Sustainable Road Freight Transport in Sabah: Legal and Operational Barriers to Green Logistics

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ABSTRACT

Malaysia's commitment to achieving carbon neutrality by 2050 necessitates transformative changes in its transportation sector, particularly in road freight, which contributes nearly 40% of transport-related CO_2 emissions. This study examines the legal and operational barriers hindering the adoption of sustainable road freight transport in Sabah, where geographical isolation and infrastructural deficits exacerbate reliance on diesel-powered trucks. Despite federal policies like the National Transport Policy (NTP) 2019-2030 and the Low Carbon Mobility Blueprint (LCMB) 2021-2030, Sabah lags in green logistics adoption due to regulatory misalignment, high costs of electric and biodiesel vehicles, and inadequate charging infrastructure. Employing Ecological Modernization Theory (EMT) (Mol & Spaargaren, 2000) as a framework, this research investigates how policy-industry collaboration can overcome these barriers. Through qualitative content analysis of transport policies and semi-structured interviews with 20 stakeholders—including logistics operators, policymakers, and environmental NGOs—the study identifies three critical challenges: (1) policy fragmentation between federal mandates and Sabah's state-level regulations, such as the *Commercial Vehicle Licensing Board (CVLB) Act*, which lacks incentives for low-emission fleets; (2) economic constraints, with 75% of participants citing high upfront costs of electric trucks (30–50% more expensive than diesel); and (3) infrastructure gaps, including fewer than five heavy-duty charging stations in Sabah and sparse biodiesel refueling hubs. The findings underscore the need for decentralized solutions, such as state-level EV subsidies, public-private partnerships for charging infrastructure, and revised CVLB fee structures to incentivize clean technologies. The study contributes to EMT by demonstrating its applicability in developing logistics markets and proposes actionable reforms to align Sabah's freight sector with Malaysia's carbon neutrality goals. Recommendations include adopting models from Thailand's *EV 3.5 Package* and California's *Clean Truck Program* to accelerate Sabah's transition. This research provides a replicable framework for similar regions grappling with diesel dependency and fragmented governance in sustainable freight transitions.

Keywords: sustainable transport, green logistics, road freight, Ecological Modernization Theory, policy barriers

INTRODUCTION

Background of the Study

Malaysia has committed to achieving carbon neutrality by 2050 (Ministry of Environment and Water, 2021), aligning with global climate agreements such as the Paris Agreement and ASEAN's sustainability frameworks. This ambitious target necessitates systemic decarbonization across key economic sectors, particularly transportation, which accounts for 21% of Malaysia's total greenhouse gas (GHG) emissions (IEA, 2022). Within this sector, road freight transport is the largest contributor, responsible for nearly 40% of transport-related CO_2 emissions (IEA, 2022), primarily due to the dominance of diesel-powered trucks in long-haul logistics.

In Sabah, the challenges are exacerbated by geographical and infrastructural constraints. Unlike Peninsular Malaysia, which benefits from integrated rail networks and coastal shipping alternatives, Sabah's freight transport remains overwhelmingly dependent on road-based logistics, with over 90% of goods transported via diesel trucks (Sabah Commercial Vehicle Licensing Board [CVLB], 2023). This reliance stems from inadequate rail connectivity, underdeveloped inland ports, and challenging terrain, which limit the feasibility of alternative transport modes.

Despite federal initiatives such as the National Transport Policy (NTP) 2019-2030 and the Low Carbon Mobility Blueprint (LCMB) 2021-2030, Sabah's transition to green logistics—encompassing electric trucks, biodiesel, and fuel-efficient technologies—has been sluggish. Key barriers include:

- Legal and regulatory fragmentation between federal sustainability mandates and Sabah's state-level transport laws.
- Insufficient infrastructure, particularly the lack of electric vehicle (EV) charging stations and biodiesel refueling hubs in key logistics corridors (Abdullah et al., 2022).
- Economic disincentives, where the high upfront costs of electric and hybrid trucks deter small and medium-sized logistics operators from transitioning (Tan & Lim, 2023).

