

EV-DRIVING BEHAVIOR IN TRANSPORTATION AND DISTRIBUTION: A SYSTEMATIC LITERATURE REVIEW ON ENERGY EFFICIENCY, OPERATIONAL COSTS, AND DELIVERY TIMELINESS AT PT DAPENSI DWIKARYA

Alzena Wahyu Kirana¹, Erna Mulyati²

^{1,2}Universitas Logistik & Bisnis Internasional, Bandung, Indonesia

Email : alzenawk3112@gmail.com

Abstract

The electrification of distribution fleets shifts the primary source of inefficiency from internal combustion engines to a complex interplay between battery technology characteristics, charging infrastructure, and driving behavior. At PT Dapensi Dwikarya, internal Fleet Management System (FMS) data from 2025–2026 reveals driving behavior deviations accompanied by an actual energy consumption of 0.23 kWh/km compared to a baseline reference of 0.17 kWh/km representing an excess of approximately 35.29% along with operational incidents that threaten to elevate costs and disrupt delivery schedules. This article conducts a systematic literature review (SLR) to synthesize empirical and conceptual evidence on the relationship between EV-driving behavior, energy efficiency, operational costs, and delivery timeliness. Guided by the PRISMA 2020 framework, the review examines literature published between 2021 and 2026 focusing on electric vehicles, commercial/freight transport, eco-driving, energy consumption, total cost of ownership (TCO), charging, routing, and delivery time. The thematic synthesis highlights three main pathways: (1) aggressive acceleration, frequent deceleration, and underutilization of regenerative braking directly increase energy consumption; (2) total operational costs are driven more strongly by energy efficiency, charging frequency, downtime, and operational patterns than by electricity tariffs alone; and (3) limited driving range, charging delays, and routing decisions impair schedule reliability if not managed in tandem with driver behavior. Managerial implications for PT Dapensi Dwikarya emphasize the need for an integrated framework incorporating driver coaching, FMS-based feedback, coordinated charging scheduling, and cross-functional KPIs balancing kWh/km, cost/km, and on-time delivery performance.

Keywords: delivery timeliness; energy efficiency; EV-driving behavior; operational costs; systematic literature review



By Authors

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1. Introduction

Electric vehicles (EVs) are increasingly positioned as critical instruments for decarbonizing transportation and distribution networks. This transition is highly relevant for logistics service providers, given that freight transport operates under high energy requirements, strict delivery schedules, and high sensitivity to cost per kilometer. Sustainable logistics literature emphasizes that vehicle efficiency, technology selection, fleet utilization, and network design are interconnected components vital for mitigating environmental impact while sustaining service performance (Grant et al., 2022). From a vehicle engineering perspective, the unique characteristics of electric motors, traction batteries, regenerative braking, and powertrain control cause EV dynamics to differ fundamentally from internal combustion engine (ICE) vehicles, meaning traditional driving habits do not necessarily yield optimal energy efficiency in EVs (Ehsani et al., 2018).

These altered technical characteristics elevate EV-driving behavior to a major operational factor. EVs feature instantaneous torque, responsive throttle characteristics, and the capability to recover kinetic energy back into the battery via regenerative braking. Consequently, driver-induced variations in acceleration, deceleration, cruising speed, traffic anticipation, and regenerative braking utilization cause substantial variances in net energy consumption across drivers. Lee et al. (2023) demonstrated that real-world EV energy consumption is heavily dictated by speed profiles, traffic conditions, and the extent of regenerative braking. Similarly, naturalistic driving studies by Zhang et al. (2025) revealed that high-energy-consuming drivers exhibit significantly more frequent and intense acceleration and deceleration events, particularly under congested conditions.

Crucially, empirical evidence indicates that driving behavior can be effectively intervened upon and optimized. Chada et al. (2023) developed a predictive eco-driving assistance system and demonstrated average energy savings of up to 10% in simulator evaluations, alongside notable reductions in speeding violations and unnecessary stops. Eco-driving strategies implemented at signalized intersections have also been shown to reduce both energy consumption and delay by optimizing acceleration and deceleration profiles. These findings reinforce the principle that EV efficiency is not purely a function of static vehicle specifications, but rather an emergent property of human-vehicle-environment interactions.

