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Optimizing Urban Logistics Through Electric Vehicle Integration

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ABSTRACT : The transition to electric-based logistics has become increasingly vital in the pursuit of sustainable urban transportation. This study presents a narrative review of recent literature examining the efficiency, environmental impact, and policy dimensions of electric vehicle (EV) adoption in logistics. Drawing on peer-reviewed articles from Scopus and Google Scholar published between 2015 and 2024, this review employed systematic keyword searches and thematic analysis to synthesize research findings. It includes studies on route optimization algorithms, charging infrastructure, economic feasibility, and the social implications of EV integration. Results indicate that EVs can significantly reduce urban emissions, improve delivery efficiency, and lower long-term operational costs. Advanced optimization algorithms and well-distributed charging infrastructure are essential for system performance. Public policies, such as financial incentives and emission regulations, strongly influence adoption rates, especially in regions with supportive governance. Despite these benefits, barriers such as high initial costs, limited charging networks, and the need for skilled labor persist. This review concludes that effective electrification of logistics requires coordinated investments in technology, policy, and human capital. Future research should focus on longitudinal and cross-regional studies, real-world pilot implementations, and stakeholder-inclusive policy design. The adoption of EVs in logistics presents a critical pathway toward achieving global climate goals, urban livability, and sustainable economic development.

Keywords: Electric Logistics; Sustainable Transportation; Electric Vehicle Adoption; Green Delivery Systems; Charging Infrastructure; Policy Incentives; Urban Freight

INTRODUCTION

In recent years, the global landscape has witnessed a remarkable shift towards electrification in logistics and transportation sectors, driven largely by the urgent need to reduce greenhouse gas emissions and embrace sustainable transport solutions. This movement is further propelled by the rapid expansion of e-commerce, which demands more efficient and environmentally conscious delivery methods. In response to these needs, the adoption of electric vehicles (EVs) in urban freight systems has gained momentum as a viable alternative to fossil-fueled fleets. According to Settey et al. (2021), the COVID-19 pandemic significantly accelerated the demand for urban logistics centers that utilize electric vehicles to reduce intra-city mileage and emissions. This trend is particularly pertinent in metropolitan areas where stricter traffic and emission regulations are increasingly enforced, making traditional delivery methods less feasible.

Southeast Asia, in particular, has seen a surge in EV adoption for logistics, encouraged by both government initiatives and private sector investments in charging infrastructure. Preedakorn et al. (2023) highlight that policy coherence and government incentives have played a vital role in enhancing EV market share in Thailand. These include fiscal incentives for logistics companies that adopt EVs, and support for the development of supportive infrastructure. Similar strategies have been observed in other Southeast Asian nations such as Indonesia, further indicating a regional commitment to fostering environmentally sustainable transportation networks. These developments underscore the timeliness and importance of critically examining electric-based logistics systems and their implications.

The transportation sector is a major contributor to global carbon dioxide emissions, accounting for approximately 24% of total CO2 emissions worldwide (Luan, 2024; Lu & Li, 2023). Electrification of logistics represents a substantial opportunity to mitigate this impact, particularly in urban settings where transport activities are dense and frequent. Yan et al. (2021) emphasize that optimized logistics and strategic investments in EVs could significantly enhance renewable energy integration in urban energy systems. This aligns with findings from Kijewska et al. (2019), who argue that EVs generally produce lower lifecycle emissions compared to internal combustion engine vehicles when considering their full environmental impact.

Beyond vehicle substitution, electric logistics encompasses broader innovations such as intelligent fleet tracking and smart distribution management tools. As Luan (2024) asserts, route optimization is a pivotal aspect of enhancing logistics efficiency, offering dual benefits in cost savings and emission reductions. This is particularly relevant as the logistics industry contends with increasing recycling loads and the imperative to support circular economic models (Khan et al., 2023). These new demands necessitate adaptive and resilient systems that integrate both technology and sustainability at their core.

