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A Strategic Role for Aircraft Manufacturers in Indonesia's Sustainable Aviation

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Abstract

As Indonesia's aviation sector experiences rapid growth, the urgency for integrating sustainability into its development trajectory has intensified. While global initiatives, such as IATA's target of achieving net-zero emissions by 2050, provide a benchmark, their implementation in emerging markets like Indonesia involves complex challenges. This study adopts a qualitative research approach, combining strategic tools including PESTLE, SWOT, TOWS, and Multi-Criteria Decision Analysis (MCDA), to investigate how A Global Aircraft Manufacturer, a leading global aerospace company, can play a strategic role in advancing Indonesia's sustainable aviation agenda. Primary data were collected through expert interviews with company leadership and local aviation stakeholders. The analysis reveals internal strengths such as advanced fleet technology, operational expertise, and strong stakeholder networks, contrasted against external barriers including regulatory ambiguity, limited sustainable aviation fuel (SAF) infrastructure, and financial constraints among domestic carriers. Based on a structured evaluation, four strategic pathways are proposed: (1) leading SAF policy development, (2) supporting fleet modernization, (3) enhancing airline operational efficiency, and (4) initiating ecosystem-wide SAF demonstration projects. Among these, enhancing operational efficiency emerges as the most actionable and high-impact strategy in the near term, offering an optimal balance of feasibility, institutional alignment, and environmental benefits. The study contributes a grounded framework for global aerospace firms navigating sustainability in emerging markets and offers actionable guidance for public and private stakeholders aiming to accelerate Indonesia's transition toward greener aviation.

Keywords: Sustainable Aviation, Strategy Pathway, Multi-Criteria Decision Analysis, Indonesia Aviation Market

A. INTRODUCTION

As global attention toward climate change intensifies, the aviation industry faces increasing pressure to reconcile growth with environmental responsibility. Although aviation contributes approximately 1%–2% of total global CO_2 emissions, its non-CO_2 effects—such as contrail formation and nitrogen oxide emissions—amplify its total contribution to global warming to around 4% (Ritchie, 2024). Recognizing this impact, key international institutions such as the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO) have laid clear roadmaps targeting net-zero emissions by 2050. These global strategies are anchored in five interconnected pillars: expanding sustainable aviation fuel (SAF), accelerating advances in aircraft technology, enhancing operational efficiency, implementing market-based mechanisms such as CORSIA, and developing long-term innovations including electric and hydrogen propulsion systems.

The urgency of this global mandate takes on particular significance in Indonesia. As a geographically dispersed archipelagic nation undergoing rapid economic and demographic transformation, Indonesia is poised for substantial growth in air travel demand. Industry forecasts suggest that the country may need over 1,500 new aircraft by 2042 to accommodate this expansion (Hemmerdinger, 2024). While such projections present tremendous economic opportunity, they underscore the environmental costs of unmitigated aviation growth if sustainability is not embedded from the outset. Currently, Indonesia's aviation ecosystem offers a mixed landscape. On the one hand, the government has initiated policy dialogues regarding SAF blending mandates and begun setting national-level decarbonization targets. On the other hand, the sector continues to face challenges such as aging aircraft fleets, high fuel and operational costs, fragmented regulatory oversight, and an underdeveloped

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SAF infrastructure. Although Indonesia is endowed with rich sources of bio-feedstock, the implementation of SAF remains limited and inconsistent, hindering broader climate progress in aviation.

Against this backdrop, aircraft manufacturers emerge as strategic actors with untapped potential. While most sustainability literature in aviation emphasizes the roles of airlines, fuel producers, and regulators, relatively little attention has been paid to the influence of original equipment manufacturers (OEMs). However, these entities possess the technological expertise, global partnerships, and institutional leverage to facilitate transitions across the aviation ecosystem. Beyond delivering aircraft, OEMs can play a catalytic role—supporting SAF roadmaps, advising on fleet modernization, transferring decarbonization know-how, and fostering stakeholder alignment. This role becomes even more vital in emerging markets like Indonesia, where sustainability transitions are nascent and regulatory frameworks are still evolving. Here, OEMs can function as technical advisors and systems integrators—bridging gaps between policy, technology, and practice. Despite their influence, few empirical studies have explored how aircraft manufacturers can contribute meaningfully to aviation sustainability in developing economies. This gap in the literature underscores the need to reframe OEMs not merely as equipment providers but as system-level actors that help build capacity and coherence in fragmented markets.

To address this research gap, the present study investigates how a global aircraft manufacturer can strategically support Indonesia's aviation decarbonization. It seeks to (1) identify the internal and external factors influencing the manufacturer's strategic positioning; (2) formulate potential sustainability strategies grounded in expert insights; and (3) assess and prioritize these strategies through a structured Multi-Criteria Decision Analysis (MCDA) framework. This research contributes a novel perspective to the sustainable aviation literature that links global climate imperatives with local institutional realities while positioning aircraft manufacturers as essential stakeholders in the transition toward net-zero air travel.

B. LITERATURE REVIEW

The aviation industry's journey toward decarbonization has prompted widespread academic and policy attention. Central to this conversation are international frameworks developed by the International Air Transport Association (IATA) and the International Civil Aviation Organization (ICAO), which call for the aviation sector to achieve net-zero CO_2 emissions by 2050. IATA's roadmap outlines five strategic pillars to support this goal: increasing the use of sustainable aviation fuels (SAF), deploying new aircraft technologies, enhancing operational efficiency, adopting market-based mechanisms like CORSIA, and exploring long-term breakthroughs such as electric or hydrogen propulsion (IATA, 2024a; IATA, 2024b). While these frameworks offer a shared vision, the implementation realities vary significantly across national contexts, particularly in emerging economies like Indonesia. As aviation demand grows in the Global South, studies have increasingly examined these regions' structural barriers: aging fleets, fragmented policy environments, high capital costs, and uneven infrastructure development. Within Southeast Asia, prior research has explored SAF readiness and policy environments in countries like Malaysia and Thailand (Atmowidjojo et al., 2021), while (Nugroho et al., 2024) highlight the institutional gaps and technology constraints facing SAF deployment in Indonesia. These studies underscore the importance of policy coherence, stakeholder alignment, and public–private collaboration in enabling sustainable transitions.

A growing body of literature also emphasizes the role of stakeholders in shaping sustainability outcomes. As (Daioglou et al., 2023) illustrate through their global stakeholder study, decarbonization in aviation is not merely a technical challenge—it is a multi-actor process involving governments, airlines, fuel producers, and civil society. This perspective aligns with the decision-making frameworks used in this study, where stakeholder-informed criteria, such as regulatory readiness, market acceptance, and implementation speed, were used to evaluate strategic priorities. However, while the roles of governments, airports, and airlines are well represented in existing research, one actor remains underexplored: the aircraft manufacturer. Traditionally viewed as equipment and technology suppliers, manufacturers are rarely examined as active participants in sustainability transitions. However, given their capacity to influence fleet composition, collaborate on SAF roadmaps, and advise on operational performance, manufacturers can serve as key enablers of national and regional decarbonization efforts, especially in countries where institutional capabilities are still developing.

