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Strategic Decision-Making In The Biodiesel Supply Management Using Analytic Hierarchy Process At An Indonesian Fuel Distribution Company

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Abstract

Indonesia's biodiesel blending mandate requires a national fuel distribution company to maintain supply continuity across a geographically dispersed, maritime-dependent distribution network while complying with fixed delivery-point and volume-allocation rules established by the government. Rigid allocation regulations frequently cause localized stockouts that interrupt blending operations and expose the company to compliance penalties. This study develops a strategic decision-support model to prioritize biodiesel supply-management alternatives under these operational and regulatory constraints. A quantitative Analytic Hierarchy Process (AHP) was applied to pairwise-comparison judgments collected from 15 internal and external expert stakeholders, comprising senior management, supply schedulers, fuel terminal managers, biodiesel producers, and government representatives. Individual judgments were aggregated using the weighted geometric mean and evaluated through consistency ratios, all of which were below the 0.10 threshold. Supply Disruption Resilience emerged as the dominant decision criterion (0.5322), followed by Infrastructure Readiness (0.3195) and Regulation and Mandate Compliance (0.1483). The highest-ranked alternative was the Integrated Buffer Stock and Inventory Resilience Package (0.4828), ahead of the Supply and Logistics Resilience Package (0.3393) and the Regulatory Governance and Coordination Package (0.1780). The findings indicate that proactive inventory visibility, early-warning signals, buffer-stock policy, and replenishment scheduling should form the core of the company's biodiesel supply strategy, supported by logistics contingency arrangements and formal regulatory coordination. The study provides a transparent and auditable prioritization framework for sustaining blending compliance while reducing stockout risk under the B40–B50 transition.

INTRODUCTION

Biodiesel blending has become a central instrument of Indonesia's renewable-energy transition and national energy security agenda. Indonesia is currently the leading biodiesel-blending country in the world, with blended biofuel usage reaching approximately 22 million kiloliters in 2025. Through the B40 program, the government mandates the incorporation of 40% biodiesel into diesel fuel, and the mandate is on track to increase to B50 in 2026. The policy is intended to reduce dependence on imported fossil fuels, contain production costs, and expand the role of renewable energy in the national energy mix. As the blending obligation escalates, however, the volume of biodiesel that must be produced, transported, stored, verified, and blended increases substantially, placing growing pressure on the supply system that underpins the mandate.

The oil and gas supply chain (OGSC) comprises a range of interdependent activities, including production, inventory, transportation, processing, and distribution of oil and natural gas (Attia, 2025). Within this chain, distribution plays a decisive role because it ensures that products reach their intended destinations without interruption. Distribution is simultaneously exposed to numerous operational risks, including supply disruptions, transportation failures, and infrastructure constraints, which the industry must continuously mitigate to protect product availability and business continuity (Okeke, 2024). Rising production costs and record-high fossil fuel consumption further intensify the need for efficient and resilient distribution arrangements in downstream energy operations.

The national fuel distribution company is a subsidiary of Indonesia's state-owned energy company and has been designated as the Commercial and Trading Sub-Holding since 2021. It serves as the primary executor of government-assigned fuel supply mandates, including the biodiesel blending program. The Company handles more than 76% of national biodiesel supply volumes and operates a maritime-dependent supply chain that includes mother vessels, barges, fuel terminals, and last-mile depots across Indonesia's archipelagic geography. As a nationwide energy distributor, the Company is entrusted with ensuring the availability, accessibility, and affordability of fuel products in all regions. This role is particularly demanding in Eastern Indonesia, where longer lead times, higher unit logistics costs, weather-dependent shipping windows, and limited port infrastructure complicate the objective of maintaining equitable service levels.

