standards, as confirmed through component inspections and used oil analysis [8]. The results also indicate that B40 is operable under Indonesia's low-temperature conditions. These findings support the near-term feasibility of B40 implementation, with projections suggesting its integration could raise the biodiesel share in the national energy mix above 40%, thereby strengthening Indonesia's efforts to achieve its 2025 renewable energy target [9].

In parallel, this research addresses the absence of comprehensive evaluations of B35's contribution to national renewable energy goals. Specifically, it seeks to: (1) quantify B35's share in achieving the 23% renewable energy target, (2) assess the critical success factors and challenges in implementing the B35 adoption policy, and (3) develop policy recommendations to facilitate the mandatory transition toward B40.

METHOD

This study employed a mixed-method approach, a common strategy in energy sector research and policy analysis [10]. Data were obtained through a literature review of secondary sources, including official statistics from the Ministry of Energy and Mineral Resources (MEMR), annual and periodic reports on Indonesia's palm oil industry, peer-reviewed journals, and regulatory documents from recognized institutions. Sources were selected for their credibility, relevance, and recency, with a focus on publications from 2023 to 2024. Data processing and analysis were conducted using Microsoft Excel to identify trends in B35 biodiesel adoption and to estimate its percentage contribution to Indonesia's renewable energy (RE) targets.

In renewable energy research, energy conversion calculations use the standard formulas below [11]:

$$\text{Energy (GJ)} = \text{Capacity (MW)} \times \text{Capacity factor} \times 8760 \text{ hour/year} \times 3,6 \quad (1)$$

$$\text{B35 Contribution} = \frac{\text{Energy B35}}{\text{Total Renewable Energy}} \times 100\% \quad (2)$$

Following the calculation of B35's percentage contribution, a simple regression analysis was applied to evaluate the relationship between one dependent and one independent variable [12]. Regression methods are commonly employed in renewable energy and biodiesel studies due to their effectiveness in identifying causal or correlative patterns [13]. In this study, the analysis was used to examine the relationship between B35 biodiesel production and the overall renewable energy output.

The regression model was developed using the following equation:

$$Y = a + bX \quad (3)$$

Where :

Y= Use of biodiesel

a= Intercept

b= Regression Coefficient

X= Prediction Variable (biodiesel production)

The regression coefficient is calculated using the least squares method [14]:

$$b = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sum(X_i - \bar{X})^2} \quad (4)$$

$$a = \bar{Y} - b\bar{X} \quad (5)$$

An in-depth analysis was undertaken to identify the success factors and challenges of biodiesel implementation, using a research design that combined systematic review and comparative analytical tools. The process began with the examination of secondary sources published between 2023 and 2024, selected based on credibility, relevance, and timeliness. This analysis highlighted both the critical drivers of success and the major obstacles to biodiesel adoption in Indonesia.

The focus on 2023 and 2024 was strategic, as 2023 marked the official launch of the B35 biodiesel mandate, providing the first full year of implementation data. Limiting the scope to these two years allowed for a more precise evaluation aligned with research objectives and the timeline of policy actions.

To strengthen the analysis, a structured comparative framework was developed using tabular comparisons between B35 and the projected B40 program. This method provided clear visual representations, enabling stakeholders to evaluate trade-offs between benefits and challenges at different biodiesel stages. The final step involved synthesizing evidence-based conclusions and formulating policy recommendations [15]. The sequential stages of the research are illustrated in Figure 1.