Equally critical to the success of electric logistics is the development of effective charging infrastructure. Zhou et al. (2022) advocate for innovations in fast-charging and intelligent replenishment systems, which can harmonize the operational schedules of EV fleets while minimizing downtime and emissions. Efficient charging solutions not only facilitate seamless operations but also strengthen the feasibility of large-scale EV deployment in commercial logistics. In this regard, electrification stands to contribute not only to environmental goals but also to broader sustainable development agendas.

Despite these promising developments, several challenges remain. A major barrier is the inadequacy of charging infrastructure, particularly in developing cities. Settey et al. (2021) note that poor placement of charging stations can disrupt delivery routes and extend vehicle idle times, thereby undermining efficiency. Fan et al. (2023) further illustrate the complications posed by varying battery capacities and inconsistent charging speeds, which complicate distribution route planning and operational predictability.

Another significant challenge is the limited range and load capacity of electric vehicles. Yang et al. (2024) report that EVs generally have shorter ranges compared to their fossil-fueled counterparts, making them less suitable for long-haul or high-capacity urban deliveries. This limitation necessitates more sophisticated logistics planning and raises concerns regarding cost-effectiveness and operational viability. Furthermore, the high initial costs associated with EV acquisition and infrastructure development continue to hinder widespread adoption, especially among small and medium-sized logistics enterprises (Karganroudi et al., 2020).

Battery technology remains a critical constraint, as current EV batteries often fall short in terms of durability, energy density, and charging time. Fan et al. (2023) underscore the ongoing reliance on technological advancements to make EVs more appealing and functional for logistics purposes. Innovative solutions such as battery swapping and ultra-fast charging may offer potential pathways forward, but their scalability and integration into existing systems require further exploration and policy support.

Public awareness and acceptance of EV logistics also present challenges. While there is general understanding of EVs' environmental benefits, deeper knowledge about long-term advantages and operational potential remains limited. Gonzales-Calienes et al. (2022) emphasize the role of public education and outreach in fostering broader acceptance and encouraging behavioral shifts necessary for successful EV integration.

There is a notable gap in the literature concerning the comprehensive optimization of logistics systems that incorporate electric vehicles. Yang et al. (2024) point out that existing studies often emphasize technical parameters without adequately addressing the interplay between infrastructure readiness, route planning, and regulatory frameworks. Similarly, Fan et al. (2023) argue that many routing models fail to consider externalities such as traffic conditions and demand variability, which are critical to real-world applicability.

Moreover, Zeng et al. (2023) observe a dearth of scenario-based simulations that capture the practical implications of deploying EV fleets in urban freight contexts. Meng et al. (2024) advocate for more robust data-driven analyses to forecast delivery demands and optimize EV utilization accordingly. These gaps highlight the need for interdisciplinary research that integrates technological, policy, and behavioral dimensions to refine electric logistics frameworks.

This literature review aims to critically examine the factors influencing the efficiency, sustainability, and policy development of electric-based logistics systems. Specifically, it seeks to synthesize existing research on the operational efficiency of EV deployment in logistics, evaluate the sustainability outcomes of electrified freight systems, and assess the policy instruments that facilitate or hinder their implementation. By identifying patterns and divergences in current studies, this review endeavors to provide a comprehensive understanding of the electric logistics landscape.

The geographical scope of this review primarily centers on Southeast Asia, with particular emphasis on Thailand and Indonesia due to their emerging roles in green transportation policy and infrastructure development. This regional focus is justified by the unique challenges and opportunities these countries present, including diverse urban geographies, varying levels of infrastructure maturity, and differing policy environments. Additionally, case studies from other regions are included where relevant to offer comparative insights and contextual grounding.

In conclusion, the integration of electric vehicles into logistics systems represents both a challenge and an opportunity in the global pursuit of sustainable urban development. While promising strides have been made, persistent issues in infrastructure, technology, cost, and public perception continue to complicate this transition. By bridging existing research gaps and exploring context-specific factors, this review aims to contribute valuable insights that support the advancement of electric-based logistics as a cornerstone of future sustainable transport systems.