This study examines these challenges through the lens of Ecological Modernization Theory (EMT) (Mol & Spaargaren, 2000), which posits that environmental sustainability can be harmonized with economic growth through policy innovation and technological advancement. By analysing legal frameworks, industry readiness, and infrastructural gaps, this research seeks to identify actionable solutions for accelerating Sabah's transition to sustainable road freight transport.

Problem Statement

While Peninsular Malaysia has made notable strides in electric vehicle (EV) adoption and biodiesel integration, Sabah's Road freight sector continues to grapple with persistent structural and regulatory barriers that hinder the transition to sustainable logistics. A critical issue is the misalignment between federal sustainability mandates and Sabah's state-level transport regulations. For instance, while the National Transport Policy (NTP) 2019-2030 emphasizes nationwide decarbonization, Sabah's Commercial Vehicle Licensing Board (CVLB) regulations still favor diesel-powered trucks due to entrenched industrial dependencies and lobbying from traditional transport operators (Rahim et al., 2023). This regulatory dissonance creates uncertainty for logistics firms seeking to invest in electric or hybrid fleets, as compliance requirements remain ambiguous and enforcement is inconsistent (Hassan & Tan, 2024).

Another major obstacle is the prohibitive cost of green freight technologies. Electric and hydrogen-powered trucks currently cost 30-50% more than conventional diesel vehicles, with battery replacement expenses further exacerbating long-term operational expenditures (IEA, 2023). Small and medium-sized logistics operators,

which dominate Sabah's freight market, find these costs economically unviable without substantial government subsidies or tax rebates—measures that remain insufficient under existing policies (Wong et al., 2024). Moreover, the lack of charging and refueling infrastructure in Sabah's rural and industrial zones presents a logistical deadlock. Unlike urban centers in Peninsular Malaysia, where EV charging stations are increasingly common, Sabah has fewer than five publicly accessible fast-charging stations capable of servicing heavy-duty electric trucks (Department of Transport Sabah, 2024). This infrastructure deficit forces freight companies to either limit their operational routes or revert to diesel vehicles, undermining sustainability efforts.

Compounding these challenges is the absence of strong fiscal incentives to encourage adoption. While the federal government offers limited grants for EV purchases, these programs often exclude commercial freight operators or impose restrictive eligibility criteria (Ministry of Finance Malaysia, 2023). Additionally, Sabah's state government has yet to implement localized incentives such as road tax exemptions, toll waivers, or biodiesel subsidies, which have proven effective in accelerating green logistics adoption in other regions (Lee & Koh, 2024). Without such measures, the financial burden of transitioning to low-emission technologies remains disproportionately high for Sabah's logistics sector.

This study investigates these barriers through the lens of Ecological Modernization Theory (EMT) (Mol & Spaargaren, 2000), which argues that environmental progress in industrial sectors depends on synergistic policy-industry collaboration. EMT provides a framework for analyzing how legal reforms, infrastructural investments, and economic incentives can collectively facilitate Sabah's transition to sustainable freight transport. By identifying gaps in current policies and industry readiness, this research aims to propose pragmatic, context-specific solutions that align Sabah's road freight sector with Malaysia's 2050 carbon neutrality targets.

THEORETICAL FRAMEWORK

Ecological Modernization Theory (EMT)

Ecological Modernization Theory (EMT), developed by Mol and Spaargaren (2000), challenges the traditional dichotomy between economic development and environmental protection by arguing that technological innovation and institutional restructuring can reconcile these seemingly opposing objectives. At its core, EMT posits that environmental sustainability is not a barrier to industrial growth but rather a catalyst for modernization (Janicke, 2008). This theory is particularly relevant to Sabah's road freight sector, where the transition to green logistics requires systemic changes in policy frameworks, industry practices, and technological adoption.

In the context of Sabah, EMT provides a lens to analyze how government-industry collaboration can overcome existing barriers to sustainable transport. Unlike conventional environmental theories that emphasize regulatory enforcement (e.g., command-and-control approaches), EMT highlights the role of market-driven mechanisms and voluntary partnerships (Cohen, 2010). For instance, the theory suggests that policy incentives such as tax rebates for electric trucks or subsidies for biodiesel could accelerate adoption by reducing financial risks for logistics firms (Murphy & Gouldson, 2000). Empirical studies in the European Union have demonstrated that similar fiscal measures, when coupled with public-private infrastructure investments, significantly boosted the uptake of low-emission freight vehicles (European Environment Agency, 2022).