For transportation and distribution enterprises, energy efficiency must be evaluated alongside operational expenditures. While battery electric trucks and light commercial EVs offer lower direct energy costs and reduced powertrain maintenance requirements, their overall financial viability remains contingent upon vehicle acquisition costs, operational utilization, total mileage, electricity tariffs, battery capacity, fast-charging requirements, downtime, and asset longevity. Total Cost of Ownership (TCO) studies on light commercial vehicles show that EVs can achieve cost parity under favorable operating conditions (Lal et al., 2023; Sendek-Matysiak et al., 2022). For medium and heavy commercial segments, Samet et al. (2024) demonstrated that driving range, battery costs, operating speed, charging power, ambient temperature, and opportunity charging serve as key determinants of the Levelized Cost of Driving (LCOD). Therefore, driving behaviors that elevate kWh/km not only deplete effective battery range but also increase required charging cycles, non-productive dwell time, and per-kilometer operating costs.

The third key operational dimension is delivery timeliness. In EV-based distribution networks, service reliability is shaped not only by distance and traffic congestion, but also by

state of charge (SoC), charging infrastructure location, charging duration, queue times, and customer time windows. Teoh (2021) highlighted that charging strategies must be seamlessly synchronized with fleet operations, as intrusive or emergency charging severely degrades operational efficiency and causes downstream delivery delays. Queue dynamics at depots and public charging stations must be modeled alongside time windows to prevent scheduling failures and customer dissatisfaction. Boysen et al. (2023) further established energy replenishment as an integral constraint in electric vehicle scheduling and routing models.

The operational context of PT Dapensi Dwikarya illustrates the urgent necessity of integrating these three dimensions. Internal Fleet Management System (FMS) audit records revealed 50 minor accident incidents and 121 speeding events within the audit period, while actual energy consumption across the electric fleet reached 0.23 kWh/km against an optimal benchmark of 0.17 kWh/km (PT Dapensi Dwikarya, 2026). This 35.29% energy penalty is directly linked to accelerated component wear, unplanned maintenance overheads, and compromised delivery schedule reliability. Consequently, this study re-frames these operational challenges into a systematic literature review to examine the underlying mechanisms across broader scientific literature.

Based on this background, the paper aims to:

1. Identify how EV-driving behavior influences energy efficiency.
2. Elucidate the causal mechanisms connecting driving habits to operational expenditures.
3. Analyze how EV characteristics, charging constraints, and driving practices affect delivery timeliness.
4. Formulate actionable managerial recommendations tailored for PT Dapensi Dwikarya.

The primary contribution of this review lies in synthesizing three distinct streams of literature eco-driving/energy efficiency, total cost of ownership, and electric vehicle routing/service reliability into a unified operational framework.

2. Method

2.1 Research Design

This study employs a Systematic Literature Review (SLR) methodological approach to identify, evaluate, and synthesize empirical and conceptual literature regarding EV-driving behavior within commercial transportation and distribution. The review protocol strictly adheres to the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to guarantee methodological transparency, replicability, and rigor (Page et al., 2021). The SLR design was chosen to build an integrative, multi-dimensional understanding across eco-driving, electric freight operations, TCO, charging infrastructure, routing, and logistics service reliability streams.

2.2 Participants / Data Source

The data sources comprise peer-reviewed academic literature alongside internal Fleet Management System (FMS) audit data from PT Dapensi Dwikarya. Eligibility criteria for the literature selection were defined as follows:

1. Primary focus on articles published between 2021 and 2026.

2. Investigation of battery electric vehicles (BEVs) or EVs in road transport, commercial fleets, freight, last-mile, or urban distribution.
3. Quantitative or qualitative assessment of at least one target outcome variable (energy consumption, operational cost/TCO, charging duration, travel time, time windows, or delivery reliability).
4. Clear reporting of research methodologies and outcomes.
5. Publication in English.

Exclusion criteria were strictly applied to filter out: (1) studies focusing exclusively on battery chemistry manufacturing or life-cycle emissions without operational driving implications; (2) consumer EV adoption studies lacking commercial fleet or driving behavior perspectives; and (3) non-peer-reviewed commentaries, news reports, and trade articles.