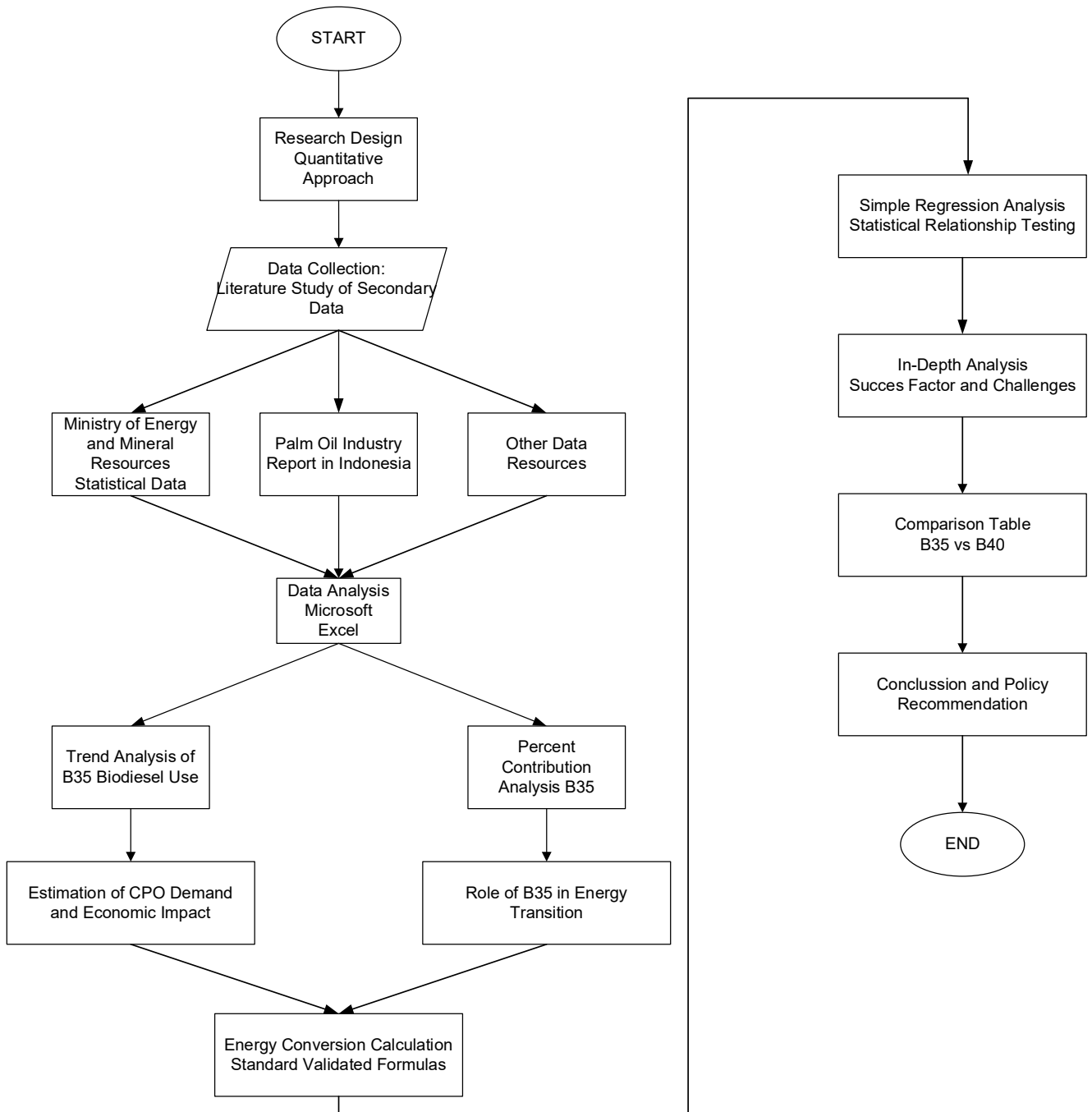


Figure 1. Research Flowchart

RESULT AND DISCUSSION

The Indonesian government has established a biodiesel production target of 15.62 million kiloliters (kL) by 2025. At present, only 81% of the national production capacity equivalent to 19 million kL is being utilized, leaving approximately 19% as surplus capacity for potential future use. This underutilization is primarily attributed to the need for technical adjustments and fine-tuning of biodiesel plants before achieving full operational efficiency [16].

Figure 2 illustrates the distribution of companies contributing to Indonesia’s biodiesel production capacity, highlighting the structural composition of the industry and its potential to expand output in line with national energy targets.