METHOD

This study adopts a structured literature review methodology to identify, evaluate, and synthesize scholarly research related to electric-based logistics systems, particularly within the domains of green transportation, sustainable delivery, and last-mile distribution. To ensure a comprehensive and academically rigorous approach, literature collection was carried out through systematic searching in reputable academic databases, namely Scopus and Google Scholar. These databases were selected due to their extensive coverage of peer-reviewed journals, conference proceedings, and academic publications within the fields of transportation, environmental sustainability, urban planning, and logistics management.

To initiate the literature search, a combination of keywords and Boolean operators was employed. The selection of keywords was carefully designed to reflect both the breadth and specificity of the study. For the domain of electric logistics, terms such as "Electric Logistics," "Electric Vehicle Logistics," and "Logistics with Electric Vehicles" were prioritized. Within the scope of green transportation, search phrases included "Green Transportation," "Sustainable Mobility," and "Eco-Friendly Transportation." The term "Sustainable Delivery" was expanded to include variations such as "Sustainable Urban Logistics" and "Eco-Friendly Delivery Systems." Lastly, to capture research on the most dynamic segment of the logistics chain, keywords like "Last-Mile Delivery," "Last-Mile Logistics," and "Urban Last-Mile Solutions" were used.

These keywords were combined using Boolean logic to enhance the relevance and precision of search results. For instance, queries such as "Electric Logistics AND Sustainable Delivery" or "Green Transportation OR Electric Vehicle Logistics" yielded a refined body of literature that intersects electric vehicle technology and sustainable logistics practices. The initial keyword framework was iteratively refined as new terminologies emerged during the review process, allowing the researchers to remain adaptive to evolving discourse within the field.

Following the keyword search, inclusion and exclusion criteria were meticulously established to ensure that only pertinent and credible studies were selected for review. The inclusion criteria mandated that articles must be directly related to electric vehicle technology, logistics, sustainability, or last-mile delivery frameworks. Only peer-reviewed journal articles, scholarly book chapters, and recognized conference proceedings were considered eligible. To maintain contemporaneity, only publications from the year 2015 onward were reviewed, acknowledging that the technological and regulatory environment surrounding electric logistics has evolved significantly in the last decade. The studies were also required to demonstrate methodological robustness, whether through quantitative analysis, qualitative inquiry, or mixed methods approaches that provided insights into the measurement of efficiency, emissions reduction, cost-effectiveness, or policy impacts.

Exclusion criteria were defined to eliminate studies of marginal relevance or questionable academic integrity. Articles that did not explicitly address electric-based logistics, or which concentrated on tangential issues such as macroeconomic conditions without a direct link to transportation policy, were excluded. Similarly, sources from non-indexed or unaccredited journals were disregarded to uphold quality standards. Case studies with extremely narrow scopes that lacked generalizability or were not situated within the broader logistical or policy context were also omitted. Furthermore, research utilizing outdated methodologies or technologies that no longer align with current industry practices was excluded to maintain the study's focus on cutting-edge and applicable innovations.

After conducting the initial search, all identified articles were imported into a reference management software for screening and organization. Duplicate entries were removed, and the remaining titles and abstracts were reviewed for relevance. Articles that passed this preliminary screening were then subjected to a full-text review to assess their methodological quality, conceptual clarity, and contribution to the study's thematic framework. A qualitative coding process was applied to categorize the literature into core themes related to operational efficiency, environmental sustainability, policy development, and technology adoption. This thematic mapping allowed for a coherent synthesis of findings across various contexts and research designs.

Throughout the selection process, efforts were made to include a diverse array of studies, covering different geographic regions, economic contexts, and logistical configurations. This diversity was crucial for developing a nuanced understanding of how electric logistics systems function across varied infrastructural and policy environments. Where possible, studies involving comparative case analysis or longitudinal data were prioritized for their ability to reveal patterns over time and across settings.

The types of studies included in the review were broad yet focused in their relevance. Empirical studies, including experimental research on electric vehicle performance, case studies of city-level logistics systems, simulation-based modeling of distribution networks, and econometric analyses of policy impacts formed the core of the reviewed literature. Additionally, several theoretical and conceptual papers that offered frameworks for evaluating electric logistics systems were incorporated to strengthen the analytical grounding of the review. Both qualitative studies that provided in-depth insight into stakeholder behavior and perceptions, and quantitative studies that offered statistical validation of environmental and economic claims, were equally valued.