Theoretically, this study draws upon the firm's Resource-Based View (RBV) concepts, which emphasize the strategic use of internal capabilities, such as brand reputation, technology leadership, and stakeholder networks, to achieve competitive advantage. RBV has been used in sustainability contexts to explain how firms leverage non-financial assets to respond to environmental challenges. In this case, the aircraft manufacturer's operational knowledge, long-standing relationships with regulators, and technical infrastructure represent valuable resources that can be mobilized to support Indonesia's aviation transition. Finally, the study applies a Multi-Criteria Decision Analysis (MCDA) framework, a method increasingly used in sustainability planning due to its ability to integrate diverse evaluation criteria and stakeholder perspectives (Belton & Stewart, 2002). Prior energy transition and public infrastructure research has demonstrated how MCDA balances trade-offs among environmental impact, policy alignment, financial feasibility, and stakeholder acceptance—critical factors in emerging aviation markets. This study is situated at the intersection of three underexplored areas: (1) the strategic role of aircraft manufacturers in sustainability, (2) the application of stakeholder-informed decision frameworks in aviation planning, and (3) the contextual challenges of implementing decarbonization strategies in an emerging economy. By bringing these elements together, the study aims to fill an important gap in the literature and offer actionable insights for both industry and policy actors.

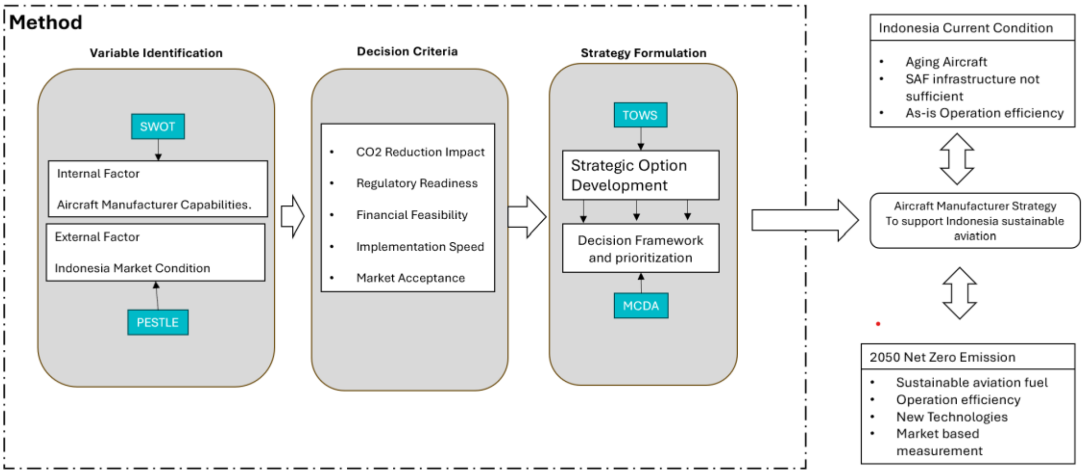

Figure 1. Conceptual Framework
Source: Research data, 2025

C. METHODS

This study used qualitative research to explore how a global aircraft manufacturer can contribute to Indonesia's sustainable aviation transition through strategic decision-making. The qualitative approach was chosen given sustainable aviation's complex, multi-stakeholder nature, which intersects with regulation, infrastructure, technology, and market behavior—factors not easily captured through quantitative analysis alone. Data was collected via two key informant interviews (KIIs) to gather rich, strategic insights. The informants were purposefully selected for their high-level expertise and relevance to the research objectives: (1) a senior representative from the global aircraft manufacturer involved in sustainability efforts in Indonesia and (2) an external expert with in-depth knowledge of Indonesia's aviation ecosystem and decarbonization landscape. Following (Patton, 2015), emphasis "information-rich" cases in purposeful sampling; the limited number of interviews reflects the goal of strategic depth rather than generalization. These individuals were uniquely positioned to offer insight into global corporate sustainability strategy and the institutional realities of the Indonesian aviation sector. Interviews were conducted in a semi-structured format, recorded with informed consent, and transcribed verbatim.

A structured instrument was developed to guide the interviews based on five pillars of the IATA Fly Net Zero Strategy—Fleet Modernization, Sustainable Aviation Fuel (SAF) Adoption, Operational Efficiency, Market-Based Measures, and Advanced Technology. Interview questions also explored organizational strengths and weaknesses, stakeholder engagement, and regulatory alignment. The full KII structure is summarized in Table 1.

Table 1. Key Informant Interview (KII) Guide

Objectives	1. Explore strategic conditions affecting aircraft manufacturer sustainability efforts in Indonesia. 2. Identify internal capabilities and ecosystem challenges shaping strategic options.
Participants	1. Aircraft Manufacturer Leadership 2. External Aviation Decarbonization Expert
Data Tool	Semi-structured interviews (2 KIIs)
Framework of Interview Questions (Manufacturer):	1. Can you describe Aircraft Manufacturer's current sustainability initiatives in Indonesia? 2. What are the aircraft manufacturer's internal strengths to support sustainability goals? 3. What internal challenges does an Aircraft Manufacturer face when supporting sustainable aviation in Indonesia? 4. How does an Aircraft Manufacturer prioritize sustainability opportunities in emerging markets like Indonesia? What criteria or decision-making logic is applied? 5. Can you elaborate on the Aircraft Manufacturer's collaboration with key stakeholders to achieve sustainable aviation? 6. What role does an Aircraft Manufacturer see itself playing in scaling up Sustainable Aviation Fuel (SAF) adoption, given that it does not produce fuel? 7. What are Aircraft manufacturers' views on the regulatory gaps in Indonesia, and how does it work with the government to influence or support policy? 8. What kind of investments or commitments is Aircraft Manufacturer making to continue innovating aircraft technology for long-term sustainability? 9. In your opinion, what key actions are necessary for Aircraft manufacturers to accelerate sustainability adoption in Indonesia's aviation ecosystem?
Framework of Interview Questions (External Expert):	1. How would you describe Indonesia's regulatory environment for sustainable aviation? 2. What are the biggest challenges Aircraft Manufacturer faces in supporting Indonesia's sustainability SAF Roadmap policies? 3. How do SAF blending mandates and emission reduction targets impact Aircraft manufacturers' operations and airlines? 4. Are there policy gaps or inconsistencies that Aircraft manufacturers must navigate in Indonesia? 5. How do Indonesian airlines view sustainability and green aviation solutions? 6. What are the biggest barriers to SAF adoption among Indonesian airlines? 7. What trends in operational efficiency or market-based measures support airline decarbonization? 8. How does Indonesia compare to other ASEAN countries in adopting sustainable aviation technologies? 9. How does an Aircraft Manufacturer collaborate with government agencies, airlines, and fuel suppliers to advance sustainability? 10. What roles do SAF producers, infrastructure providers, and policymakers play in enabling sustainable aviation? 11. What strategic opportunities exist for an Aircraft Manufacturer to expand its sustainability initiatives in Indonesia? 12. How can Aircraft manufacturers strengthen partnerships with ASEAN governments to enhance sustainability efforts?