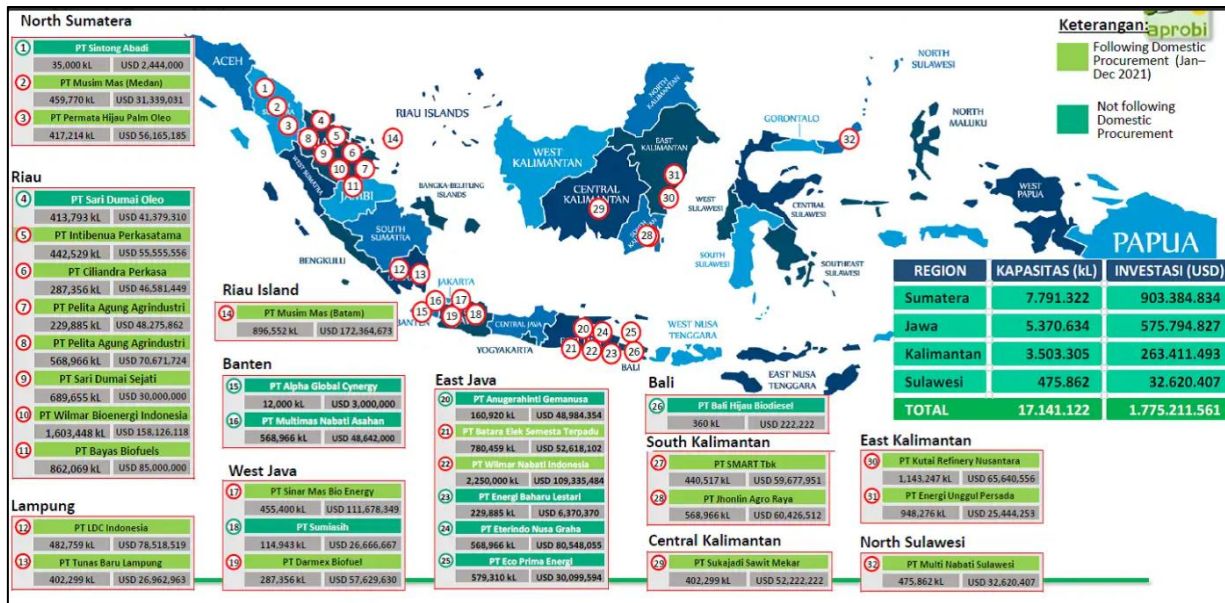


Figure 2. The Distribution of Biodiesel Companies

Figure 2 indicates that crude palm oil (CPO) production in Indonesia is concentrated on three main islands: Java, Sumatra, and Kalimantan. Among these, Sumatra is the largest contributor, with a production capacity of 7.8 million kL. By 2021, most mills in Sumatra had already complied with the domestic procurement policy designed to secure palm oil supply for the local market, while non-compliance was more prevalent among mills in Java. Such non-compliance poses risks of feedstock shortages for biodiesel production.

Furthermore, Figures 3 and 4 present the trends in biodiesel production and consumption from 2009 to 2024, offering insights into the industry’s growth trajectory and the evolving dynamics of domestic utilization.