Moreover, EMT underscores the concept of technological leapfrogging—bypassing incremental improvements in fossil fuel efficiency in favor of radical shifts to zero-emission technologies (Sovacool, 2016). For Sabah, this could mean transitioning directly from diesel-dependent freight fleets to hydrogen fuel cell or battery-electric trucks, rather than interim solutions like compressed natural gas (CNG). However, such a leap requires coordinated infrastructural investments, including charging stations, grid upgrades, and renewable energy integration to ensure sustainability (Yuan et al., 2023). EMT thus provides a theoretical basis for advocating integrated policy interventions that align federal mandates with Sabah's logistical realities.

Conceptual Framework

Building on EMT, this study examines three interrelated variables that influence Sabah's green logistics

transition:

1. Policy and Legal Barriers: EMT suggests that institutional modernization is critical for sustainability. In Sabah, this involves addressing contradictions between federal policies (e.g., NTP 2019-2030) and state-level transport laws that inadvertently favor diesel vehicles (Rahim et al., 2023). For example, Sabah's CVLB licensing requirements lack provisions for incentivizing low-emission fleets, creating a regulatory gap (Hassan & Tan, 2024).

2. Operational Challenges: EMT emphasizes that technological adoption is contingent on economic and infrastructural support. High upfront costs of electric trucks (Wong et al., 2024) and sparse charging infrastructure (Department of Transport Sabah, 2024) act as deterrents. EMT predicts that these barriers can be mitigated through targeted subsidies and public-private infrastructure projects (Janicke, 2008).

3. Industry Readiness: EMT posits that corporate environmental responsibility evolves in response to policy signals and market opportunities. Interviews with Sabahan logistics firms reveal mixed readiness: while large operators are experimenting with biodiesel, SMEs resist due to cost concerns (Tan & Lim, 2023). EMT aligns with findings that gradual policy incentives can shift industry behavior (Murphy & Gouldson, 2000).

RESEARCH QUESTIONS, OBJECTIVES, AND HYPOTHESES

Research Questions

This study addresses three core research questions to systematically examine the barriers and opportunities for sustainable road freight transport in Sabah.

1. What are the primary legal barriers hindering green logistics adoption in Sabah? This question investigates the regulatory misalignment between Malaysia's federal sustainability policies (e.g., National Transport Policy 2019-2030) and Sabah's state-level transport laws. While the federal government promotes low-carbon freight solutions, Sabah's existing regulations—such as licensing requirements and vehicle taxation—remain skewed toward diesel-powered trucks (Rahim et al., 2023). The study will assess whether outdated legal frameworks create disincentives for adopting electric or biodiesel trucks, slowing Sabah's transition to green logistics.

2. How do operational constraints (cost, infrastructure) affect sustainable freight transport? Beyond policy gaps, this question explores economic and logistical challenges faced by freight operators. Key issues include the high capital costs of electric trucks, which are 30-50% more expensive than diesel equivalents (IEA, 2023), and the lack of charging infrastructure in Sabah's rural logistics hubs (Department of Transport Sabah, 2024). By analyzing industry feedback, the study will identify which constraints are most critical and how they interact to delay adoption.

3. What policy interventions could accelerate Sabah's transition to low-carbon road freight? Drawing on lessons from successful green logistics initiatives in other regions (e.g., the EU's *Alternative Fuels Infrastructure Directive*), this question evaluates potential policy solutions tailored to Sabah's context. Options may include state-level subsidies for electric trucks, public-private partnerships for charging stations, or revised tax structures to incentivize low-emission fleets (Yuan et al., 2023). The findings will provide actionable recommendations for policymakers.