The principal operational challenge arises from the rigidity of the regulatory allocation framework. Under the Ministry of Energy and Mineral Resources (ESDM) decrees governing the mandate, each biodiesel supplier is assigned a fixed delivery point and an allocated volume that cannot be altered under particular circumstances. Once the allocated volume for an area is fully utilized, suppliers are no longer permitted to ship additional biodiesel, even when a terminal approaches stockout while other locations retain unused allocation. When biodiesel stock is depleted, pure diesel cannot be blended into biodiesel-blended fuel, forcing the distribution of non-blended product. Such incidents create service, operational, and compliance risks, including fines for non-compliance with the blending mandate, and constitute a significant operational and regulatory burden for the company.

Beyond the regulatory constraint, the core managerial problem is the absence of a scalable, multi-criteria decision framework, anchored in the B40 timeline and extensible to B50, that the national fuel distribution company can use to prioritize supply-management strategies while balancing service levels, regional equity, cost containment, and subsidy integrity. Current practice relies on disjointed, experience-based decisions taken across strategic, tactical, and operational horizons without an integrated formal structure that systematically weighs competing objectives. Although standard operating procedures exist, they do not explicitly prioritize resilience, infrastructure, and mandate compliance in supply decisions, leaving the organization exposed to recurring stockout events as mandated volumes rise.

The supply chain management literature underlines the strategic significance of this problem. Supply chain management is defined as the coordinated management of sourcing, production, logistics, and the flow of information and capital across organizational boundaries to enhance efficiency, competitiveness, and sustainability (Wang et al., 2025), and as the set of activities undertaken by an organization to promote effective management of its supply chain (Okeke, 2024). Contemporary perspectives position supply chain management as an integrated system aligning production, inventory, and supply decisions within multimodal transportation networks to ensure resilience and environmental responsibility (Tabatabaei, 2025). Supply chain risk management extends this view by identifying, evaluating, managing, and controlling risks originating from processes, control, demand, supply, and the environment as a source of competitive advantage (Mottaghi et al., 2022; Rodionov et al., 2023). Risks arising in supply chain activities, including scheduling, technology, and uncertain costs, can be managed separately based on risk perception (Richert & Dudek, 2023; Subbiah et al., 2025).

These risks are particularly acute in the oil and gas industry, whose scale, technical sophistication, geographic dispersion, and global interconnectedness render its supply chain vulnerable to disruption across upstream, midstream, and downstream layers (Okeke, 2024; Piya et al., 2025). Exploration and extraction take place in remote and hostile settings where accidents can escalate rapidly (Bhattacharyya, 2012; Wahono et al., 2025), while equipment degradation presents persistent threats to asset integrity (Wahono et al., 2025). Complexity drivers, including globalization, supplier proliferation, volatile demand, fluctuating commodity prices, and regulatory and geopolitical pressures, further compound exposure (Piya et al., 2022, 2025; Wu & Tham, 2023). A disruption in one part of the chain can propagate far beyond its point of origin, making structured risk-informed decision-making essential to reliable and affordable energy supply.

Multi-criteria decision-making (MCDM) provides a suitable analytical response when decision makers must evaluate multiple, usually conflicting, objectives simultaneously (Mottaghi et al., 2022). MCDM techniques manage both quantitative and qualitative criteria while analyzing conflicts among criteria and decision makers (Abu Taha & Daim, 2013), enabling more informed and rational decisions (Nadeem & Singh, 2025). Among MCDM methods, the Analytic Hierarchy Process (AHP) structures complex problems into a hierarchy and derives ratio-scale priorities from pairwise comparisons (Saaty, 1987). AHP accommodates both subjective and objective factors, supports active stakeholder participation, and provides consistency calculations that verify the logical coherence of judgments (Shehab et al., 2024; Taherdoost & Madanchian, 2023). The method has been applied in contexts ranging from quality control systems (Badri, 2001) and renewable energy analysis (Abu Taha & Daim, 2013) to digital heritage (Nofal et al., 2025), and recent applications demonstrate its relevance for evaluating supply chain management in oil and gas enterprises (Wang et al., 2025).