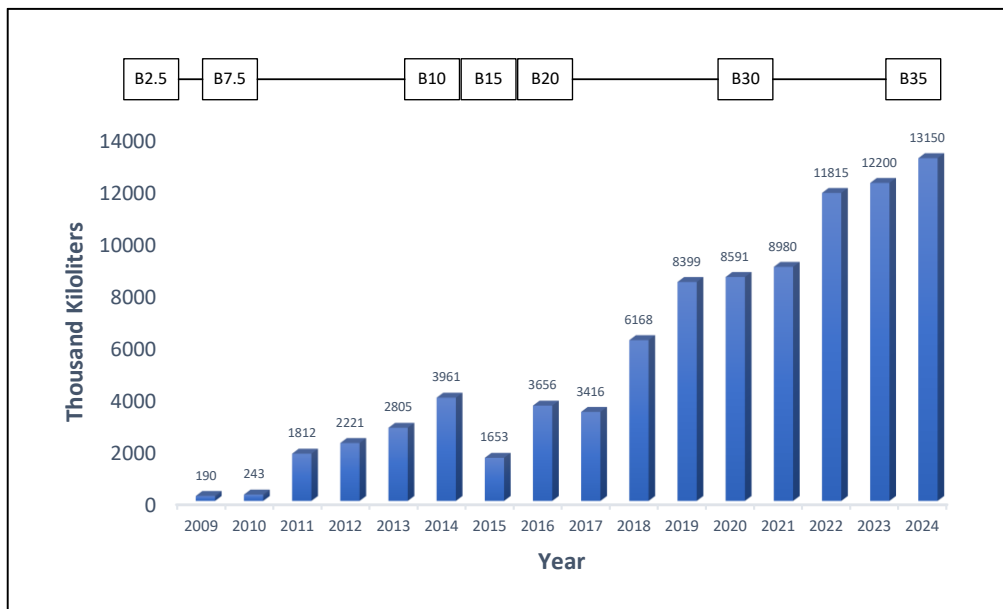


Figure 3. Biodiesel Production in Indonesia

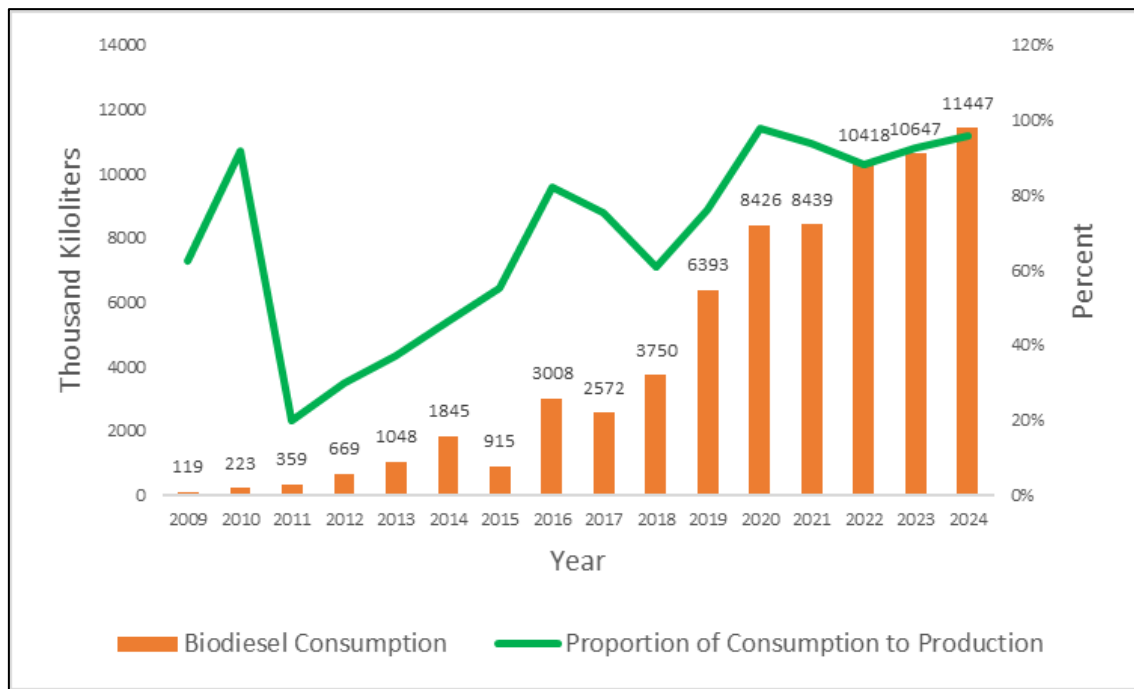


Figure 4. The Trend of Biodiesel Consumption in Indonesia

Figures 3 and 4 demonstrate a consistent annual increase in Indonesia's biodiesel production and consumption, reflecting the government's ongoing commitment to promoting clean and renewable energy development.

B35 Contribution to the Renewable Energy Target

In 2023, the government implemented the mandatory B35 program, requiring fossil fuels to be blended with 35% biodiesel. According to the Minister of Energy and Mineral Resources, domestic biodiesel consumption in 2023 reached 12.2 million kL, exceeding the target of 10.65 million kL. By 2024, production further increased to 13.15 million kL, demonstrating the program's continued expansion.

The contribution of biodiesel to the national renewable energy target was determined by converting production volumes into energy units and comparing them with Indonesia's total renewable energy supply for the corresponding year. Using a conversion factor of 10,300 MJ per kiloliter of B35 biodiesel, the calculated results are as follows:

Year 2023

In 2023, the Ministry of Energy and Mineral Resources (MEMR) reported that Indonesia's total renewable energy capacity reached 13,150 MW [17]. The energy content of B35 biodiesel was calculated as 12.2 million kL \times 10,300 MJ/kL, resulting in 125.87×10^6 GJ. Assuming a capacity factor of 80% for renewable power plants, the equivalent renewable energy output was estimated using the formula: $13,150 \text{ MW} \times 0.8 \times 8,760 \text{ hours} \times 3.6 \text{ GJ/MWh}$, yielding 331.76×10^6 GJ.

Therefore, contribution of B35 biodiesel to renewable energy can be calculated as follows:

$$\text{Contribution of B35 biodiesel to renewable energy} = \frac{125,87 \times 10^6 \text{ GJ}}{331,76 \times 10^6 \text{ GJ}} \times 100\% = 38\%$$

The calculations indicate that B35 biodiesel accounted for 38% of Indonesia's total renewable energy mix in 2023. Furthermore, the Ministry of Energy and Mineral Resources reported that the program generated foreign exchange savings of approximately USD 7.9 billion (IDR 120.54 trillion) [18].