Source: Research data, 2025

Data analysis followed a three-stage manual thematic coding approach, consistent with qualitative strategy research (Isangula, Kelly, & Wamoyi, 2024). First, transcripts were reviewed line-by-line and assigned deductive codes reflecting SWOT categories (Strengths, Weaknesses, Opportunities, and Threats). Second, these codes were grouped into broader themes, such as "regulatory ambiguity" or "operational readiness." Third, insights were synthesized into a SWOT matrix, which was then transformed into a TOWS matrix to derive four high-level strategic themes using combinations of internal and external factors (e.g., SO, WO, ST, WT). A codebook was developed to enhance transparency, capturing definitions, data sources, and representative quotes.

Table 2. Example of Thematic Codebook

Theme	Definition	Representative Quote	Source
Regulatory Ambiguity	Uncertainty around SAF blending mandates and policy targets	"There is still no official SAF blending timeline from the government."	External Expert
Operational Readiness	Airline capacity for sustainable operations	"Most airlines want to do better, but lack benchmarking tools and support."	Aircraft Manufacturer

Source: Research data, 2025

To prioritize the resulting strategies, the study applied a Multi-Criteria Decision Analysis (MCDA) framework (Belton & Stewart, 2002). This approach is widely used in sustainability studies because it balances multiple, sometimes conflicting, evaluation criteria. Each strategic theme was assessed based on five dimensions drawn from both literature and stakeholder input: (1) carbon reduction potential, (2) financial feasibility, (3) policy/regulatory alignment, (4) ease and speed of implementation, and (5) market readiness. Expert weightings and scores were incorporated into a weighted composite ranking to identify the most actionable strategy. To ensure robustness, a sensitivity analysis was performed by adjusting the dominant criterion's weight and proportionally redistributing the others using the formula:

$$w_i = \frac{w_i}{1 \pm \Delta\% \text{ applied to } w_{\text{target}}}$$

Where:
w_i is the weight of any criterion not being adjusted
w_{target} target is the criterion being tested
$\Delta\%$ is the percentage change being applied
This process tested the stability of strategy rankings under different decision scenarios and weight distributions.

The scope and limitations of the study are clearly defined. While the small sample size limits statistical generalizability, it aligns with accepted qualitative research norms in elite interviewing, where access is constrained but insight is deep. Manual coding was chosen for its transparency, and triangulation was achieved by aligning interview findings with academic literature and expert validation. Although the sample is narrow, the approach offers a rigorous and context-aware framework for examining strategic contributions in developing aviation markets like Indonesia.

D. RESULTS AND DISCUSSION

The qualitative data collected through two Key Informant Interviews (KIIs) was analyzed using a deductive thematic coding approach to uncover strategic insights into the role of a global aircraft manufacturer in Indonesia's sustainable aviation landscape. The coding structure was designed to align with the study's core objectives, capturing internal organizational conditions and the external ecosystem affecting strategy formulation. Codes were categorized into six overarching themes: internal strengths, weaknesses, external opportunities, external threats/barriers, decision-making logic, and sustainability strategy alignment. Each interview transcript was reviewed line-by-line and coded manually. Each code was defined, sourced, and linked to a representative subtheme for consistency and analytical transparency. A codebook was developed (see Table 2), allowing direct traceability from raw data to strategic output. This structure facilitated thematic depth and ensured that each coded insight contributed systematically to the final strategy synthesis in the TOWS and MCDA frameworks.

The interviews revealed strong alignment with the five sustainability pillars derived from IATA's Net Zero 2050 Strategy: fleet modernization, operational efficiency, sustainable aviation fuel (SAF), advanced technology, and market-based mechanisms. Aircraft manufacturers' internal assets—particularly fuel-efficient aircraft, operational knowledge, and global partnerships—emerged as significant enablers. However, internal limitations such as resource constraints (both financial and human) and reliance on external actors for SAF adoption and infrastructure development were also evident. Externally, Indonesia's growing market potential, feedstock availability, and emerging government commitment were highlighted as strategic opportunities. At the same time, several systemic barriers were flagged, including high SAF prices, uncertain regulatory frameworks, technological readiness gaps, and stakeholder hesitancy due to cost and policy ambiguity. These factors underscore the complexity of operationalizing sustainability in an emerging aviation market.

Table 2. Interview Codebook

Deductive Theme	Subtheme	Definition	Remarks
Aircraft Manufacturer Sustainability Strategy	Fleet Modernization	Replacing older aircraft with more efficient models to reduce emissions	(a)
	Operational Efficiency	Optimizing flight operations to conserve fuel and reduce emissions	(a)
	Renewable Energy - SAF	Promoting the adoption of Sustainable Aviation Fuel to achieve carbon reduction targets	(a)

Deductive Theme	Subtheme	Definition	Remarks
	Advanced Technology	Investing in experimental aircraft and innovation for long-term sustainability	(a)
	Market-Based	Leveraging carbon offset schemes to mitigate SAF costs or encourage adoption	(a)
Internal Strength	Sustainable Aircraft	Fleet compatibility with SAF and superior fuel efficiency	(a)
	Operational Knowledge	Expertise in airline optimization and fuel-efficient operations	(c)
	Global Industry Leader	Brand strength and innovation leadership in global markets	(b)
	Stakeholder Relationships	Collaborative networks with regulators, airlines, and academia	(c)
Internal Weakness	Resource Constraint - Financial	Budget limitations for implementing sustainability projects	(c)
	Dependence on External Stakeholders	Inability to independently drive SAF scale-up; reliance on others	(a)
	Resource Constraint - Manpower	Limited staff capacity for sustainability initiatives	(c)
External Opportunities	Indonesia Market Growth	Expansion of air travel and fleet demand in Indonesia	(a)
	Feedstock Availability	Access to local bioresources for SAF production	(a)
	Government Commitment	Signs of increasing national policy support for decarbonization	(c)
External Threats/Barriers	Renewable Energy - Price	High SAF production and distribution costs	(a)
	Regulatory Clarity Gap	Ambiguities or a lack of clear SAF and sustainability regulations	(c)
	Stakeholder Willingness	Cost-based resistance from airlines or partners	(c)
	Infrastructure Readiness	Absence of refining and logistics infrastructure for SAF	(c)
	Technological Readiness	Lack of near-term viability for hydrogen or electric aircraft	(c)
	Public Awareness	Limited societal understanding or engagement with aviation sustainability	(c)
Decision-Making Logic	Opportunity-Based Engagement	Selection of initiatives based on feasibility and alignment	(c)
	Strategic Fit Evaluation	Matching sustainability activities with corporate goals	(c)
	Collaborative Approach	Multi-stakeholder emphasis in developing and implementing strategy	(a)

Remarks: (a) Data derived from both theory and interviews; (b) Data derived from supporting literature; (c) Data derived from interviews only

Source: Research data, 2025

This thematic coding identified strengths and constraints and revealed the Aircraft Manufacturer's strategic logic: a preference for opportunity-based engagement, alignment with global goals, and collaborative implementation mechanisms. These insights laid the groundwork for the TOWS matrix and the subsequent prioritization of strategies through MCDA. This study stage bridges exploratory insight and structured strategy formulation by distilling complex, qualitative inputs into clearly defined and analytically consistent categories.

