WEP Warwick Evans Publishing

International Journal of Global Economics and Management

ISSN: 3005-9690 (Print), ISSN: 3005-8090 (Online) | Volume 10, Number 1, Year 2026
DOI: https://doi.org/10.62051/ijgem.v10n1.07
Journal homepage: https://ijgem.org

Electric Vehicle Routing Optimization Oriented to Intelligent Transportation Systems: A Review and Future Trends

Shiqi Zhang

School of Economics and Management, Chongqing Jiaotong University, Chongqing, 400074, China

622230122016@mails.cqjtu.edu.cn

ABSTRACT

With increasingly stringent environmental constraints and the rapid growth of urban logistics demand, electric vehicles (EVs) have become an important component of urban delivery systems due to their low-carbon, energy-efficient, and low-noise characteristics. However, limited driving range, charging requirements, and the uneven spatial distribution of charging infrastructure make the electric vehicle routing problem (EVRP) significantly more complex than conventional vehicle routing problems, posing new challenges to logistics operations and traffic management. In recent years, extensive research has been conducted on EV routing optimization, covering route planning, charging strategy coordination, mixed fleet operations, and charging infrastructure deployment. Meanwhile, the rapid development of intelligent transportation systems (ITS) has provided new technical support for EV routing optimization. By leveraging real-time traffic information, data sharing, and intelligent dispatching, ITS enhances the adaptability and responsiveness of routing decisions, thereby improving delivery efficiency and reducing energy consumption and emissions. This paper presents a comprehensive review of EV routing optimization oriented to ITS, systematically summarizing key research issues and application scenarios. Future development trends related to technological integration, infrastructure planning, and system-level coordination are also discussed, providing insights for the development of efficient, low-carbon, and sustainable urban logistics and transportation systems.

KEYWORDS

Electric vehicle routing problem; Intelligent transportation systems; Urban logistics; Green transportation

1. INTRODUCTION

With the intensification of global climate change and the continuous enhancement of environmental awareness, electric vehicles (EVs) have gradually gained prominence in the logistics and transportation sector due to their low-carbon, environmentally friendly and energy-efficient characteristics [1]. Compared with conventional fuel-powered vehicles, EVs offer significant advantages such as zero tailpipe emissions, low noise levels, and reduced operating costs, making them an effective solution for mitigating urban air pollution and traffic-related environmental impacts. As a result, EVs are increasingly adopted in urban logistics, express delivery, and on-demand distribution services, while governments worldwide have introduced supportive policies and incentives to accelerate their market penetration. Fig. 1 illustrates the overall workflow of an electric vehicle-based delivery system, providing a comprehensive overview of the distribution process.