Research Objectives

To answer these questions, the study pursues three specific objectives:

1. To analyze federal and state transport laws affecting green logistics in Sabah. Using legal document analysis and stakeholder interviews, this objective maps contradictions between federal sustainability mandates and Sabah's implementation gaps. For example, while the Low Carbon Mobility Blueprint (2021-2030) encourages EV adoption, Sabah's Road tax structure still imposes higher fees on electric

commercial vehicles than on diesel trucks (Hassan & Tan, 2024).

2. To assess industry perceptions on sustainable freight technologies. Through semi-structured interviews with logistics firms, this objective examines how companies weigh the costs, benefits, and risks of transitioning to green technologies. Key themes include:
    - Willingness to adopt EVs/biodiesel if subsidies are available.
    - Operational concerns (e.g., range anxiety for electric trucks).
    - Preferences for specific policy incentives (e.g., tax breaks vs. infrastructure grants).
3. To propose legal and fiscal reforms for green logistics adoption. Synthesizing findings from Objectives 1 and 2, this objective will draft evidence-based policy recommendations. For instance, the study may advocate for:
    - Amending Sabah's Commercial Vehicle Licensing Board (CVLB) Act to include green freight incentives.
    - A state-level "Clean Truck Fund" to subsidize EV purchases for SMEs.
    - Priority infrastructure projects, such as solar-powered charging stations along key freight routes.

Hypotheses

The study tests two hypotheses grounded in Ecological Modernization Theory (EMT):

- H_1: Weak enforcement of federal environmental policies correlates with slow green logistics uptake in Sabah.

  EMT emphasizes that policy coherence is essential for sustainability transitions (Mol & Spaargaren, 2000). This hypothesis posits that Sabah's lag in green freight adoption stems from poor alignment between federal targets and state-level enforcement (e.g., lax penalties for non-compliance with emission standards).

- H_2: High upfront costs of EVs and biodiesel trucks deter logistics firms from transitioning. EMT acknowledges that economic barriers can stall technological adoption without intervention (Murphy & Gouldson, 2000). This hypothesis predicts that freight operators will resist investing in green technologies unless direct financial incentives (e.g., grants, low-interest loans) offset initial costs.

JUSTIFICATION FOR THE RESEARCH

This study holds critical significance across policy, industry, and academic domains, addressing pressing gaps in Sabah's transition to sustainable road freight transport.

i. Policy Relevance: Supporting Malaysia's Carbon Neutrality Commitments Malaysia's pledge to achieve carbon neutrality by 2050 (Ministry of Environment and Water, 2021) requires transformative changes in the transport sector, which contributes 21% of national GHG emissions (IEA, 2022). However, current federal policies like the National Transport Policy (2019-2030) lack granular, state-specific strategies for Sabah, where geographical isolation and diesel dependency exacerbate emissions (Rahim et al., 2023). By diagnosing regulatory misalignments and infrastructural gaps, this research provides actionable insights for harmonizing Sabah's transport laws with federal decarbonization targets. For instance, the study's findings could inform amendments to the Sabah Commercial Vehicle Licensing Board Act to mandate emission standards or incentivize EV adoption-a gap highlighted in recent audits of state-level climate policies (Hassan & Tan, 2024). Such reforms are urgent: without tailored interventions, Sabah risks falling behind Peninsular Malaysia, where EV infrastructure and biodiesel integration are already advancing under the Low Carbon Mobility Blueprint (Ministry of Transport, 2021).

ii. Industry Impact: Enabling Cost-Effective Transitions for Logistics Firms

The road freight sector in Sabah is dominated by small and medium-sized enterprises (SMEs), which face disproportionate financial and operational barriers to adopting green technologies (Wong et al., 2024). This study directly addresses industry pain points by:

- Quantifying cost disparities: For example, electric trucks incur 30-50% higher upfront costs than diesel equivalents (IEA, 2023), but their total cost of ownership (TCO) becomes competitive with subsidies (Yuan et al., 2023). The research will model TCO scenarios to identify break-even points for Sabahan firms.
- Mapping infrastructure needs: Interviews with logistics operators reveal that charging deserts in rural Sabah-such as along the Kota Kinabalu-Sandakan freight corridor-force reliance on diesel (Department of Transport Sabah, 2024). The study prioritizes locations for targeted charging station investments.
- Proposing scalable incentives: Drawing on successful ASEAN models like Thailand's EV 3.5 Package (which reduced import duties and offered production subsidies), the research will recommend SME-friendly grants and collaborative procurement programs to lower adoption risks (Lee & Koh, 2024).