PESTLE Analysis: Mapping the External Strategic Environment

A PESTLE analysis was conducted to systematically assess the external macro-environmental conditions that shape the feasibility of sustainable aviation strategies in Indonesia. This framework allows for categorizing Political, Economic, Social, Technological, Legal, and Environmental forces, which were identified through triangulation between Key Informant Interviews (KIIs) and existing literature. Each factor was analyzed for its strategic impact on the five sustainability pillars derived from the IATA roadmap: Fleet Modernization, Sustainable Aviation Fuel (SAF), Operational Efficiency, Advanced Technology, and Market-Based Mechanisms. The results are summarized in Table 3 below.

Table 3. PESTLE Analysis of Indonesia's Sustainable Aviation Environment

Dimension	External Factor	Interview Evidence	Strategic Pillar Impact
Political	P1. The government pushes for decarbonization (2060)	"If the government mandates—like SAF in Bali—airlines must comply." – Expert	Enabler to all pillars
	P2. Limited enforcement capability	"There must be clear regulations for Pertamina to focus on SAF." – Expert	Barrier to SAF
Economic	E1. High SAF cost	"Airlines challenged economically; LCCs resist SAF." – Aircraft Manufacturer & Expert.	Barrier to SAF
	E2. Thin profit margins among airlines	"Airlines are still cost-oriented." – Expert	Barrier to SAF, Fleet, Tech; Enabler to Ops Efficiency
	E3. Aviation market growth	"Indonesia needs 1500 new aircraft." – Aircraft Manufacturer	Enabler to Fleet Modernization
Social	S1. Low public awareness	"Social awareness is very low; more engagement is needed." – Expert & Manufacturer.	Barrier to all pillars (except Ops Efficiency)
Technological	T1. SAF production/refining gaps	"Our refining capacity is still low." – Expert	Barrier to SAF
	T2. MRTBO implementation slow	MRTBO and single-engine taxi cited as fuel savers – Manufacturer	Enabler to Operational Efficiency
	T3. Hydrogen/electric propulsion not viable pre-2050	"Battery weight challenges." – Aircraft Manufacturer	Barrier to Advanced Tech
Legal	L1. Emerging SAF mandates (e.g., 5% blend)	"ESDM 2027 SAF target introduced." – Expert	Enabler to SAF
	L2. SAF regulatory clarity lacking	"Urgency to harmonize international certification." – Manufacturer	Barrier to SAF
Environmental	Ev1. Abundant feedstock availability	"Indonesia is the world's largest non-palm coconut producer." – Manufacturer.	Enabler to SAF
	Ev2. Aviation's small share of emissions, but growing scrutiny	"Only 1.8–1.9% now, but pressure is rising." – Manufacturer	Enabler to all pillars

Source: Research data, 2025

From the political perspective, interviews and literature suggest that Indonesia has initiated concrete steps toward aviation decarbonization, including net-zero commitments and pilot SAF blending mandates (e.g., Bali). This aligns with broader national policies such as Presidential Regulation No. 98/2021 and Ministerial Regulation No. 12/2015. However, limited enforcement and fragmented regulatory authority remain persistent challenges, echoing concerns raised by (Nugroho et al., 2024), who emphasize the need for multi-stakeholder coordination in SAF governance. Economic forces pose the most immediate and consistent barriers, particularly in the SAF adoption pathway. Both KIIs highlighted the high cost of SAF relative to conventional jet fuel and the narrow profit margins of Indonesian carriers, especially low-cost airlines, which reduce their financial flexibility to invest in green technology. Despite this, the long-term growth of Indonesia's aviation market (projected to require 1,500 new aircraft by 2042) presents a structural opportunity for fleet modernization, an insight supported by (Hemmerdinger, 2024). Although less frequently addressed in technical literature, the social dimension surfaced as a subtle yet significant barrier. Both interviewees emphasized low public and institutional awareness regarding sustainable aviation practices. While not a direct inhibitor of operations, this low awareness weakens societal and political demand for cleaner alternatives, delaying wider ecosystem alignment. In terms of technology, the interviews provided contrasting insights. On the one hand, operational efficiency solutions such as MRTBO (Minimum Required Track-Based Operations) and single-engine taxiing are already technically viable and show promise for quick wins in emission reduction.

On the other hand, SAF production remains nascent, and large-scale deployment faces constraints in refining capacity, issues also highlighted by (Atmowidjojo et al., 2021). Although Pertamina has announced the construction of a dedicated SAF refinery in Cilacap (Pertamina, 2024), infrastructure gaps persist. Meanwhile, advanced technologies like hydrogen or electric propulsion are not expected to be viable in Indonesia before 2050. The legal landscape shows early signs of supportive regulation, with SAF mandates under development and emerging alignment with international frameworks like CORSIA. However, ambiguity remains around certification, blending standards, and inter-agency coordination, which undermines investment confidence. This finding is consistent with (Nugroho et al., 2024), who argue that SAF success depends heavily on regulatory harmonization and policy sequencing. From an environmental perspective, the interviews reinforced that Indonesia's abundant biomass and agricultural output (e.g., used cooking oil, coconuts, palm oil) provide the feedstock potential necessary for local SAF production. This presents a clear long-term enabler—albeit one dependent on infrastructure and logistics development.

The PESTLE analysis confirms that Indonesia's pathway to sustainable aviation is multi-faceted, with SAF deployment facing the highest complexity due to overlapping economic, regulatory, and technological barriers. At the same time, Operational Efficiency emerges as a more immediate and achievable pillar, supported by technological readiness and cost alignment. Figure 2 (Sankey Diagram) illustrates this interplay of enablers and barriers, which maps the external forces to each strategic pillar. The diagram reveals that Renewable Energy (SAF) is influenced by the widest set of conflicting external factors, while Operational Efficiency benefits from strong enabling conditions with minimal resistance. Fleet modernization also emerges as a robust pathway, driven primarily by market growth and political momentum.