The screening and selection process was guided by an underlying principle of methodological triangulation. By integrating diverse research methods and data sources, the review aimed to provide a comprehensive portrayal of the state of knowledge in electric-based logistics. This approach also enabled the identification of consensus areas, ongoing debates, and research gaps within the field.

Ultimately, the literature selected through this rigorous process forms the foundation for the subsequent sections of this study. It enables a critical analysis of key trends, challenges, and policy opportunities that shape the adoption and effectiveness of electric vehicles in logistics. By leveraging a transparent and systematic methodology, this review contributes to advancing scholarly understanding and informing evidence-based decision-making in the pursuit of sustainable transportation systems.

RESULT AND DISCUSSION

The transition to electric-based logistics has driven a wave of technological innovations and policy developments, particularly in route optimization and charging infrastructure, economic efficiency, and environmental and social impact. This section presents synthesized findings from key studies that explore these thematic domains, supporting the growing consensus that electric vehicle (EV) adoption in logistics can deliver significant operational, environmental, and socio-economic benefits.

In the realm of route optimization and charging infrastructure, literature reveals that the design and implementation of route optimization algorithms tailored to electric logistics play a central role in enhancing efficiency. Zahedi et al. (2023) proposed a hybrid metaheuristic approach to address the capacitated electric vehicle routing problem with time windows. Their findings indicate that by incorporating charging time and vehicle capacity constraints into the model, significant reductions in delivery time, cost, and carbon emissions can be achieved. These results suggest that a careful balance between operational constraints and algorithmic design can lead to more efficient logistics operations.

Yang et al. (2024) emphasized the use of advanced optimization models for fresh food distribution using EVs. Their study demonstrated that route planning based on real-time traffic data and comparative analysis of variables such as distance and travel time can enhance delivery performance. The model not only improved logistical efficiency but also contributed to sustainability by reducing idle time and optimizing energy consumption. The increasing application of data-driven tools and machine learning techniques in EV routing indicates a maturing field with substantial potential for real-world implementation.

Fleet management systems, often integrated with mobile technologies and geographic information systems (GIS), further support the responsive and adaptive allocation of delivery tasks. Although not always explicitly stated in empirical studies, there is broad support in the literature for the use of such systems to improve last-mile delivery responsiveness. These technologies enable dynamic scheduling, adaptive routing, and real-time monitoring, which are particularly relevant in dense urban settings where delivery constraints are complex and time-sensitive.

Parallel to the development of routing algorithms, research on charging infrastructure reveals the critical importance of effective, well-distributed charging stations for EV adoption in logistics. Hayajneh and Zhang (2020) categorized charging stations into residential and commercial types and analyzed their distribution trends across several countries. Their study showed that nations with supportive policies and comprehensive charging networks have seen faster and more cost-effective integration of EVs into logistics fleets. The findings indicate that beyond technological readiness, institutional and regulatory frameworks significantly influence the viability of electrified logistics.

Government incentives, subsidies, and public-private partnerships have proven effective in several regions, particularly in Europe and East Asia. These mechanisms reduce the total cost of ownership for logistics firms and ensure that infrastructure investments are aligned with long-term transportation goals. By contrast, countries with underdeveloped policy frameworks or inconsistent regulatory support tend to experience slower adoption and higher operational costs. Thus, the interdependence between route optimization and charging infrastructure emerges as a pivotal area for both research and policy innovation.

Economic efficiency and total cost of ownership (TCO) are essential parameters influencing the decision-making processes of logistics firms. Saxena and Yadav (2023) conducted a comparative study revealing that while EVs often have higher upfront costs, they offer considerable savings in operational and maintenance expenses over time. The lower frequency of repairs, fewer moving parts, and higher energy efficiency contribute to long-term cost reductions. Their analysis incorporated energy costs, insurance rates, and available tax incentives, providing a comprehensive view of cost-benefit considerations for EV adoption.