Despite the breadth of AHP applications, its use in prioritizing biodiesel supply strategies within a developing-country, archipelagic, and mandate-driven logistics context remains limited. This study addresses that gap by developing an AHP-based decision-support model for biodiesel supply management at the national fuel distribution company. Three research questions guide the analysis: (1) what are the primary criteria influencing strategic decision-making in biodiesel supply management; (2) what are the most viable options for managing biodiesel supply under current regulatory and operational constraints; and (3) How can AHP be used to prioritize alternatives and guide the national fuel distribution company biodiesel supply strategy? Correspondingly, the study aims to identify the decision criteria, to identify strategic alternatives feasible under current regulations, and to develop a prioritized decision-support model for biodiesel supply management. The scope is confined to biodiesel supply within the national fuel distribution company capabilities and regulatory framework; external biodiesel producers are engaged as expert respondents rather than as objects of the study.

METHODS

This study used a quantitative approach with a decision-modeling design based on the Analytic Hierarchy Process. The design was selected because the research problem requires the simultaneous evaluation of competing operational, infrastructural, and regulatory considerations in order to rank strategic alternatives, a situation for which AHP is well suited (Saaty, 1987; Taherdoost & Madanchian, 2023). The research proceeded through eight stages: identification of the business issue, problem identification, literature review, questionnaire modeling and validation, data collection, AHP computation, result analysis and interpretation, and formulation of conclusions and recommendations. The business issue stage framed the strategic context of biodiesel supply at the national fuel distribution company and identified key stakeholders; problem identification mapped the as-is supply flow, bottlenecks, and constraints, and articulated the decision problem in a form suitable for multi-criteria analysis.

The AHP model was developed through expert consultation and stakeholder validation. Experts involved in biodiesel supply chain management at the national fuel distribution company were consulted to identify the most relevant factors influencing supply decisions. Through this process, three main decision criteria were identified: Infrastructure Readiness, Supply Disruption Resilience, and Regulation and Mandate Compliance. Each criterion was decomposed into three sub-criteria representing specific operational considerations, and three strategic alternatives were formulated at the lowest level of the hierarchy, producing a four-level structure of goal, criteria, sub-criteria, and alternatives. Before use, the proposed model was validated by stakeholders using the Content Validity Ratio (CVR) method to ensure that all criteria, sub-criteria, and alternatives were relevant and representative of the decision context.

Primary data were collected through a structured pairwise-comparison questionnaire administered to 15 expert stakeholders directly engaged in the biodiesel supply process: three senior managers, three members of the biofuel supply scheduling team, and three fuel terminal managers as internal respondents, and three biodiesel producer representatives and three government representatives from the Directorate General of New, Renewable Energy and Energy Conservation (EBTKE) and the Oil Palm Plantation Fund Management Agency (BPDP) as external respondents. Respondents were selected purposively based on their operational responsibilities, decision-making authority, and practical experience in biodiesel supply management, with most respondents possessing more than 15 years of professional experience.

The questionnaire was distributed as a spreadsheet in which respondents compared decision elements in pairs using Saaty's fundamental scale from 1 (equally preferred) to 9 (extreme importance), with the values 2, 4, 6, and 8 serving as intermediate judgments. The instrument comprised three comparisons among the main criteria, nine comparisons among sub-criteria within their respective criteria, and three comparisons among alternatives repeated for each of the nine sub-criteria, in accordance with the AHP formula $n(n-1)/2$, yielding 27 pairwise evaluations at the alternative level and 39 evaluations in total per respondent.

All responses were processed using the AHP calculation template developed by Goepel (2018), which computes priority weights as the components of the normalized eigenvector associated with the largest eigenvalue of each comparison matrix. Because the study involves multiple respondents, individual judgments were aggregated using the weighted geometric mean method to obtain a single representative comparison value for each matrix. Composite (global) weights were derived by multiplying local weights along each path of the hierarchy. Judgment quality was evaluated using the Consistency Index (CI) and the Consistency Ratio (CR), with CR ≤ 0.10 adopted as the acceptance threshold; matrices exceeding the threshold would have been returned to respondents for revision, although in practice none required it.