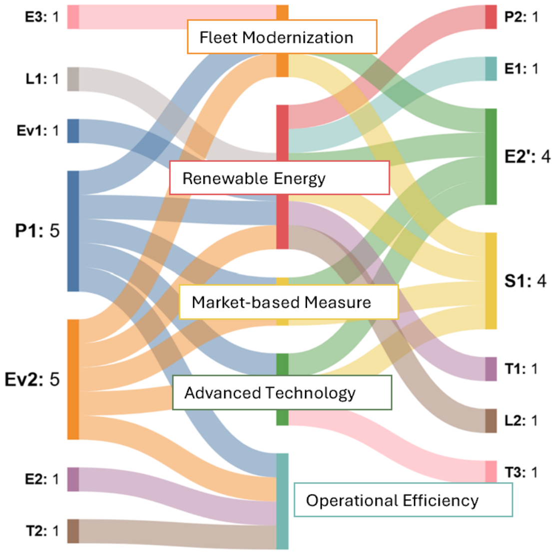

Figure 2. Sankey Diagram of PESTLE Landscape For Sustainable Aviation Strategies In Indonesia
Source: Research data, 2025

SWOT Analysis: Strategic Positioning of the Aircraft Manufacturer

A SWOT analysis was conducted to assess a global aircraft manufacturer's strategic readiness and positioning in supporting Indonesia's sustainable aviation transition. This analysis synthesizes internal strengths and weaknesses derived from qualitative interview coding (see Table 4) and external opportunities and threats mapped through the prior PESTLE analysis (see Table 5). The findings are consolidated into a comprehensive SWOT Matrix (Table 5), which provides the foundation for subsequent strategy formulation using the TOWS framework. The identification of internal strengths reveals four key themes. First, the aircraft manufacturer is positioned as a technological leader, particularly in producing fuel-efficient aircraft that are SAF-compatible and designed with sustainability in mind. Interview excerpts emphasized the company's advancements in SAF-ready aircraft and recyclable components: "We've demonstrated 100% SAF flights," and "Our aircraft are over 90% recyclable." These capabilities address future regulatory demands and offer tangible sustainability value to airline customers.

Second, the company benefits from its strong operational expertise, notably in flight optimization and fuel efficiency strategies. Aircraft Performance Monitoring (APM) and single-engine taxi procedures are cited as embedded practices that can reduce emissions immediately. Third, the company's brand equity and global reputation enable convening ecosystem actors and influencing regional aviation policy. Finally, strong stakeholder networks—including regulators, airlines, and academia—position the company as an integrator of sustainability efforts across the aviation value chain. Conversely, several internal weaknesses constrain the company's ability to scale its efforts in Indonesia. Interview responses identified financial resource limitations as a key barrier to deploying localized sustainability initiatives. Similarly, manpower constraints—a lack of personnel dedicated to emerging markets or sustainability innovation—limit operational bandwidth. A third recurring theme is the dependence on external stakeholders, such as fuel producers and regulators, for SAF deployment and infrastructure development. One interviewee noted, "*We are not fuel producers—our role is aircraft readiness and ecosystem convening*."

On the external front, several opportunities emerge from Indonesia's evolving aviation landscape. Chief among them is strong government support for aviation decarbonization, including SAF blending mandates and net-zero commitments. This political momentum aligns with the company's core offerings and creates an enabling environment for SAF integration. In addition, the projected growth in aircraft demand—estimated at 1,500 new aircraft by 2042—offers a significant window for fleet modernization. There is also potential in advancing operational efficiency initiatives, which can deliver sustainability outcomes and cost savings for cost-sensitive airlines. Moreover, Indonesia's abundant bio-feedstock resources (e.g., used cooking oil, palm oil, coconuts) provide a promising foundation for localized SAF production, provided supply chain gaps are addressed. Despite these opportunities, several external threats pose significant challenges. The high cost and low availability of SAF, driven by limited refining capacity and underdeveloped infrastructure, is a major constraint for widespread adoption. Additionally, regulatory ambiguity—especially around SAF certification standards and agency alignment—creates uncertainty that may stall industry investment. Other threats include technological delays in long-term decarbonization pathways, such as hydrogen propulsion, and low public awareness of sustainable aviation, which could hinder the formation of social and political support coalitions.

The quotes and codes that inform the identification of internal factors are detailed in Table 4, while external opportunities and threats synthesized from the PESTLE findings are presented in Table 5. These insights are collectively summarized in the SWOT Matrix (Table 6) below.

Table 4. Strength and Weakness Coding Excerpts

Code	Quote	Source	Theme
Sustainable Aircraft	"We have demonstrated 100% SAF flights … now working with regulators for full approval."	Aircraft Manufacturer	Strength
Global Industry Leader	"Committed to R&D and investments to reduce emissions, improve fuel efficiency…"	Aircraft Manufacturer	Strength
Operational Knowledge	"APM is crucial—can detect abnormal fuel flow every flight."	External Expert	Strength
Stakeholder Relationship	"When Garuda purchases our aircraft… we provide program/warranty."	External Expert	Strength
Financial Constraint	"Our biggest challenge is having the resources … financial situation limits our capacity."	Aircraft Manufacturer	Weakness
Manpower Constraint	"We just need to have the resources."	Aircraft Manufacturer	Weakness
External Dependency	"We are not fuel producers … we depend on other stakeholders."	Aircraft Manufacturer	Weakness

Source: Research data, 2025

Table 5. External Opportunities and Threats

Opportunities	Description
O1	Government commitment to SAF acceleration (e.g., 5% blending mandate)
O2	Projected demand growth for 1,500+ aircraft by 2042
O3	Operational efficiency as a profit and sustainability lever
O4	Abundant domestic feedstock for SAF (e.g., UCO, palm oil)

Source: Research data, 2025

Table 6. SWOT Matrix

	Opportunities	Threats
Strengths	**S1**: Global leader in aircraft tech **S2**: Operational knowledge and airline advisory **S3**: Strong stakeholder engagement	**S1–T1**: Leverage brand strength to support SAF cost awareness **S2–T3**: Use operational efficiency to counter infrastructure bottlenecks
Weaknesses	**W1**: Financial constraints **W2**: Limited manpower for local sustainability **W3**: Dependency on external actors	**W1–T2**: Limited internal resources to navigate unclear SAF regulation **W3–T5**: Dependency risk amplified by low public and institutional awareness

Source: Research data, 2025

The SWOT framework reveals a well-positioned yet resource-constrained manufacturer. Its technical and operational strengths, global influence, and stakeholder networks offer a solid foundation to lead sustainability transitions. However, to be effective in the Indonesian context, the company must mitigate its internal limitations, navigate external regulatory and economic barriers, and proactively leverage its strengths to influence policy and public discourse. These findings serve as the basis for the next analysis phase: strategy formulation using the TOWS matrix.

TOWS Strategy Generation: Converting Analysis into Action

Building upon the prior SWOT analysis, this study applies the TOWS matrix as a strategic planning tool to bridge internal capabilities and external dynamics with actionable strategic direction. TOWS differs from traditional SWOT in that it pushes beyond descriptive analysis to generate specific, directional strategies by systematically pairing Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) into four strategic quadrants: SO (Strength–Opportunity): Using strengths to capitalize on opportunities; WO (Weakness–Opportunity): Overcoming internal weaknesses to exploit external opportunities; ST (Strength–Threat): Leveraging strengths to neutralize or minimize threats; and WT (Weakness–Threat): Defensive strategies to mitigate both internal and external risks. This process generated 25 preliminary strategy statements, as shown in Table 7. Each raw statement reflects a potential pathway informed by interviews and PESTLE factors. However, to ensure clarity, feasibility, and alignment with organizational priorities, these statements were reviewed, filtered, and consolidated into four overarching strategic themes (see Table 8).