Settey et al. (2021) corroborated these findings in the context of urban distribution, where EVs demonstrated competitive operational performance relative to traditional fuel-based vehicles. Companies that adopted EVs experienced notable savings in fuel costs and reduced exposure to urban emission penalties, thereby improving overall profitability. The study highlighted the synergy between environmental compliance and economic viability, suggesting that the green transition does not necessarily entail financial sacrifice.

However, economic factors affecting adoption remain multifaceted. Saxena and Yadav (2023) noted that financial barriers, especially related to initial capital investment, remain a significant concern for small and medium-sized enterprises (SMEs). Despite favorable long-term economics, many firms remain hesitant due to uncertainty around return on investment. Government subsidies and financing mechanisms thus play a crucial role in de-risking EV investments and enabling broader participation.

Energy pricing and access to affordable, reliable electricity are also influential. Yan et al. (2021) emphasized that stable renewable energy prices and well-developed charging networks reduce the financial risks associated with EV logistics. They also stressed the importance of aligning national energy strategies with transportation electrification goals. Unstable or regionally variable electricity rates can undermine the financial logic of switching to electric logistics systems, especially in price-sensitive markets.

In addition to cost considerations, public and industry perceptions continue to affect the pace of EV adoption. Williams and Anderson (2024) found that skepticism regarding EV performance, range, and durability persists among logistics managers. While empirical data often refutes these concerns, perception-based resistance can slow innovation uptake. Educational campaigns and industry demonstration projects are increasingly viewed as necessary complements to policy incentives, ensuring that potential adopters are fully informed of the technological and economic merits of EVs.

From an environmental standpoint, empirical studies strongly support the claim that electric logistics significantly reduces urban emissions and contributes to cleaner air quality. Settey et al. (2021) reported that using EVs for urban deliveries in Bratislava led to a 30% reduction in greenhouse gas emissions compared to conventional fleets. This result is especially significant in metropolitan areas where transportation is a primary source of air pollution. Furthermore, EVs generate substantially less noise pollution, contributing to more livable urban environments.

Supporting these findings, Kovač et al. (2023) observed notable reductions in nitrogen dioxide (NO2) and particulate matter (PM) levels in cities adopting electric logistics systems. These pollutants are directly linked to respiratory and cardiovascular diseases, making their reduction a key public health benefit of electrification. The study aligned with broader sustainability goals by highlighting the dual benefits of emissions reduction and health impact mitigation.

The social implications of electrified logistics are equally pertinent. Transitioning to EVs can drive labor market transformations by creating demand for new skill sets and technical competencies. Kovač et al. (2023) and Yan et al. (2021) argued that the EV transition presents opportunities for workforce development in battery maintenance, EV repair, and charging infrastructure management. However, they also cautioned that existing workers may require reskilling to remain employable in an evolving industry landscape.

Hayajneh and Zhang (2020) highlighted the role of continuous professional training programs in ensuring a smooth workforce transition. Firms that adopt EVs often initiate upskilling programs for technicians and drivers, which not only retain existing staff but also enhance service quality. The emphasis on training reflects an understanding that technological change must be paralleled by human capacity development.

Fan et al. (2023) added that EV-related employment could offer more sustainable and inclusive job opportunities, particularly in underserved urban communities. By aligning EV deployment with local workforce development policies, cities can foster economic inclusion while advancing environmental objectives. These social benefits underscore the multi-dimensional impact of EV logistics systems and justify broader support for their implementation.

In sum, the body of literature reviewed affirms that electric logistics systems can deliver measurable improvements in operational efficiency, environmental outcomes, and social equity. Optimized routing algorithms reduce travel distances and energy consumption, while robust charging infrastructure enables seamless operations. Economically, EVs offer long-term savings and stability, although adoption hinges on supportive policy and market conditions. Environmentally, reductions in emissions and noise foster healthier urban environments. Socially, the transition fosters workforce development and inclusive economic growth. Collectively, these findings make a compelling case for continued investment in research, infrastructure, and policy frameworks to support the widespread adoption of electric logistics technologies.