RESULTS AND DISCUSSION

Result

The respondents represent the complete set of stakeholder functions in the national fuel distribution company biodiesel supply system. Senior management oversees the strategic direction of the biodiesel supply chain and aligns operational decisions with national renewable-energy policy; the biofuel supply scheduling team plans and coordinates biodiesel flows from producers to fuel terminals; and fuel terminal managers are responsible for receiving, inventory, and blending operations at delivery points. Externally, biodiesel producers contribute the upstream perspective on production capacity, quality assurance, and delivery logistics, while EBTKE and BPDP representatives capture the regulatory and financing dimensions of the mandate program. Table 1 summarizes the respondent profile.

Table 1. Respondent Profile

Respondent	Stakeholder Type	Department	Position	Years of Exp.
1	Internal	Management	Fuel Supply Operation Manager	16–20
2	Internal	Management	Non-Fuel Supply Operation Manager	>20
3	Internal	Management	Manager Sustainable Infrastructure Planning	16–20
4	Internal	Scheduling Team	Fuel Supply Planning Operation Ast. Manager	16–20
5	Internal	Scheduling Team	Biofuel Supply Planning Operation Ast. Manager	16–20
6	Internal	Scheduling Team	Biofuel Supply Planning Operation Officer	6–10
7	Internal	Terminal Manager	Integrated Terminal Wayame Manager	16–20
8	Internal	Terminal Manager	Integrated Terminal Jakarta Manager	16–20
9	Internal	Terminal Manager	Integrated Terminal Surabaya Manager	16–20
10	External	Biodiesel Producer	Commercial Biofuel Manager	6–10
11	External	Biodiesel Producer	Marketing Manager	6–10
12	External	Biodiesel Producer	Operations Manager	1–5
13	External	Government – EBTKE	Assistant Coordinator for Bioenergy Oversight	16–20
14	External	Government – EBTKE	Junior Policy Analyst	6–10
15	External	Government – BPDP	Senior Advisor	6–10

The decision hierarchy links the overall goal of optimizing biodiesel supply to three criteria, nine sub-criteria, and three strategic alternatives. Infrastructure Readiness concerns the ability to provide and maintain adequate production, storage, and transportation infrastructure;

Supply Disruption Resilience concerns the ability to prevent or recover from disruptions across transport, terminals, and upstream supply; and Regulation and Mandate Compliance concerns the ability to comply with allocation rules and blending mandates under auditable controls. The three alternatives represent distinct strategic postures: an inventory-centered resilience strategy, a logistics-centered resilience strategy, and a governance-centered coordination strategy. Table 2 presents the elements of the hierarchy and their definitions.

Table 2. AHP Decision Hierarchy: Goal, Criteria, Sub-Criteria, and Alternatives

Element	Definition
Goal – Optimizing Biodiesel Supply	Select the best strategy for managing biodiesel supply to maintain blending compliance while handling supply disruption and infrastructure readiness.
C1 – Infrastructure Readiness	Ability to provide and maintain adequate production, storage, and transportation infrastructure to support reliable and efficient biodiesel supply.
C2 – Supply Disruption Resilience	Ability to prevent or recover from disruptions across transport, terminals, and upstream supply.
C3 – Regulation & Mandate Compliance	Ability to comply with allocation rules and blending mandates with auditable controls.
SC1.1 – Production Infrastructure Readiness	Preparedness and adequacy of biodiesel production facilities to consistently meet supply requirements through sufficient capacity, reliability, and responsiveness.
SC1.2 – Transportation Mode Readiness	Preparedness and adequacy of transportation resources, including vehicles, vessels, and logistics networks, to support timely and reliable biodiesel supply.
SC1.3 – Receiving Infrastructure Readiness	Preparedness and adequacy of receiving facilities, including storage tanks and unloading systems, to receive, handle, and store biodiesel.
SC2.1 – Supply Reliability	Inbound supply arrives as scheduled.
SC2.2 – Transport Disruption Tolerance	Resilience to delays and constraints in logistics.
SC2.3 – Contingency Preparedness & Time-to-Recover	Speed and effectiveness of recovery actions.
SC3.1 – Compliance with Fixed Delivery Point & Allocated Volume Rules	Meet decree constraints; avoid allocation breaches.
SC3.2 – Blending Mandate Compliance Continuity	Avoid non-blended supply incidents.
SC3.3 – Reporting & Auditability	Demonstrate compliance with reliable records.
A1 – Integrated Buffer Stock & Inventory Resilience Package	Forecasting, early-warning signals, inventory policy, and proactive replenishment scheduling.
A2 – Supply & Logistics Resilience Package	Routing and scheduling resilience, backup logistics options, and disruption response planning.
A3 – Regulatory Governance & Coordination Package	Formal exception and contingency coordination workflow with stakeholders and documented approvals.