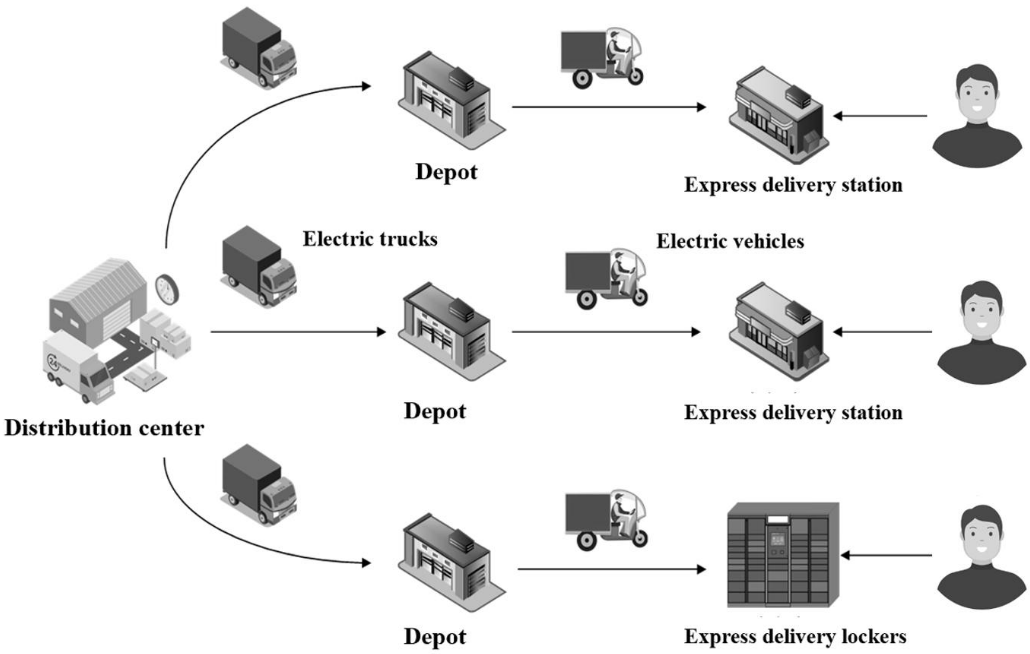

Figure 1. Framework of an electric vehicle–based urban delivery system

Despite these advantages, the electric vehicle routing problem (EVRP) is considerably more complex than the traditional vehicle routing problem (VRP). In addition to conventional constraints such as vehicle capacity and time windows, EVRP must explicitly account for EV-specific limitations, including restricted driving range, prolonged charging time, and the spatial heterogeneity of charging infrastructure [2]. These factors substantially increase the complexity of route planning and pose significant challenges to logistics operators, particularly in densely populated urban environments where delivery efficiency is critical. In response to these challenges, a growing body of literature has investigated EVRP and proposed a wide range of routing optimization methods and solution frameworks. Existing studies not only focus on routing problems involving homogeneous electric vehicle fleets but also extend to mixed fleet routing with both electric and conventional vehicles, as well as integrated optimization of routing decisions and charging station location [3, 4]. These research efforts have greatly enriched the theoretical foundation of EVRP and provided valuable insights for practical logistics operations.

Meanwhile, the rapid advancement of intelligent transportation systems (ITS) has created new possibilities for enhancing EV routing performance. By leveraging real-time traffic data, vehicle positioning technologies, and information-based traffic management, ITS enables dynamic route optimization, intelligent vehicle dispatching, and adaptive charging strategies [5]. The integration of EV routing optimization with ITS has the potential to significantly improve delivery efficiency, reduce energy consumption, and support the development of intelligent and sustainable urban transportation systems. In summary, an in-depth investigation of EVRP from the perspective of ITS is of great significance for improving logistics efficiency, promoting the large-scale adoption of EVs, and advancing the intelligent, green, and sustainable development of urban transportation networks.

2. ELECTRIC VEHICLE ROUTING PROBLEM

The EVRP focuses on determining optimal delivery routes that originate from a depot, serve a set of customer nodes, and ultimately return to the depot, with the primary objective of minimizing total travel distance or overall distribution cost [6]. To provide a more intuitive illustration of the basic structure and operational characteristics of the electric vehicle routing problem, Fig. 2 presents a representative schematic example of an EVRP network. The network is organized around a depot that serves as both the origin and destination of delivery routes. During the service of customer nodes, vehicles may need to visit charging stations for energy replenishment depending on their remaining battery levels. As shown in Fig. 2, different delivery routes vary in terms of whether charging stations are visited and the number of customers served, highlighting the inherent characteristics of electric vehicle routing that require simultaneous consideration of travel distance, energy constraints, and charging requirements. Compared with conventional fuel-powered vehicles, electric vehicles must pay greater attention to energy consumption dynamics and the spatial distribution of charging infrastructure during delivery operations, which constitutes a key distinguishing feature of EVRP relative to the traditional vehicle routing problem.