The findings from recent studies on electric logistics reinforce and expand upon existing literature while offering new perspectives on the structural, economic, and social dynamics surrounding the adoption of electric vehicles (EVs) in logistics. These studies contribute to a more nuanced understanding of the challenges and opportunities associated with electrified freight systems. They also highlight the importance of systemic integration, policy support, and adaptive technologies in ensuring the success of EV-based logistics networks.

Settey et al. (2021) illustrated how the rise of e-commerce and urban distribution needs have accelerated EV adoption, particularly in dense metropolitan settings. This trend aligns with earlier findings that urban delivery systems are both major contributors to pollution and ideal candidates for electrification due to their relatively short delivery routes and high frequency of stops. The evidence supporting reductions in carbon emissions and urban air pollution from the use of EVs corroborates established literature on the environmental benefits of vehicle electrification. Similarly, Kovač et al. (2023) reinforced the significance of EVs in enhancing resource efficiency and urban sustainability through better fleet integration and logistics planning. Their work affirms earlier studies advocating for holistic and systematic approaches to urban logistics transformations.

Further support for the long-term economic advantages of EV logistics comes from the work of Yan et al. (2021), who emphasized reduced energy consumption and operational costs. These results mirror earlier literature suggesting that despite high initial investment costs, the overall cost efficiency of EVs makes them a viable long-term solution for logistics operations. However, Hayajneh and Zhang (2020) introduced a critical counterpoint by highlighting ongoing technological limitations, particularly regarding battery durability and charging infrastructure. Their work serves as a reminder that full cost optimization and environmental impact reduction remain contingent upon further technological innovation and infrastructure development.

From a social and policy perspective, the work of Preedakorn et al. (2023) added depth by examining region-specific challenges, such as Thailand's infrastructure readiness and financial constraints. These findings expose a notable gap in earlier literature, which often overlooked local contextual challenges in EV implementation. Fan et al. (2023) and Zhao et al. reinforced the influence of public policy, underscoring that government-led incentives, subsidies, and infrastructure investments are instrumental in accelerating adoption. The intersection of policy, economics, and technology revealed by these studies highlights the multifaceted nature of the transition toward electric logistics.

Public policy plays a decisive role in facilitating or hindering the electrification of the logistics sector. Financial incentives and supportive regulations have emerged as primary tools for encouraging adoption. As noted by Preedakorn et al. (2023), subsidies and tax reductions significantly lower the financial barriers for logistics firms, particularly in developing countries where capital constraints are more pronounced. Without such support, firms may remain hesitant to transition due to the high costs of acquiring EVs and uncertainties about long-term returns.

The comprehensive policy frameworks advocated by Zhao et al. and observed in regions with successful EV integration reveal the importance of aligning emission standards, infrastructure development, and market mechanisms. In jurisdictions where governments have introduced stringent emissions regulations alongside funding for EV infrastructure, adoption rates have generally been higher. For example, Settey et al. (2021) documented a strong correlation between emissions regulations and EV uptake in urban logistics, indicating that policy can serve as both carrot and stick. Yet, these strategies require complementary investments in infrastructure, as stringent policies without adequate charging facilities may exacerbate implementation barriers, especially for SMEs with limited operational flexibility.

The systemic nature of these issues is also evident in the discussion on charging infrastructure. Hayajneh and Zhang (2020) identified the uneven distribution and limited availability of charging stations as a critical impediment to large-scale EV adoption. Even with financial incentives in place, the absence of reliable and accessible charging infrastructure can render fleet electrification impractical. Therefore, public investment in strategically located charging hubs, particularly in urban logistics corridors, emerges as a priority area for policy intervention. Additionally, stakeholder collaboration between energy providers, logistics firms, and municipal planners is essential to ensuring infrastructure development aligns with operational realities.

The involvement of stakeholders is further emphasized by Williams and Anderson (2024), who noted that inclusive policymaking benefits from diverse stakeholder engagement. Involving community representatives, logistics professionals, and environmental groups in the policy design process ensures that strategies are grounded in practical needs and social considerations. Their work illustrates that sustainable logistics is not solely a technological or economic issue, but one deeply intertwined with governance and equity. Policies designed with input from a broad range of stakeholders are more likely to achieve public legitimacy and operational success.