All fifteen respondents produced logically consistent judgments, with every comparison matrix yielding a consistency ratio below the 0.10 threshold, and the individual results showed a high degree of convergence across stakeholder groups. The aggregated results at the criteria level are presented in Table 3. Supply Disruption Resilience is the dominant criterion for determining the optimal biodiesel supply strategy, with a weight of 0.5322, representing more than half of the total decision priority. Compared with Infrastructure Readiness (0.3195), Supply Disruption Resilience is approximately 1.67 times more important, and compared with Regulation and Mandate Compliance (0.1483) it is approximately 3.59 times more important. The consistency ratio of the criteria matrix is 0.0026, indicating highly consistent expert judgment.

Table 3. Aggregated Priority Weights of the Main Criteria

Criterion	Weight	Share (%)	Rank
Supply Disruption Resilience	0.5322	53.22	1
Infrastructure Readiness	0.3195	31.95	2
Regulation & Mandate Compliance	0.1483	14.83	3

Note: λmax = 3.0030; CI = 0.0015; CR = 0.0026 (RI = 0.58); judgments consistent.

Table 4 presents the local and global weights of the nine sub-criteria. Within Infrastructure Readiness, Production Infrastructure Readiness carries the highest local weight (0.4857), followed by Receiving Infrastructure Readiness (0.2870) and Transportation Mode Readiness (0.2273); production capacity is thus approximately 1.69 times more important than receiving infrastructure and 2.14 times more important than transport capacity within this criterion. Within Supply Disruption Resilience, Supply Reliability dominates with a local weight of 0.5137, followed by Transport Disruption Tolerance (0.3098) and Contingency Preparedness and Time-to-Recover (0.1765). Within Regulation and Mandate Compliance, Compliance with Fixed Delivery Point and Allocated Volume Rules (0.4835) and Blending Mandate Compliance Continuity (0.4136) are nearly balanced, differing by only 0.0699, while Reporting and Auditability receives the lowest weight (0.1029).

Table 4. Local and Global Weights of the Sub-Criteria

Criterion	Sub-Criterion	Local Weight	Global Weight	Global Rank
Infrastructure Readiness (0.3195)	Production Infrastructure Readiness	0.4857	0.1552	3
	Transportation Mode Readiness	0.2273	0.0726	6
	Receiving Infrastructure Readiness	0.2870	0.0917	5
Supply Disruption Resilience (0.5322)	Supply Reliability	0.5137	0.2734	1
	Transport Disruption Tolerance	0.3098	0.1649	2
	Contingency Preparedness & Time-to-Recover	0.1765	0.0939	4
Regulation & Mandate Compliance (0.1483)	Compliance with Fixed Delivery Point & Allocated Volume Rules	0.4835	0.0717	7
	Blending Mandate Compliance Continuity	0.4136	0.0613	8
	Reporting & Auditability	0.1029	0.0153	9

Note: CR of the sub-criteria matrices = 0.0027 (C1), 0.0003 (C2), and 0.0008 (C3); all consistent.