Year 2024

In 2024, the Ministry of Energy and Mineral Resources (MEMR) reported that Indonesia's total renewable energy capacity reached 13,886 MW [19]. The energy potential of B35 biodiesel was estimated at 13.15 million kL \times 10,300 MJ/kL, equivalent to 135.68×10^6 GJ. Assuming an 80% capacity factor for renewable power plants, the conversion yields a total renewable energy output of $13,886 \text{ MW} \times 0.8 \times 8,760 \text{ hours} \times 3.6 \text{ GJ/MWh}$, or 350.33×10^6 GJ.

Therefore, contribution of B35 biodiesel to renewable energy can be calculated as follows:

$$\text{Contribution of B35 biodiesel to renewable energy} = \frac{135,68 \times 10^6 \text{ GJ}}{350,33 \times 10^6 \text{ GJ}} \times 100\% = 38,73 \%$$

The results show that in 2024, B35 biodiesel contributed 38.73% to Indonesia's total renewable energy mix. The Ministry of Energy and Mineral Resources further projected that its adoption would generate foreign exchange savings of approximately IDR 123 trillion [20].

Projected Biodiesel Contribution to Renewable Energy Target of 2025

Table 1 presented the calculated contributions of B35 biodiesel in 2023 and 2024 which is then utilized to project the biodiesel contribution for 2025.

Table 1. B35 Contribution Calculation Results

Year	Biodiesel Production (X)	Contribution to RE (Y)
2023	12,2	38%
2024	13,15	38,73%

Calculate b :

$$b = \frac{(12,2-12,675)(38-38,365)+(13,15-12,675)(38,73-38,365)}{(12,2-12,675)^2+(13,15-12,675)^2}$$

$$b = \frac{0,173+0,173}{0,451}$$

$$b = 0,77$$

Calculate a :

$$a = \bar{Y} - b\bar{X} = 38,375 - (0,77 \times 12,675) \approx 28,62$$

Regression Equation

$$Y = 28,62 + 0,77X$$

$$Y = 28,62 + (0,77 \times 15,62)$$

$$Y \approx 40,65\%$$

Critical success factors

Wijaya et al. [21] emphasized that Indonesia's biodiesel policy success is driven by increased production capacity, feedstock supply incentives, enhanced plant productivity, and subsidies to maintain affordability. Achieving mandatory biodiesel targets requires an integrated strategy, as measures such as CPO disincentives and tax exemptions alone are insufficient to ensure energy security. Similarly, Souza et al. [22] found that in South American countries, early regulatory frameworks, a strong domestic soybean industry, and effective responses to international competition were critical in establishing biodiesel as a sustainable

transport fuel. These outcomes also reflect the influence of political and market dynamics across nations.

In the Indonesian context, Wirawan et al. [23] identified B35 success factors to include a robust supply chain, consistent demand, supportive regulations, economic viability, and environmental benefits. Economic feasibility depends largely on biodiesel market index pricing, while the implementation of a carbon tax could further strengthen biodiesel's competitiveness against conventional diesel.

Moreover, Suhara et al. [24] highlighted that resolving challenges related to feedstock availability, price stability, and consistent policy support is essential to accelerating biodiesel adoption. Given the volatility of petroleum prices, these factors are critical to ensuring the sustainability and effectiveness of biodiesel as a reliable biofuel alternative.

Indonesia's biodiesel success is determined by the interaction of regulatory frameworks, economic feasibility, and the stability of the CPO supply chain. A resilient supply chain, supported by clear regulations and efficient production, is vital for effective policy implementation. Without this synergy, the long-term sustainability of the biodiesel program remains uncertain.

Challenges in Implementing B35 Adoption Policy

Indonesia's B35 biodiesel mandate encounters a range of obstacles. From an economic perspective, the policy risks generating higher financial losses from declining CPO exports compared to the savings from reduced fuel imports. In addition, its viability depends heavily on government subsidies, while scaling up production would require significant land expansion, estimated at 48–76% beyond the current oil palm plantation area. On the technical side, challenges include insufficient CPO supply to meet demand, potential competition with food crops, and the absence of a structured financing mechanism to ensure long-term program sustainability [6][25].