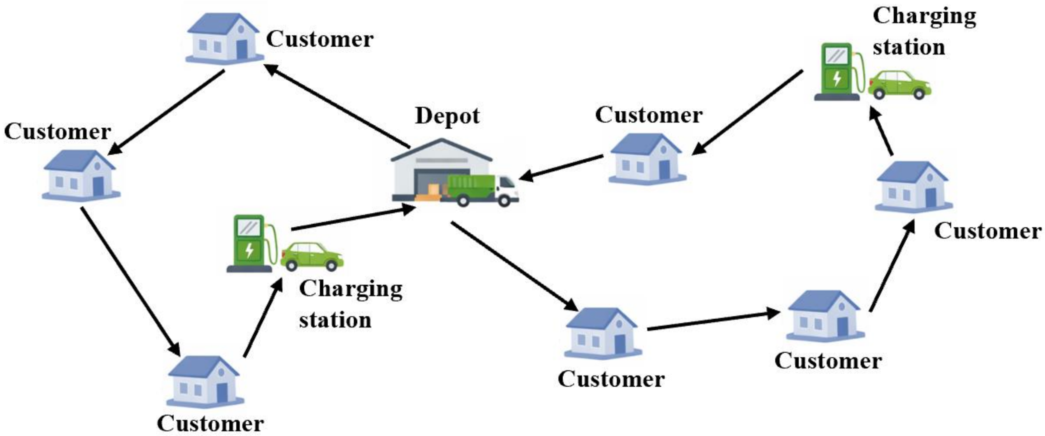

Figure 2. Illustrative electric vehicle delivery routing network

In recent years, the optimization of driving range utilization and charging strategies has emerged as a central research theme in EVRP. By systematically analyzing vehicle energy consumption characteristics, travel routes, and charging behaviors, researchers have proposed a variety of effective optimization approaches. For instance, dynamic programming–based charging strategies enable real-time monitoring of a vehicle's remaining battery level, travel distance, and prevailing traffic conditions, allowing for adaptive decisions regarding charging station selection and charging timing. Such strategies ensure the timely completion of delivery tasks while minimizing unnecessary charging stops and detours, thereby significantly improving delivery efficiency, reducing operational costs, and promoting the environmental sustainability of logistics systems [7].

With the rapid development of the Internet of Things (IoT) and big data technologies, real-time and dynamic EVRP has gradually become a prominent research direction. In practical delivery operations, vehicles are required to dynamically adjust routing and charging decisions in response to real-time traffic conditions, network states, and customer demand variations. To address these challenges, researchers have developed dynamic traffic network models and real-time optimization algorithms that integrate vehicle battery status and energy consumption characteristics, enabling online optimization of routing and charging strategies [8]. This dynamic decision-making framework not only enhances the responsiveness of delivery systems but also improves their resilience to unexpected traffic disruptions and demand fluctuations, providing robust technical support for intelligent and efficient EV-based logistics operations.

3. INTEGRATED DEVELOPMENT OF INTELLIGENT TRANSPORTATION SYSTEMS AND ELECTRIC VEHICLE DELIVERY

3.1. Data Sharing and Intelligent Dispatching

The core of an ITS lies in the real-time acquisition, sharing, and intelligent processing of multi-source data. In the context of EV delivery, the integration of traffic flow information, road conditions, customer demand, and vehicle battery status enables the system to dynamically generate optimal delivery routes and charging strategies, thereby supporting real-time dispatching decisions. This data-driven management approach allows delivery vehicles to schedule charging activities rationally while ensuring on-time delivery performance, and to proactively avoid congestion through traffic condition prediction, ultimately improving overall distribution efficiency. Moreover, the data-sharing capability of ITS enables real-time feedback of vehicle locations and battery states to centralized control platforms, providing valuable information for urban traffic management and facilitating bidirectional coordination between logistics operations and traffic systems.