At the global level, Supply Reliability is the single most influential sub-criterion, contributing 0.2734, or more than one-quarter of the total decision weight. It is followed by Transport Disruption Tolerance (0.1649) and Production Infrastructure Readiness (0.1552). Together, these three sub-criteria account for approximately 59.35% of the total decision priority, indicating that the AHP result is strongly concentrated on supply reliability, transport resilience, and production readiness.

Table 5 reports the priority of the three strategic alternatives with respect to each sub-criterion. The Integrated Buffer Stock and Inventory Resilience Package shows the strongest performance across most of the hierarchy, ranking first in six of nine sub-criteria: Production Infrastructure Readiness (0.5825), Transportation Mode Readiness (0.5311), Receiving (Terminal) Infrastructure Readiness (0.6259), Supply Reliability (0.4615), Transport Disruption Tolerance (0.5680), and Contingency Preparedness and Time-to-Recover (0.5889). Its highest local performance occurs in receiving infrastructure readiness, where it captures 62.59% of the priority. The Supply and Logistics Resilience Package ranks first in Compliance with Fixed Delivery Point and Allocated Volume Rules (0.5148) and performs moderately in several operational sub-criteria, including Supply Reliability (0.4070). The Regulatory Governance and Coordination Package dominates the two remaining regulation-related sub-criteria, Blending Mandate Compliance Continuity (0.6963) and Reporting and Auditability (0.6298), but performs weakly on operational dimensions such as Contingency Preparedness (0.0973).

Table 5. Priority of Alternatives with Respect to Each Sub-Criterion

Sub-Criterion	A1 Buffer Stock	A2 Supply & Logistics	A3 Regulatory Governance
Production Infrastructure Readiness	0.5825	0.2729	0.1446
Transportation Mode Readiness	0.5311	0.3573	0.1116
Receiving Infrastructure Readiness	0.6259	0.2662	0.1079
Supply Reliability	0.4615	0.4070	0.1315
Transport Disruption Tolerance	0.5680	0.3213	0.1106
Contingency Preparedness & Time-to-Recover	0.5889	0.3138	0.0973
Allocated Volume Compliance	0.1800	0.5148	0.3052
Blending Mandate Compliance	0.1069	0.1968	0.6963
Reporting & Auditability	0.1185	0.2517	0.6298

Note: All CR values at the alternative level are below 0.10; the highest is 0.0213 (Alternatives vs. Receiving Infrastructure Readiness).

The final synthesis, obtained by weighting each alternative's sub-criterion priorities through the hierarchy, is presented in Table 6. The Integrated Buffer Stock and Inventory Resilience Package is the most preferred strategy, with a final global weight of 0.4828, accounting for approximately 48.28% of the total decision priority. The Supply and Logistics Resilience Package ranks second with 0.3393, and the Regulatory Governance and Coordination Package ranks third with 0.1780. The margin between the first and second alternatives is 0.1435, indicating that the inventory-based strategy holds a clear priority advantage in the overall decision structure.

Table 6. Final Priority Weights of the Strategic Alternatives

Alternative	Infrastructure Readiness	Supply Disruption Resilience	Regulation & Mandate Compliance	Final Weight	Rank
Integrated Buffer Stock & Inventory Resilience Package	0.1863	0.2751	0.0213	0.4828	1
Supply & Logistics Resilience Package	0.0927	0.1938	0.0528	0.3393	2
Regulatory Governance & Coordination Package	0.0404	0.0633	0.0742	0.1780	3

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DISCUSSION

This numerical pattern indicates that expert assessment places operational resilience as the main priority in strategic decision-making. Infrastructure Readiness remains a substantial supporting factor, accounting for almost one-third of the total priority, while Regulation and Mandate Compliance, although mandatory in nature, is numerically the least dominant consideration. The result suggests that experts regard regulatory compliance as a necessary baseline rather than the primary driver of strategy: the central challenge in biodiesel supply is not merely fulfilling regulatory obligations but ensuring that the supply system is operationally capable of sustaining reliability under increasing mandate requirements.