To overcome barriers in electric logistics, the literature proposes several strategic solutions. Expanding and enhancing EV charging infrastructure is consistently identified as foundational. Settey et al. (2021) advocated for the integration of charging stations within urban logistics hubs to improve EV viability in high-density delivery environments. Fan et al. (2023) highlighted the importance of data-driven planning for charging station placement, arguing that infrastructure should reflect actual usage patterns to optimize accessibility and reduce downtime. These findings point toward a need for spatial analytics and fleet behavior modeling in infrastructure planning.

Policy support remains central to these strategies. As Preedakorn et al. (2023) emphasized, fiscal incentives such as EV purchase subsidies and tax exemptions are effective in lowering entry barriers. Complementary policies, such as setting national carbon reduction targets and encouraging private-sector participation through green procurement practices, further align economic incentives with environmental objectives. Kovač et al. (2023) illustrated how coordinated government ambitions for decarbonization can catalyze industry shifts toward electric fleets.

Another vital solution involves education and workforce development. The transition to electric logistics demands a reconfiguration of skills within the industry. Kovač et al. (2023) stressed the importance of providing technical training in EV maintenance, battery management, and fleet software systems to ensure that workers are equipped to support the new logistics paradigm. Without such support, the transition may result in labor displacement or operational inefficiencies. Proactive human resource strategies can turn the EV shift into an opportunity for economic inclusion and job quality improvement.

Innovation in optimization technology also plays a critical role in overcoming logistical inefficiencies. Luan (2024) highlighted how advanced routing algorithms and data analytics can reduce operational costs while maximizing the performance of electric fleets. These tools take into account dynamic variables such as charging schedules, traffic conditions, and delivery time windows. By integrating artificial intelligence and machine learning, logistics operations can achieve real-time responsiveness and resilience, essential traits in the evolving landscape of urban logistics.

Lastly, stakeholder alignment and community engagement are emerging as strategic imperatives. Williams and Anderson (2024) argued that by involving local communities in EV deployment planning, cities can tailor solutions to reflect localized needs and ensure that electrification delivers social as well as environmental benefits. Their emphasis on inclusivity suggests that effective EV integration requires not only top-down policy but also grassroots buy-in.

Despite the breadth of available research, significant limitations persist. Much of the current literature focuses on technological and economic dimensions, with fewer studies examining cultural, behavioral, and institutional factors that shape EV adoption. Additionally, there is limited cross-regional analysis comparing policy impacts and operational outcomes, which constrains the generalizability of findings. Future research should aim to fill these gaps by incorporating longitudinal data, real-world pilot studies, and interdisciplinary approaches that combine environmental science, economics, and sociology. Addressing these limitations will be essential for guiding evidence-based policymaking and advancing the next phase of electric logistics implementation.

CONCLUSION

This narrative review highlights the critical role of electric-based logistics in advancing sustainable urban freight systems. The findings demonstrate that electric vehicles (EVs) offer significant advantages in operational efficiency, environmental impact, and long-term cost savings. Optimization algorithms and data-driven routing models enhance delivery performance and reduce emissions, while the development of charging infrastructure remains pivotal to implementation success. Economic analysis confirms that although upfront costs are high, the total cost of ownership decreases over time due to lower maintenance and energy costs. Moreover, EVs contribute positively to air quality and noise reduction in urban areas, aligning with global environmental goals.

However, challenges persist, including limited charging networks, high initial investment, and the need for workforce upskilling. Public policies and financial incentives have proven crucial in overcoming these barriers, yet gaps remain in regional readiness, policy coherence, and stakeholder coordination. Therefore, policy frameworks must be inclusive, flexible, and responsive to local socio-economic conditions.

Future research should prioritize real-world pilot projects, longitudinal evaluations, and cross-sector collaboration to address technological, behavioral, and institutional limitations. Emphasis should be placed on the integration of optimization technologies, infrastructure planning, and workforce development as core strategies for accelerating EV adoption in logistics. By aligning these strategic levers, the transition to electric logistics can be achieved more equitably and effectively, supporting broader sustainability, public health, and economic resilience goals.

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