3.2. Coordination Between Delivery Route Optimization and Traffic Flow Management

ITS facilitates dynamic route planning for EV delivery vehicles through continuous traffic flow monitoring and algorithmic optimization. During peak delivery periods, the system can automatically adjust routes based on real-time traffic conditions, reducing travel time and energy consumption while alleviating urban congestion [9]. By coordinating delivery route planning with traffic signal control, EVs can be prioritized on critical corridors, thereby improving delivery punctuality. Such coordinated optimization not only enhances logistics performance but also contributes to the scientific management of urban road resources.

3.3. Green Logistics and Low-Carbon Transportation

The application of ITS in EV-based delivery operations provides a practical pathway for implementing green logistics. By jointly considering vehicle battery levels, charging station availability, and delivery task priorities, the system can plan energy-efficient delivery routes and schedule charging activities optimally, reducing unnecessary detours, idle driving, and excessive charging. Furthermore, the integration of EV delivery with other low-carbon transport modes—such as public transit, cycling, and shared mobility—helps to establish a comprehensive low-emission urban transportation network, thereby reducing overall transport-related carbon emissions.

3.4. Technology-driven Improvements in Delivery Efficiency

Advancements in EV technology, combined with the deep integration of ITS, provide strong technical support for urban delivery systems. Improvements in battery performance and the deployment of fast-charging infrastructure significantly reduce vehicle downtime, while intelligent dispatching systems enable real-time optimization of delivery sequences and routes. The introduction of autonomous driving and vehicle-to-everything technologies further allows delivery vehicles to operate in coordination with traffic management systems, enhancing safety while improving operational efficiency. In parallel, supportive public policies and growing market demand are accelerating the large-scale adoption of EV-based delivery in urban logistics.

3.5. Intelligent Management and Resource Sharing of Charging Infrastructure

The spatial layout and operational management of charging infrastructure are critical for EV delivery operations in urban environments. ITS can monitor charging station utilization in real time and, by combining delivery task requirements with vehicle battery information, support charging reservation and dynamic allocation mechanisms that improve infrastructure utilization. Shared charging models further enhance resource efficiency by enabling multiple delivery vehicles to rotate charging access in a coordinated manner, reducing delays caused by insufficient infrastructure [10]. Such intelligent management approaches not only improve logistics efficiency but also promote the rational planning and sustainable development of urban charging networks.

4. FUTURE TRENDS AND DEVELOPMENT RECOMMENDATIONS

With the continuous advancement of EV technologies and ITS, the transportation sector is expected to evolve toward greater intelligence, sustainability, and efficiency. First, EVs are likely to gradually replace conventional internal combustion vehicles as the dominant mode in urban logistics and daily travel. Ongoing breakthroughs in battery technology and declining costs will substantially extend driving ranges, shorten charging times, improve operational reliability, and enhance affordability, thereby increasing acceptance among consumers and logistics operators. Second, charging infrastructure development and spatial planning will continue to improve. In future urban logistics networks, charging and battery-swapping facilities will be deployed more strategically. Through shared charging models and intelligent scheduling mechanisms, charging station utilization rates can be significantly enhanced, alleviating delivery constraints caused by infrastructure shortages. These developments will provide strong support for high-frequency delivery operations and further promote the green transformation of the logistics sector.

From an ITS perspective, the deeper integration of IoT, big data, and artificial intelligence technologies will enable fully intelligent urban traffic management. Through real-time data collection and analysis, ITS can accurately predict traffic flows, dynamically optimize signal timing, coordinate multimodal transportation, and provide environmentally friendly travel solutions. When combined with real-time EV operational data, ITS can dynamically plan delivery routes, dispatch vehicles, and optimize charging decisions, thereby substantially improving logistics efficiency, reducing energy consumption, and mitigating environmental impacts [11]. In addition, future urban transportation systems will increasingly emphasize multimodal integration. The coordinated optimization of EVs, public transport, cycling, and walking will help establish efficient, low-carbon, and sustainable urban mobility systems. For logistics operators, the deployment of intelligent logistics platforms will further enhance route optimization, reduce operating costs, and improve service quality, providing essential technical support for the development of low-carbon logistics.