This concentration is coherent with the character of the national fuel distribution company's maritime-dependent supply chain, in which delays in vessel movement, port constraints, weather-related disruptions, and regional infrastructure disparities constitute the most immediate threats to blending continuity.

The dominance of the Integrated Buffer Stock and Inventory Resilience Package is driven principally by its contribution under Supply Disruption Resilience, which accounts for 0.2751 of its final weight, the largest single criterion-based contribution among all alternatives in the synthesis. The alternative also receives a substantial contribution from Infrastructure Readiness (0.1863), while its contribution from Regulation and Mandate Compliance is comparatively small (0.0213). This pattern indicates that the first-ranked alternative is not selected primarily for regulatory reasons but because it directly addresses the operational need to strengthen supply continuity, inventory availability, and infrastructure preparedness across the biodiesel supply network. The consistency analysis reinforces the numerical validity of this conclusion: the main criteria matrix has a CR of 0.0026, the sub-criteria matrices show CR values of 0.0027, 0.0003, and 0.0008, and the highest CR at the alternative level is 0.0213, all far below the 0.10 threshold.

The second-ranked Supply and Logistics Resilience Package likewise draws its largest contribution from Supply Disruption Resilience (0.1938), confirming that routing and scheduling resilience, backup logistics options, and disruption response mechanisms remain important components of the supply strategy. Its Infrastructure Readiness contribution (0.0927), however, is considerably lower than that of the first-ranked alternative, suggesting that logistics resilience alone may be insufficient as a stand-alone strategy without stronger inventory positioning and infrastructure support. In a maritime-dependent supply chain, disruptions may occur not only at supply sources but also during inter-island transportation, port handling, and terminal delivery, so this alternative is best viewed as a complement that enhances the effectiveness of the primary buffer-stock strategy.

The Regulatory Governance and Coordination Package derives its largest contribution from Regulation and Mandate Compliance (0.0742), reflecting its relevance for allocation monitoring, SOP enforcement, reporting, audit-trail improvement, and formal coordination among stakeholders. Its low contributions under Supply Disruption Resilience (0.0633) and Infrastructure Readiness (0.0404) explain why governance-oriented intervention does not become the dominant strategy despite its strong relevance to mandate compliance. The alternative should therefore be interpreted as an enabling mechanism that supports and controls the implementation of the operational strategies, ensuring that resilience improvements remain aligned with regulatory requirements.

Taken together, the results support a layered strategic architecture for biodiesel supply management. The Integrated Buffer Stock and Inventory Resilience Package should be positioned as the core strategy because it has the highest overall priority and directly addresses stock availability, supply reliability, and infrastructure constraints. The Supply and Logistics Resilience Package should serve as a supporting strategy that improves routing flexibility, scheduling resilience, backup logistics, and disruption-response capability. The Regulatory Governance and Coordination Package should function as an enabling strategy that safeguards allocation accuracy, blending-mandate continuity, and auditability. This layered interpretation matters because the current constraints on biodiesel supply are not only regulatory but also deeply operational, involving storage capacity, maritime logistics dependency, regional service disparity, and stockout risk under rising mandate volumes.

The findings are particularly consequential for the transition from B40 toward B50. Higher blending mandates will increase the volume of biodiesel to be distributed, stored, verified, and delivered across the national supply network, intensifying pressure on storage tanks, blending facilities, segregation systems, vessel and barge availability, and port handling capacity, with Eastern Indonesia disproportionately exposed. Under these conditions, the ability to maintain buffer stock at strategic points, improve inventory visibility, and develop storage infrastructure from upstream to downstream becomes increasingly important for reducing stockout probability and maintaining service continuity across regions. The high scores of the first-ranked alternative under both Supply Disruption Resilience and Infrastructure Readiness indicate that the strategy is well aligned with these future requirements.