Table 7. TOWS Strategy Pairings (Excerpt)

Matrix	Description	Matrix	Description
[S1][O1]	Global Aircraft Manufacturer engages directly with the Ministry of Energy, the Ministry of Transportation, and the state-owned enterprise to shape SAF certification, incentives, and national decarbonization roadmaps using Global Aircraft Manufacturer's brand credibility.	**S1T1**	Not Viable
[S1][O2]	Leverage Global Aircraft Manufacturer's International brand and product credibility to position its newer, fuel-efficient aircraft as the optimal solution in Indonesia.	**S1T2**	Use Global Aircraft Manufacturer's international policy credibility to advocate for SAF regulatory clarity in Indonesia.
[S1][O3]	Offer Global Aircraft Manufacturers' performance optimization services as part of broader cost-saving support for Indonesian carriers.	**S1T3**	Not Viable
[S1][O4]	Use Global Aircraft Manufacturer's stakeholder relationships to co-develop SAF policy with ministries, Pertamina, and industry.	**S1T4**	Not Viable
[S2][O1]	Promote Global Aircraft Manufacturers' SAF-ready aircraft as aligned with Indonesia's decarbonization targets and policy direction.	**S1T5**	Not Viable
[S2][O2]	Position Global Aircraft Manufacturer's fuel-efficient fleet as a best-fit for Indonesian airlines undergoing fleet renewal.	**S2T1**	Promote Global Aircraft Manufacturers' sustainable aircraft as a way for airlines to offset high SAF costs through fuel efficiency.

Matrix	Description	Matrix	Description
[S2][O3]	Demonstrate lifecycle fuel savings of Global Aircraft Manufacturer aircraft as part of airline operational improvement initiatives.	**S2T2**	Not Viable
[S2][O4]	Not Viable	**S2T3**	Not Viable
[S3][O1]	Not Viable	**S2T4**	Not Viable
[S3][02]	Support airlines in fleet planning with operational modelling tools to optimize total emissions reduction.	**S2T5**	Not Viable
[S3][O3]	Provide Indonesian airlines with implementation support for fuel-saving initiatives (MRTBO, taxi ops).	**S3T1**	Not Viable
[S3][O4]	Not Viable	**S3T2**	Not Viable
[S4][O1]	Use Global Aircraft Manufacturer's stakeholder relationships to co-develop SAF policy with ministries, Pertamina, and industry.	**S3T3**	Not Viable
[S4][O2]	Partner with airlines and banks on fleet modernization initiatives.	**S3T4**	Not Viable
[S4][O3]	Launch a cross-sector working group with universities, regulators, and airlines to promote optimized operation initiatives.	**S3T5**	Not Viable
[S4][O4]	Facilitate SAF demonstration projects using Indonesia's feedstock through tripartite collaboration (Global Aircraft Manufacturer, university, producer).	**S4T1**	Not Viable
S4T2	Use stakeholder relationships to co-facilitate SAF certification clarity.	**W1T1**	Not Viable
S4T3	Not Viable	**W1T2**	Not Viable
S4T4	Not Viable	**W1T3**	Not Viable
S4T5	Collaborate with NGOs and universities to launch public awareness campaigns on aviation sustainability.	**W1T4**	Not Viable
W1O1	Position SAF demonstration and Supply Chain within Indonesia's Proyek Strategies Nasional (PSN), a Global Aircraft Manufacturer, acts as a technical advisor while using PSN status to access financial investment.	**W1T5**	Not Viable
W1O2	Not Viable	**W2T1**	Not Viable
W1O3	Monetize Global Aircraft Manufacturer's operational efficiency as part sustainable solution for the airline	**W2T2**	Not Viable
W1O4	Develop the SAF project using co-funded investment.	**W2T3**	Not Viable
W2O1	Utilize public-sector collaboration to establish a Working Together Team (WTT)	**W2T4**	Prioritize SAF initiatives requiring minimal manpower (e.g., certification, policy support) over long-term R&D.
W2O2	Partner with the growing aviation ecosystem to develop and promote sustainable aviation	**W2T5**	Not Viable
W2O3	Focus on existing manpower to promote an operational efficiency program.	**W3T1**	Not Viable
W204	Not viable	**W3T2**	Collaborate with Indonesian regulators through joint task forces to mitigate exposure to unclear SAF rules.
W3O1	Create a joint task force with government and industry to create a roadmap towards decarbonization using SAF.	**W3T3**	Convene SAF infrastructure stakeholders into a coalition to accelerate readiness and reduce the Global Aircraft Manufacturer's external dependency.
W3O2	Not Viable	**W3T4**	Not Viable
W3O3	Structure the stakeholders framework towards utilizing operational efficiency.	**W3T5**	Not Viable

Matrix	Description	Matrix	Description
W3O4	Establish PPPs with SAF producers and regulators to build a local SAF supply chain with shared accountability.		

Source: Research data, 2025

Through this consolidation, the study proposes four key strategies, each aligned with one or more of IATA's five sustainable aviation pillars: Renewable Energy (SAF), Fleet Modernization, Operational Efficiency, and Market-Based Measures. These strategies are presented in Table 7 with their supporting strategy codes and thematic rationale.

Table 8. Consolidated Strategic Themes from TOWS Matrix

Strat.	Theme	Description	Sustainability Pillar
1	National SAF Policy Leadership	Proactively lead the development of SAF-related policies by collaborating with Indonesian ministries (Energy, Transportation), state-owned enterprises, and SAF suppliers. The aircraft manufacturer leverages its technical expertise and global brand to shape SAF certification, blending mandates and roadmap development through joint task forces and multi-stakeholder forums.	Renewable Energy (SAF)
2	Integrated Fleet Transition	Position the company's aircraft as a lower-emission, SAF-ready solution for Indonesian airlines' decarbonization and fleet renewal efforts. Support the economic viability of aircraft purchases through facilitation with global export credit agencies and green financing instruments.	Fleet Modernization
3	Airline Operation Initiatives	Launch an operational efficiency advisory program to assist Indonesian carriers in adopting cost-effective, sustainable practices (e.g., MRTBO, single-engine taxi, Aircraft Performance Monitoring). This approach balances economic and environmental goals, potentially supporting CORSIA compliance.	Operational Efficiency
4	Sustainable Ecosystem Development & Demonstration Projects	Serve as a facilitator in multi-actor SAF demonstration initiatives using Indonesia's indigenous feedstock. Engage SAF producers, academia, regulators, and NGOs to build awareness, align policies, and improve infrastructure readiness. Promote ecosystem-wide collaboration and launch public engagement campaigns.	Renewable Energy (SAF), Operational Efficiency, Market-Based Measures

Source: Research data, 2025

These consolidated strategies reflect a distinct strategic posture: Strategy 1 (SAF Policy Leadership) represents a proactive institutional engagement model, where the manufacturer contributes directly to shaping national aviation decarbonization policy. Strategy 2 (Fleet Transition) is a market-driven approach, integrating green product positioning with financing mechanisms. Strategy 3 (Operational Initiatives) offers a solution-based commercial service, monetizing the firm's technical advisory capabilities. Strategy 4 (Ecosystem Development) is a systems integrator model, promoting collaboration across sectors for broader decarbonization and awareness-building. Together, these strategies reflect the dual role of the global aircraft manufacturer as both a technology supplier and ecosystem convener, tailored specifically to the Indonesian context.