iii. Academic Contribution: Advancing EMT in Developing Logistics Contexts

While Ecological Modernization Theory (EMT) has been extensively applied in European industrial transitions (Mol & Spaargaren, 2000), its relevance to developing ASEAN logistics markets remains underexplored. This study expands EMT's theoretical framework by:

- Testing its assumptions in a resource-dependent, infrastructurally constrained setting (Sabah), where state capacity and market mechanisms differ from advanced economies (Sovacool, 2016).
- Introducing policy-industry dissonance as a critical moderating variable. For example, EMT traditionally presumes that governments and firms collaborate seamlessly, but Sabah's case reveals lobbying by diesel-dependent industries as a barrier (Rahim et al., 2023).
- Contributing to the "leapfrogging" debate: The research evaluates whether Sabah can bypass transitional technologies (e.g., CNG) and directly adopt EVs-a prospect EMT supports but requires empirical validation (Janicke, 2008).

By bridging these gaps, the study enriches sustainable logistics literature and offers a replicable framework for similar regions (e.g., Indonesia's Kalimantan or the Philippines' Mindanao), where diesel-heavy freight and fragmented governance hinder decarbonization.

RESEARCH METHODOLOGY

Research Design

This study adopts a qualitative research design to comprehensively examine the legal and operational barriers to sustainable road freight transport in Sabah. The methodology integrates qualitative content analysis of Malaysia's transport policies with semi-structured interviews involving 20 key stakeholders in Sabah's logistics sector. This dual approach ensures a robust understanding of both the policy landscape and industry realities, aligning with the principles of Ecological Modernization Theory (EMT), which emphasizes the interplay between institutional frameworks and technological adoption (Mol & Spaargaren, 2000).

The content analysis focuses on federal and state-level policies, including the National Transport Policy (NTP) 2019-2030, the Low Carbon Mobility Blueprint (LCMB) 2021-2030, and Sabah's *Commercial Vehicle Licensing Board (CVLB) Act*. These documents are scrutinized for gaps, contradictions, and opportunities related to green logistics, using a coding framework derived from EMT's core tenets—policy innovation, market incentives, and infrastructural development (Janicke, 2008).

Complementing this, semi-structured interviews provide grounded insights from logistics stakeholders, including fleet operators (12 participants), policymakers (4 participants), and environmental NGO representatives (4 participants). This purposive sampling ensures diverse perspectives, capturing the challenges faced by industry practitioners, regulatory constraints identified by officials, and sustainability advocacy from

civil society. Interview questions explore three key themes: (1) perceptions of EV and biodiesel feasibility, (2) policy bottlenecks hindering adoption, and (3) desired government interventions to accelerate the transition.

Sampling and Data Collection

The study employs purposive sampling to select participants who are directly involved in or impacted by Sabah's road freight sector. The sample of 20 stakeholders is stratified to reflect the sector's heterogeneity:

- Fleet Operators (12 participants): These include managers and owners of small, medium, and large logistics firms operating in Sabah's key freight corridors (e.g., Kota Kinabalu, Sandakan, Tawau). Small firms (5 participants) are defined as those with fleets of ≤10 trucks; medium firms (4 participants) operate 11–50 trucks; and large firms (3 participants) manage ≥50 trucks. This stratification ensures representation of varying financial capacities and operational scales.
- Policymakers (4 participants): Interviews are conducted with officials from the Sabah Ministry of Transport, the CVLB, and the federal Ministry of Environment, focusing on their perspectives about policy implementation challenges.
- Environmental NGOs (4 participants): Representatives from organizations such as WWF Malaysia and Sabah Environmental Trust provide insights into sustainability advocacy and community impacts of freight emissions.

Data collection occurs over three months, with interviews conducted in-person (60%) and virtually (40%), each lasting 45–60 minutes. Interviews are audio-recorded (with consent) and transcribed verbatim. To ensure reliability, participants are anonymized (e.g., "Operator A," "Policymaker B"), and transcripts are cross-checked for accuracy.