The results also resonate with, and extend, the existing literature. The primacy of resilience over compliance echoes studies identifying disruption absorption as a central capability in oil and gas supply chains (Piya et al., 2022, 2025) and supports the view of supply chain risk management as a source of competitive advantage rather than a purely defensive function (Mottaghi et al., 2022). The successful application of AHP in this setting corroborates recent evidence of the method's usefulness for evaluating supply chain management in oil and gas enterprises (Wang et al., 2025) and demonstrates its transferability to a mandate-driven, archipelagic biodiesel context that previous applications in renewable energy analysis (Abu Taha & Daim, 2013) and facility-location studies (Shehab et al., 2024) have not addressed. Distinctively, the present study shows that in a regulated energy logistics environment, buffer stock and inventory resilience operate not merely as operational inventory mechanisms but as strategic resilience capabilities, while regulatory alignment functions as a boundary condition rather than the decision's driving force.

CONCLUSION

This study set out to identify the most effective strategy for optimizing biodiesel supply at a national fuel distribution company by evaluating the operational, logistical, and regulatory factors affecting the supply system through the Analytic Hierarchy Process. With respect to the first research question, the primary criterion influencing strategic decision-making in biodiesel supply management is Supply Disruption Resilience (0.5322), followed by Infrastructure Readiness (0.3195) and Regulation and Mandate Compliance (0.1483). Expert judgment thus places the greatest emphasis on the supply system's ability to maintain continuity, absorb operational disruptions, and respond to uncertainty, treating regulatory compliance as a necessary baseline rather than the principal driver of strategy. With respect to the second research question, the most viable option under current regulatory and operational constraints is the Integrated Buffer Stock and Inventory Resilience Package (0.4828), complemented by the Supply and Logistics Resilience Package (0.3393) and enabled by the Regulatory Governance and Coordination Package (0.1780). With respect to the third research question, AHP proved effective in decomposing a complex, mandate-constrained supply problem into a transparent hierarchy, translating expert judgment into consistent priorities (all CR values below 0.10), and explaining not only which alternative should be prioritized but also why and in what sequence.

Several managerial recommendations follow from these findings. The national fuel distribution company should develop an integrated buffer-stock and inventory-resilience system across the upstream-to-downstream network as its core operational priority, strengthen strategic inventory positioning at production sources, receiving terminals, blending facilities, and high-vulnerability regions, and establish optimized safety-stock policies that reflect regional demand patterns, lead-time variability, transportation risk, and infrastructure capacity. Supply reliability should be enhanced through closer coordination among suppliers, terminals, and supply planners, supported by flexible logistics arrangements including alternative routes, backup vessels, and contingency response protocols. Infrastructure readiness for B40 and B50 implementation warrants prioritized investment in storage tanks, receiving facilities, blending infrastructure, and segregation systems. Operational resilience initiatives should be integrated with regulatory governance mechanisms, including allocation monitoring, SOP enforcement, and audit-trail improvement, and complemented by regional risk-based supply planning and measurable performance indicators such as stockout rate, inventory coverage days, on-time delivery, and disruption recovery time. Finally, AHP should be employed as a recurring strategic evaluation tool and, in future analyses, combined with quantitative optimization models for network, inventory, and transportation planning.

Theoretically, the study contributes to the supply chain and energy logistics literature by demonstrating how a structured multi-criteria method can be applied to mandated biodiesel supply in a developing-country, archipelagic context, and by showing that operational resilience, rather than regulatory compliance alone, constitutes the dominant basis for strategic decision-making in regulated energy logistics. Several limitations should nonetheless be acknowledged. The analysis relies on expert judgment collected through pairwise comparisons rather than historical operational data, so the priorities reflect informed perception rather than measured performance. The study is confined to a single organization and a specific regulatory setting, constraining the direct generalizability of the numerical weights even though the method itself is transferable. In addition, AHP treats decision criteria as independent and does not capture feedback and interdependencies among demand management, supply resilience, and regulatory compliance. Future research may address these limitations by incorporating operational performance data, extending the analysis to multiple distributors or jurisdictions, and applying network-based approaches that model criteria interdependence.

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