MCDA Strategy Prioritization: Evaluating Feasibility and Impact

To determine the most practical and impactful path forward, the four consolidated strategies derived from the TOWS analysis were assessed using a Multi-Criteria Decision Analysis (MCDA) framework. MCDA is particularly valuable in strategic sustainability contexts, where decision-makers must evaluate alternatives across multiple, often competing, dimensions—such as environmental benefit, regulatory complexity, and stakeholder support. This approach enables structured prioritization grounded in both qualitative insights and quantitative weighting.

Evaluation Criteria

Five key criteria were established based on a synthesis of sustainability literature, stakeholder interviews, and the unique operational context of Indonesia's aviation sector: 1) CO_2 Reduction Impact: Expected contribution of each strategy to decarbonization and emissions reduction; 2) Regulatory Readiness: Degree of alignment with existing or emerging national regulations; 3) Financial Feasibility: Cost-benefit balance, investment intensity, and commercial viability; 4) Implementation Speed: Time and ease required to roll out the strategy in Indonesia's policy and infrastructure landscape; 5) Market Acceptance: Likelihood of adoption and support from key stakeholders, including airlines, government, and the public.

Weighting Criteria

Each criterion was assigned a relative weight reflecting its importance within the Indonesian context. Weighting was based on the frequency and emphasis of interview themes and literature mentions linked to each indicator.

Table 9. MCDA Criteria Weights

MCDA Criteria	Code Indicators	Frequency	Weight
CO_2 Reduction Impact	Fleet Modernization, Operational Efficiency, SAF, Advanced Technology	7	24%
Regulatory Readiness	Regulatory & Policy, Government Commitment	3	10%
Financial Feasibility	SAF Price, Public Awareness	3	10%
Implementation Speed	Opportunity-Based Engagement, Strategic Fit	6	21%
Market Acceptance	Stakeholder Willingness, Public Awareness, Collaboration	10	34%

Source: Research data, 2025

The heaviest weight (34%) was assigned to market acceptance, emphasizing the need for stakeholder alignment and local buy-in, critical in Indonesia's fragmented regulatory environment and cost-sensitive aviation industry. CO_2 reduction (24%) and implementation speed (21%) were also prioritized, reflecting the urgency to demonstrate visible, rapid gains.

MCDA Evaluation Results

Four external aviation and sustainability experts independently rated each of the four strategies against all five criteria using a 1–5 Likert scale. Scores were then weighted and aggregated to produce a composite ranking. Key Findings: 1) Airline Operational Initiatives emerged as the top-priority strategy, with strong scores across CO_2 impact, implementation speed, and financial feasibility. As a "quick win," this strategy aligns closely with current operational challenges and cost-efficiency needs of Indonesian airlines. 2) Integrated Fleet Transition ranked second, with high marks for CO_2 reduction and market acceptance, though it scored lower on financial feasibility due to significant capital requirements. 3) National SAF Policy Leadership and Sustainable Ecosystem Development are followed, recognized as essential long-term enablers, but constrained by slower implementation and regulatory reliance.

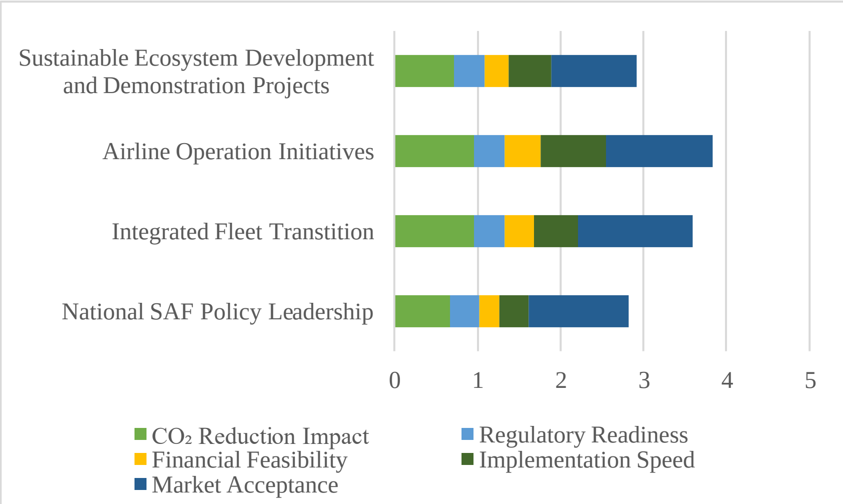

Figure 3. Weighted Strategy Scores across MCDA Criteria Sensitivity Analysis

Source: Research data, 2025

Sensitivity Analysis

To test the robustness of the MCDA results, a two-scenario sensitivity analysis was performed by varying the weights of the two most influential criteria: Scenario 1: 1) Varying Market Acceptance Weight; 2) Adjusted from 24% to 50%; 3) Other criteria re-

weighted proportionally; 4) Result: Airline Operational Initiatives maintained the top rank, confirming its stakeholder-aligned and context-resilient appeal.
Scenario 2: 1) Varying CO_2 Reduction Impact Weight; 2) Adjusted from 14% to 34%; 3) Other weights recalibrated accordingly; 4) Result: Rankings remained stable, with Airline Operational Initiatives again leading, followed closely by Integrated Fleet Transition. This demonstrates that even when environmental performance is prioritized, strategies focused on operational improvements remain dominant.

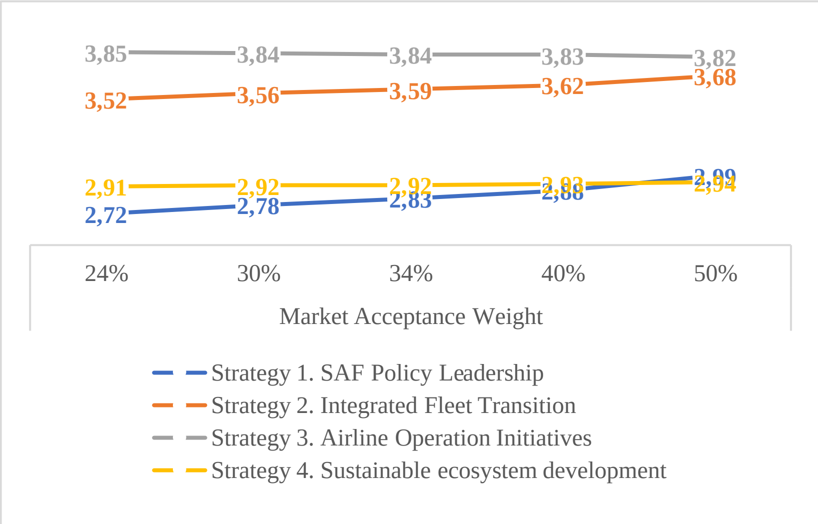

Figure 4. Sensitivity Analysis Scenario 1 Market Acceptance Weight Varied
Source: Research data, 2025