2.3 Instrument and Data Collection

Literature identification was conducted across major academic databases, including Scopus, ScienceDirect, IEEE Xplore, and SpringerLink. The search strategy utilized Boolean query combinations: ("EV-driving behavior" OR "eco-driving") AND "energy consumption" AND ("total cost of ownership" OR "operating cost") AND ("delivery time" OR "routing"). Data extraction was standardized using a structured coding matrix that recorded author details, publication year, vehicle/fleet segment, driving behavior metrics, energy outcomes, cost indicators, service/time metrics, and contextual moderating factors.

2.4 Data Analysis

Data synthesis followed a thematic synthesis approach. Extracted findings were systematically coded according to operational mechanisms and grouped into three primary thematic domains: the energy pathway, the cost pathway, and the service-time pathway. Methodological quality and evidence strength were assessed based on study design clarity, commercial fleet relevance, use of empirical real-world or calibrated simulation data, and explicit links between operational variables and outcomes. Conceptual frameworks were grounded in fundamental logistics and electric vehicle engineering theories (Ehsani et al., 2018; Grant et al., 2022; Novack et al., 2019).

3. Results and Discussion

3.1 Result

The core literature mapped during the systematic review is summarized in Table 1, categorizing study contexts, focus areas, key outcomes, and main empirical findings relating EV-driving behavior to cost and time performance.

Table 1. Main Literature Mapping on EV-Driving Behavior and Operational Performance

Study	Context	Focus	Outcome	Key Findings
Teoh (2021)	Freight EV charging	Charging strategies & driver behavior	Operational efficiency and delays	Emergency or intrusive charging significantly degrades operational efficiency and causes delays.

Study	Context	Focus	Outcome	Key Findings
Sendek-Matysiak et al. (2022)	Light commercial EV	City logistics TCO	Total costs	EV economic competitiveness depends heavily on utilization patterns and operating cost structures.
Chada et al. (2023)	BEV driver simulator	Eco-driving assistance	Energy savings, safety	Predictive eco-driving systems achieve average energy savings of up to ~10%.
Lee et al. (2023)	Real-world EV	Regenerative braking & speed	Net energy consumption	Regenerative braking efficiency and speed variation govern net battery consumption in real operations.
Lal et al. (2023)	Last-mile LCV	Fleet electrification	TCO and emissions	Last-mile BEVs reach economic competitiveness under high-utilization urban routes.
Lyu et al. (2023)	Freight PUD trucks	Diesel vs BE truck TCO	TCO and emissions	Empirical duty-cycle data is vital for accurately assessing fleet electrification economics.
Samet et al. (2024)	Medium/heavy BET	LCOD/TCO modeling	Cost per kilometer	Range, charging power, speed, temperature, and driver costs dictate Levelized Cost of Driving.
Wang et al. (2024)	Heavy goods vehicle	Zero-emission TCO	CAPEX/OPEX trade-offs	BEVs present higher TCO in heavy transport; asset lifespan and battery degradation are critical.
Zhang et al. (2025)	Naturalistic EV driving	Acceleration/deceleration	Energy intensity	Energy-inefficient drivers exhibit significantly more frequent high-intensity speed variations.
Keser (2025)	Last-mile EV routing	Charging trade-offs	Cost and service level	Charging location and timing decisions govern trade-offs between cost and last-mile service quality.

Source: Primary literature synthesis processed (2026).

3.2 Discussion

3.2.1 EV-Driving Behavior and Energy Efficiency

The synthesis demonstrates a direct, consistent relationship between driving dynamics and net energy consumption. Aggressive acceleration spikes instantaneous power draw, amplifying energy loss through internal resistance and electromechanical conversion inefficiencies. Conversely, harsh or abrupt braking bypasses regenerative capabilities, dissipating kinetic energy as friction heat. Lee et al. (2023) established that maximizing regenerative braking recovery significantly reduces net energy consumption per kilometer, though overall efficiency remains constrained by cruising speed and traffic density. Zhang et al. (2025) validated these patterns in naturalistic settings, confirming that aggressive longitudinal speed variations are the dominant behavioral drivers of excess energy consumption.

Importantly, driver feedback mechanisms can mitigate these inefficiencies. Chada et al. (2023) showed that predictive speed guidance reduces energy use by up to 10% while curbing speed limit non-compliance. Applied to PT Dapensi Dwikarya, these insights justify

introducing composite FMS driver scorecards that evaluate harsh acceleration events per 100 km, overspeed frequency, longitudinal acceleration variance, regenerative braking utilization ratios, and individual kWh/km efficiency metrics.