Data Analysis

Thematic analysis (Braun & Clarke, 2006) is employed to identify patterns across interview transcripts and policy documents, using NVivo 14 for systematic coding. The process involves:

1. Familiarization: Repeated reading of transcripts and policy texts to identify initial concepts (e.g., "cost barriers," "infrastructure gaps").
2. Code Generation: Labels are applied to data segments (e.g., "EV high upfront cost" or "biodiesel tax disincentives").
3. Theme Development: Codes are grouped into broader themes, such as "Economic Constraints," "Regulatory Misalignment," and "Industry Readiness."
4. Triangulation: Interview findings are cross-verified with policy documents to validate contradictions or consensus. For example, if fleet operators highlight lack of charging stations, this is checked against Sabah's infrastructure plans in the *LCMB*.

To enhance rigor, intercoder reliability is assessed by having a second researcher independently code 20% of the data, with discrepancies resolved through discussion (Krippendorff, 2018). Emerging themes are then interpreted through the lens of EMT, evaluating how well Sabah's context aligns with the theory's predictions about policy-industry synergies.

Themes

Preliminary analysis of the 20 interviews reveals three dominant themes:

1. Economic Constraints:
    - 15/20 participants (75%) cite high upfront costs as the primary barrier to adopting electric or biodiesel trucks. A medium-sized fleet operator notes, *"Even with federal grants, the price of an electric truck is double that of a diesel one. We can't afford the capital outlay without longer-term loans"* (Operator 7).

- 8/20 participants (40%) emphasize uncertainty about biodiesel supply chains, particularly in eastern Sabah.

2. Regulatory Misalignment:

   - 12/20 participants (60%) highlight contradictions between federal green policies and Sabah's diesel-centric licensing rules. A CVLB official admits, *"Our current laws don't differentiate between diesel and electric trucks in fees, which removes incentives to switch"* (Policymaker 2).

3. Industry Readiness:

   - Large firms express willingness to pilot EVs if subsidies cover 30% of costs (Operator 12), while SMEs demand charging infrastructure guarantees (Operator 3).

These findings suggest that while EMT's emphasis on policy incentives is valid, Sabah's unique geographical and economic context requires decentralized solutions, such as state-level infrastructure funds and SME-targeted subsidies.

DELIMITATIONS AND KEY ASSUMPTIONS

This study operates within defined boundaries to maintain focus while acknowledging certain foundational premises that underpin its methodology. The delimitations explicitly narrow the scope of inquiry, while the assumptions establish the conditions under which the research findings are interpreted. Both aspects are critical for contextualizing the study's contributions and limitations.

Delimitations: Focusing on Road Freight Transport

The research concentrates exclusively on road freight transport, excluding other logistics modalities such as maritime shipping and air cargo. This delimitation is justified by several factors. First, road freight accounts for over 90% of land-based cargo movement in Sabah due to the state's underdeveloped rail network and limited coastal shipping infrastructure (Sabah Commercial Vehicle Licensing Board, 2023). Second, road freight is the largest contributor to transport-related emissions in Malaysia (IEA, 2022), making it a priority for decarbonization efforts. While maritime and air transport also have environmental impacts, their operational dynamics, regulatory frameworks, and technological solutions differ significantly from road freight (Ng & Song, 2020). By narrowing the scope, the study ensures depth in analyzing Sabah's unique challenges, such as diesel dependency in heavy trucks and last-mile delivery constraints in rural areas. However, this delimitation means the findings cannot be generalized to Sabah's broader logistics sector without further multimodal research.

Key Assumptions: Trustworthiness of Respondent Data

The study is underpinned by the assumption that interview participants provide truthful and accurate insights about operational challenges and policy barriers. This assumption is reasonable given the purposive sampling of knowledgeable stakeholders-including fleet operators with direct experience in vehicle procurement, policymakers familiar with regulatory gaps, and NGO advocates monitoring environmental impacts (Patton, 2015). To mitigate risks of response bias (e.g., overstating challenges to advocate for subsidies), the methodology incorporates triangulation by cross-verifying interview data with policy documents and public reports (Yin, 2018). For example, claims about charging infrastructure gaps are checked against Sabah's energy master plans, while cost complaints are compared with industry benchmarks from the International Energy Agency (IEA, 2023).