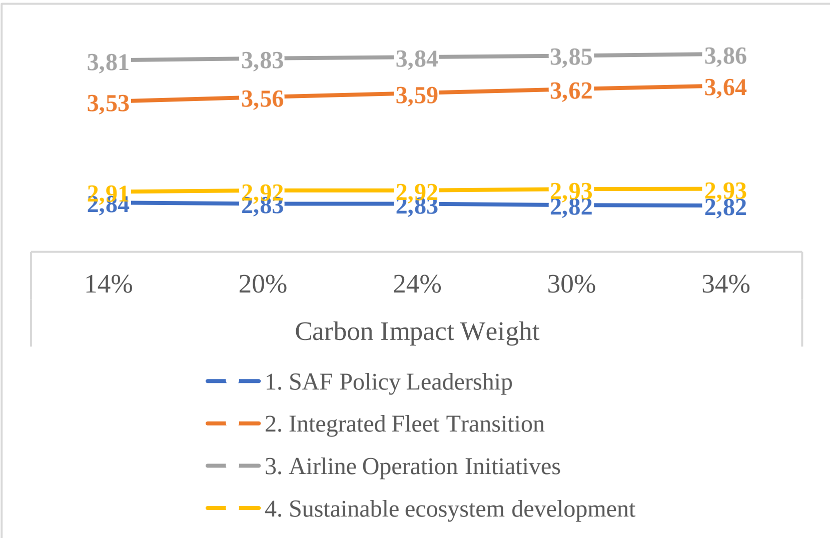

Figure 5. Sensitivity Analysis Scenario 2 Carbon Reduction Weight Varied
Source: Research data, 2025

The Airline Operational Initiatives strategy stands out as the most viable short-term intervention for a global aircraft manufacturer aiming to support sustainable aviation in Indonesia. It strikes an effective balance between cost-efficiency, regulatory feasibility, and emissions impact, making it especially suitable in a cost-sensitive, regulation-developing market such as Indonesia. Meanwhile, fleet transition and ecosystem development offer important medium- to long-term opportunities, requiring sustained policy engagement and ecosystem readiness. Together, these findings offer a prioritized roadmap to inform strategic decision-making, guiding both corporate investment and stakeholder engagement toward effective sustainability outcomes.

E. CONCLUSIONS

This study set out to explore how a global aircraft manufacturer could strategically support Indonesia's transition toward sustainable aviation. While the prevailing literature and policy discourse tend to center on governments, airlines, and fuel providers, this research addresses a less-explored yet increasingly pivotal actor: the aircraft manufacturer. By examining the intersection between organizational capability and national sustainability goals, the study contributes to both theoretical discourse and applied strategic practice. Through qualitative inquiry grounded in two key informant interviews and structured via thematic coding, SWOT–TOWS analysis, and Multi-Criteria Decision Analysis (MCDA), the findings illustrate that aircraft manufacturers, far beyond being mere technology suppliers, can act as ecosystem enablers. The firm's internal resources, including technical advisory capability, operational efficiency tools, and institutional relationships, were found to align strongly with the needs of an emerging-market context. This aligns with the Resource-Based View (RBV), which emphasizes leveraging intangible assets—such as reputation, knowledge, and partnerships—for strategic advantage in dynamic environments.

The Indonesian external environment presents a dual narrative of opportunity and complexity. While the market offers substantial fleet expansion potential and abundant SAF feedstock, these prospects are moderated by persistent infrastructure bottlenecks, regulatory ambiguity, and weak institutional coordination. The PESTLE analysis framed these macro-level factors, while the SWOT–TOWS process facilitated a systematic matching of internal strengths to external conditions. Through MCDA, the study ranked four strategic options based on five criteria: CO_2 reduction impact, regulatory alignment, financial feasibility, implementation speed, and market acceptance. Airline Operational Initiatives emerged as the highest-priority intervention. This strategy aligns with cost-sensitive airline behavior and delivers tangible emissions benefits in the short term. Integrated Fleet Transition ranked second, with high synergy between Indonesia's projected aircraft needs and the manufacturer's product offerings. Lower-ranked strategies—SAF Policy Leadership and Sustainable Ecosystem Development—were deprioritized not due to lack of strategic value but due to longer timelines and institutional dependencies. These remain essential long-term enablers, as emphasized by Belton and Stewart (2002), who note that MCDA frameworks are not merely tools of prioritization but lenses to understand implementation feasibility under constraints.

Strategic Implications

Short-Term Priorities: Operational and Market-Ready Solutions

The most immediate value aircraft manufacturers can offer lies in deploying technically mature, financially viable, and operationally feasible solutions. The Airline Operational Initiatives strategy—focusing on measures such as Aircraft Performance Monitoring (APM), single-engine taxiing, and MRTBO—requires minimal infrastructure upgrades and resonates with airlines' current cost-control imperatives. These measures offer quick wins, allowing the manufacturer to demonstrate leadership in decarbonization without requiring high capital investments. In parallel, Integrated Fleet Transition positions the manufacturer as a partner in national fleet renewal, particularly as Indonesia is projected to require over 1,500 new aircraft by 2042 (Hemmerdinger, 2024). Here, the manufacturer's competitive edge lies not only in aircraft supply but also in offering structured financing, training, and lifecycle advisory, reinforcing both commercial and sustainability value propositions.

Long-Term Enablers: Ecosystem and Policy Engagement

While less feasible in the immediate term, strategies such as SAF Policy Leadership and Sustainable Ecosystem Development are crucial for Indonesia's long-term decarbonization. These approaches call for the manufacturer to engage as a convener, working with government ministries, SOEs, universities, and SAF producers to co-develop policy clarity, build refining infrastructure, and launch SAF demonstration projects. These initiatives are inherently phased strategies—dependent on regulatory alignment, infrastructure maturity, and public awareness. The findings indicate that the manufacturer's reputational capital, coupled with global experience in SAF standardization, could be instrumental in shaping the SAF market, albeit gradually.

Limitations and Future Research

This study is exploratory and qualitative, grounded in a limited sample of elite informants. While rich in strategic insight, the findings are not statistically generalizable. Manual coding, though thematically structured, is inherently interpretive. These limitations were mitigated through triangulation with literature and validation via external expert MCDA scoring. Future research could expand the analytical rigor by incorporating quantitative techniques such as: 1) Net Present Value (NPV) and Internal Rate of Return (IRR) for financial evaluation of strategic options; 2) Monte Carlo simulations for risk sensitivity; and 3) Comparative studies across other ASEAN aviation markets to test transferability of findings.

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