3.2.2 Translating Energy Efficiency into Operational Cost Savings

While energy constitutes the primary variable cost directly altered by driver behavior, the financial impact extends well beyond electricity utility rates. Elevated kWh/km rates accelerate battery depletion, forcing fleets into higher charging frequencies or requiring larger safety state-of-charge buffers. This reduces operational availability and fleet productivity. Samet et al. (2024) emphasized that charging power, opportunity charging windows, speed profiles, and driver labor costs materially shift the Levelized Cost of Driving (LCOD). In urban delivery settings, Lal et al. (2023) and Sendek-Matysiak et al. (2022) demonstrated that EV cost competitiveness relies heavily on operational discipline to preserve high asset utilization.

Maintenance costs are similarly tied to driving behavior. Although EV powertrains have fewer moving parts than internal combustion engines, wear items such as tires, suspension bushings, mechanical brakes, and thermal management systems remain highly sensitive to driving stress. Violent acceleration and braking accelerate tire wear, whereas smooth modulation and effective regenerative braking preserve mechanical brake pads and rotors. Thus, operational cost management must move beyond monthly power bills to track energy cost per kilometer, maintenance cost per kilometer, downtime hours per 1,000 km, and route-level TCO.

3.2.3 Energy Efficiency, Charging Dynamics, and Delivery Timeliness

Driving behavior affects delivery timeliness through both direct and indirect operational mechanisms. Directly, speeding and aggressive driving elevate incident risks and create travel time variability. Indirectly, high energy consumption depletes range prematurely, forcing unscheduled or emergency charging stops. Teoh (2021) highlighted that uncoordinated, emergency charging disrupts delivery sequences and causes substantial schedule slippage.

Consequently, delivery timeliness must be managed as a systemic output rather than an isolated driver performance metric. Route topography, traffic congestion, payload weight, charger availability, queuing times, battery state-of-charge, and loading/unloading dwell times must be monitored within centralized dispatch dashboards. In line with general supply chain principles (Novack et al., 2019), delivery reliability in EV fleets requires balancing service commitments against charging constraints to prevent costly operational bottlenecks.

3.2.4 Managerial Implications for PT Dapensi Dwikarya

Synthesizing these findings offers PT Dapensi Dwikarya a strategic roadmap to transition fleet management from punitive compliance monitoring to an integrated efficiency-and-service model:

1. Upgraded FMS Telematics: Telematics should generate multi-variable driver scores incorporating harsh acceleration, harsh braking, speeding frequency, energy consumption (kWh/km), and idle time.

2. Tailored Driver Training: Training modules must focus specifically on EV dynamics, emphasizing smooth torque modulation, predictive traffic flow management, one-pedal driving techniques, and optimal regenerative braking.
3. Dynamic Charging & Dispatch: Charging schedules must be coupled dynamically with dispatch routing to ensure energy replenishment occurs during planned, non-critical window periods without compromising customer service agreements.
4. Contextual Energy Baselines: Route-specific energy baselines should be established; the 0.17 kWh/km target should be calibrated against route topography, payload mass, and seasonal temperature rather than applied as a rigid universal metric.
5. Cross-Functional KPIs: Integrated KPIs should link leading operational metrics (kWh/km) with financial outcomes (cost/km) and service levels (on-time delivery rate) to sustain long-term operational excellence.

4. Conclusion

This systematic literature review establishes that EV-driving behavior is a crucial determinant of success in commercial fleet electrification. Across empirical, simulation, and optimization studies, driving dynamics specifically acceleration control, speed consistency, and regenerative braking utilization consistently govern energy efficiency. Inefficiencies in kWh/km trigger cascading impacts on operating range, charging frequency, vehicle downtime, and cost per kilometer, while uncoordinated charging directly threatens schedule reliability and on-time delivery performance.

For PT Dapensi Dwikarya, internal FMS data indicating an actual energy consumption of 0.23 kWh/km against a 0.17 kWh/km baseline compounded by speeding and minor incidents aligns with the behavioral efficiency gaps identified in international literature. Addressing these challenges requires a holistic managerial approach that integrates driver coaching, telematics feedback, dynamic charging scheduling, and aligned performance KPIs. Future research should evaluate this framework using empirical longitudinal data from PT Dapensi Dwikarya following driver coaching interventions to measure concurrent improvements in energy consumption, operating costs, and delivery timeliness.

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