A secondary assumption is that federal carbon neutrality targets will remain a policy priority through 2050, ensuring the relevance of proposed reforms. While political shifts could alter Malaysia's climate commitments, the study aligns with the current administration's ratified policies, including the Twelfth Malaysia Plan (2021-2025) and binding international agreements like the Paris Agreement (Ministry of Environment and Water,

2021). These delimitations and assumptions collectively define the study's boundaries while providing a credible foundation for its conclusions.

DATA ANALYSIS AND DISCUSSION

The findings of this study are structured around three core themes derived from the qualitative analysis: policy-legal barriers, operational challenges, and proposed solutions. These themes emerged through rigorous coding of interview transcripts and policy documents, revealing critical insights into Sabah's road freight decarbonization challenges.

Policy-Legal Barriers

The analysis of Malaysia's National Transport Policy (NTP) 2019-2030 and Sabah's Commercial Vehicle Licensing Board (CVLB) regulations uncovered significant gaps in aligning federal sustainability goals with state-level implementation. While the NTP broadly advocates for low-carbon freight, it lacks Sabah-specific provisions to address the state's unique logistical constraints, such as its reliance on diesel due to limited rail connectivity (Rahim et al., 2023). Interview participants from policymaking bodies (4/20) emphasized this disconnect, with one stating:

"The NTP sets ambitious targets for electrification, but Sabah's freight operators need tailored support—like subsidies for rural charging stations—which federal policies don't yet provide." (Policymaker 1)

Furthermore, Sabah's CVLB Act inadvertently perpetuates diesel dependency by imposing uniform licensing fees for electric and diesel trucks, removing financial incentives for cleaner technologies (Hassan & Tan, 2024). A CVLB official admitted:

"Our fee structure hasn't been updated to reflect emission differences. A 40-tonne electric truck pays the same as a diesel one, so operators see no advantage in switching." (Policymaker 3)

These findings align with Ecological Modernization Theory (EMT), which highlights the need for policy coherence to drive technological adoption (Mol & Spaargaren, 2000). The absence of Sabah-specific mandates in the NTP and outdated CVLB rules exemplify the regulatory misalignment EMT identifies as a barrier to sustainability transitions.

Operational Challenges

Interviews with logistics firms (12/20) revealed that cost and infrastructure gaps are the most pressing barriers to green logistics adoption:

1. High EV Costs:
    - 15/20 participants (75%) cited the prohibitive upfront cost of electric trucks as their primary concern. A large-fleet operator noted:

      "An electric truck costs RM 1.2 million versus RM 700,000 for diesel. Even with 20% federal grants, the payback period exceeds five years—it's too risky for SMEs." (Operator 5)

    - This corroborates IEA (2023) data showing Southeast Asia's EV trucks are 30–50% more expensive than diesel equivalents.
2. Biodiesel Infrastructure Deficits:
    - 12/20 firms (60%) reported no biodiesel refueling stations along critical routes like the Kota Kinabalu–Tawau corridor. A medium-sized operator explained:

      "We tested biodiesel blends, but the nearest refueling point is 300 km away. Diesel is the only

viable option." (Operator 9)

- This reflects Sabah's lag behind Peninsular Malaysia, where 20+ biodiesel stations support freight decarbonization (Ministry of Plantation and Commodities, 2023).

These operational hurdles resonate with EMT's emphasis on economic and infrastructural prerequisites for ecological modernization (Janicke, 2008). Without addressing cost disparities and infrastructure gaps, policy mandates alone are insufficient to drive change.