According to Fathurrahman et al. [26], gaps between emission standards and the regulatory framework, coupled with biodiesel quality issues and limitations in vehicle technology, threaten the sustainability of the mandate. High production costs further constrain implementation, while market limitations given PT Pertamina (Persero) as the primary off-taker and low blending rates exacerbate the difficulties [27].

Overall, Indonesia's biodiesel policy is hindered by interconnected challenges spanning economic constraints (export losses, subsidy reliance, high costs), infrastructure and capacity limitations (restricted CPO output, inadequate blending capacity, large land requirements), market barriers (limited access and weak financing), technical issues (fuel quality and technology compatibility), and regulatory inconsistencies. Addressing these multidimensional obstacles requires a holistic approach that integrates economic, technical, and policy measures to ensure the long-term sustainability of the B35 program and its contribution to renewable energy targets.

Comparison of B35 and projected B40 biodiesel

Indonesia has gradually expanded its biodiesel blending mandate, moving from B35 to the planned adoption of B40 as the new mandatory standard, as outlined in Table 2. This transition has reshaped biodiesel allocation patterns, increased government subsidy needs, and reduced CPO exports, while simultaneously strengthening import substitution and promoting greater domestic CPO utilization.

Table 2. Comparison of Biodiesel B35 and B40 Projection in Indonesia

Aspect / Parameter	B35	B40
Implementation Period	Aug 2023-2024	Jan 2025 - now
Current Status	Replaced by B40	Current mandatory standard
Biodiesel Allocation (Million)	12.98 (2024)	15.6 (2025)
Export Revenue Impact	-8% CPO exports	-12% CPO exports
Government Subsidy Requirement	High	Very High
Import Substitution Value (USD Billion)	4.2-4.8	5.0-5.8
Domestic CPO Absorption	45% increase	65% increase
Investment Requirement (USD Billion)	3.2	4.1
CO Emissions	-10% vs diesel	-11% vs diesel
Plantation Area Expansion	+25% expansion	+48-76% expansion
Deforestation Risk	Moderate	High
Domestic Market Share	40% of total CPO	55% of total CPO
Industry Readiness	Mostly ready	Adaptation required
Projection timeline by 2025	Transitioned	Full implementation
Projection timeline by 2026	Comparative baseline	Performance optimization

The shift to B40 introduces several challenges, such as heightened risks of deforestation from expanded plantation requirements and substantial adjustments within the industry. Nonetheless, higher biodiesel blending ratios are projected to yield sharper reductions in CO₂ emissions. The government targets full B40 implementation by 2025, with optimization planned for 2026, reaffirming its commitment to advancing clean and renewable energy despite these constraints.

CONCLUSION AND RECOMMENDATION

Conclusion

This study demonstrates that Biodiesel B35 significantly contributes to Indonesia's renewable energy mix, reaching 38% in 2023 and 38.73% in 2024, while generating foreign exchange savings of IDR 128 trillion and IDR 123 trillion, respectively. Its adoption reduces fossil fuel imports, absorbs 30–50% of domestic CPO production, creates employment opportunities, and lowers CO₂ emissions by 8–11%, aligning with Indonesia's Paris Agreement commitments. Looking ahead, B40 has the potential to increase the renewable share to 40.65% and domestic CPO absorption to 65%, though its implementation requires stable feedstock supply and an additional USD 4.1 billion in infrastructure investment, underscoring the need for sustained policy and financial support.

Recommendation

To strengthen the role of Biodiesel B40 in achieving Indonesia's renewable energy targets, stakeholders should prioritize a consistent and comprehensive policy framework to ensure economic stability, create a competitive market space, and maintain price stability. Expanding feedstock availability requires diversification beyond CPO, including sources such as used cooking oil and jatropha. The introduction of a national carbon tax could enhance biodiesel's competitiveness relative to fossil fuels. In addition, stronger inter-ministerial collaboration particularly among the Ministry of Energy and Mineral Resources, the Ministry of Agriculture, and the Ministry of Environment and Forestry is essential for effective policy implementation.

Limitation

This study has several limitations. First, it does not employ system dynamics modeling to generate long-term projections. Second, sensitivity analysis of the B40 scenario was not conducted. Future research should incorporate multivariate regression analysis and dynamic modeling approaches to improve analytical robustness and provide deeper insights into biodiesel policy impacts.

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