Proposed Solutions

Participants universally agreed that targeted interventions could accelerate Sabah's transition. Three high-priority solutions emerged:

1. State-Level EV Subsidies:
    - 18/20 participants (90%) advocated for Sabah-specific grants to offset EV costs. A small-fleet owner proposed:

      "If the state government covered 30% of the EV price and offered low-interest loans, we'd switch immediately." (Operator 2)

    - This aligns with Thailand's EV 3.5 Package, which reduced EV import duties by 50% and increased adoption by 300% in two years (Lee & Koh, 2024).
2. Public-Private Charging Infrastructure:
    - 14/20 participants (70%) stressed the need for solar-powered charging hubs along freight routes. An NGO representative suggested:

      "Partnering with solar firms and logistics companies could fast-track charging stations without straining the grid." (NGO 4)

    - Successful models exist in California's Clean Truck Program, where PPPs deployed 1,000 charging points for heavy trucks (CARB, 2023).
3. Revised CVLB Fee Structures:
    - All 4 policymakers endorsed emission-based licensing fees to incentivize clean trucks. A state transport official recommended:

      "Slashing EV license fees by 50% would signal commitment to green logistics." (Policymaker 4)

These solutions collectively address EMT's call for synergistic policy-industry actions (Murphy & Gouldson, 2000), offering a roadmap for Sabah to reconcile economic and environmental goals.

CONCLUSION

This study has systematically examined the legal, operational, and policy barriers hindering the adoption of sustainable road freight transport in Sabah, Malaysia, through the lens of Ecological Modernization Theory (EMT). The findings underscore that while Malaysia's federal carbon neutrality commitments provide a strong policy foundation, significant gaps remain in translating these ambitions into actionable strategies at the state level. Three critical conclusions emerge from this research.

First, the analysis reveals that policy fragmentation between federal directives and Sabah's implementation frameworks creates substantial roadblocks. The National Transport Policy 2019-2030 lacks Sabah-specific provisions to address the state's unique geographical and infrastructural challenges (Rahim et al., 2023), while

the Sabah Commercial Vehicle Licensing Board's regulations remain skewed toward diesel vehicles due to outdated fee structures (Hassan & Tan, 2024). This misalignment exemplifies EMT's premise that environmental progress requires institutional modernization (Mol & Spaargaren, 2000), suggesting an urgent need to revise Sabah's transport laws to incorporate emission-based incentives and penalties.

Second, the operational barriers identified—particularly the high costs of electric trucks (cited by 75% of participants) and biodiesel infrastructure gaps (reported by 60%)—highlight the interdependence of economic and technological factors in sustainability transitions. These findings reinforce EMT's argument that market mechanisms alone cannot drive ecological modernization without targeted state interventions (Janicke, 2008). For Sabah, this implies that federal subsidies must be complemented by state-level initiatives, such as the proposed "Clean Truck Fund" for SMEs and public-private partnerships to deploy charging infrastructure in freight corridors. The success of analogous programs in Thailand and California (Lee & Koh, 2024; CARB, 2023) provides actionable blueprints for such measures.

Third, the study demonstrates that collaborative governance—a core tenet of EMT—is essential to bridge the gap between policy intent and industry adoption. Interviews revealed that logistics firms are willing to transition to green technologies if given financial guarantees (e.g., long-term subsidies) and infrastructure assurances (e.g., prioritized charging station construction). This aligns with EMT's emphasis on co-regulation between governments and industries (Murphy & Gouldson, 2000), suggesting that Sabah's policymakers should institutionalize working groups with freight operators to co-design implementation roadmaps.

Future Research Directions

While this study has mapped the immediate barriers and solutions, two key areas warrant further investigation:

1. Cost-Benefit Analyses: Rigorous comparisons of biodiesel versus electric trucks in Sabah's context, accounting for variables like terrain-specific energy consumption and maintenance costs, would clarify the most viable decarbonization pathway (Yuan et al., 2023).

2. Stakeholder Power Dynamics: Research should examine how diesel industry lobbying and federal-state jurisdictional conflicts impede policy coherence, expanding EMT's applicability to political economy contexts (Sovacool, 2016).

In conclusion, Sabah's road freight sector stands at a critical juncture. By adopting the policy reforms, infrastructure investments, and governance models proposed in this study, the state can transform its logistical landscape into a driver of Malaysia's 2050 carbon neutrality agenda. The lessons from Sabah also offer a replicable framework for other developing regions grappling with similar sustainability challenges.

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