Overall, future transportation development will be characterized by technological innovation, resource sharing, and system-level optimization. The deep integration of EV delivery systems with ITS will serve as a key enabler for improving urban distribution efficiency, advancing green transportation, and building sustainable logistics systems.

5. CONCLUSIONS

This study provides a comprehensive review of EV routing optimization and development trends within the framework of ITS. By examining key issues such as EV driving range limitations, charging strategy optimization, route planning, mixed fleet operations, and charging station location planning, the critical role and challenges of EVs in urban logistics distribution are clearly identified. In parallel, the contribution of ITS—through data sharing, traffic flow optimization, dynamic dispatching, and green mobility strategies—to EV routing optimization is systematically discussed. The integration of EV delivery systems and ITS not only enhances distribution efficiency and route planning performance but also reduces energy consumption and environmental impacts, supporting the development of efficient, safe, and sustainable urban transportation systems.

Looking ahead, continued progress in EV technologies, the expansion of charging infrastructure, and the widespread application of ITS will drive urban logistics and transportation toward more intelligent, low-carbon, and efficient paradigms. In particular, the real-time data acquisition and dynamic optimization capabilities enabled by ITS will allow EV delivery routing to become more accurate and adaptive, effectively addressing challenges such as congestion, fluctuating charging demand, and increasingly personalized delivery requirements. To fully realize these benefits, governments, industry stakeholders, and research institutions should jointly promote technological innovation, infrastructure optimization, and data sharing, fostering coordinated development between EV systems and intelligent transportation frameworks. Such efforts will be essential for delivering safer, more efficient, and environmentally sustainable solutions for urban logistics and transportation.

REFERENCES

[1] Zang, Y. S., Wang, M. Q., Qi, M. Y. A column generation tailored to electric vehicle routing problem with nonlinear battery depreciation [J]. Computers & Operations Research, 2022, 137: 105527.

[2] Wang, Y., Luo, S. Y., Fan, J. X., Zhen, L. The multidepot vehicle routing problem with intelligent recycling prices and transportation resource sharing [J]. Transportation Research Part E: Logistics and Transportation Review, 2024, 185: 103503.

[3] Macrina, G., Pugliese, L. D. P., Guerriero, F., Laporte, G. The green mixed fleet vehicle routing problem with partial battery recharging and time windows [J]. Computers & Operations Research, 2019, 101: 183-199.

[4] Zuo, X. R., Xiao, Y. Y., You, M., Kaku, I., Xu, Y. C. A new formulation of the electric vehicle routing problem with time windows considering concave nonlinear charging function [J]. Journal of Cleaner Production, 2019, 236: 117687.

[5] Dastpak, M., Errico, F., Jabali, O., Malucelli, F. Dynamic routing for the Electric Vehicle Shortest Path Problem with charging station occupancy information [J]. Transportation Research Part C: Emerging Technologies, 2024, 158: 104411.

[6] Lian, Y., Lucas, F., Sörensen, K. The electric on-demand bus routing problem with partial charging and nonlinear function [J]. Transportation Research Part C: Emerging Technologies, 2023, 157: 104368.

[7] Jeong, J., Ghaddar, B., Zufferey, N., Nathwani, J. Adaptive robust electric vehicle routing under energy consumption uncertainty [J]. Transportation Research Part C: Emerging Technologies, 2024, 160: 104529.

[8] Zhen, L., Xu, Z. H., Ma, C. L., Xiao, L. Y. Hybrid electric vehicle routing problem with mode selection [J]. International Journal of Production Research, 2020, 58(2): 562-576.

[9] Lera-Romero, G., Bront, J. J. M., Soulignac, F. J. A branch-cut-and-price algorithm for the time-dependent electric vehicle routing problem with time windows [J]. European Journal of Operational Research, 2024, 312(3): 978-995.

[10] Bezzi, D., Ceselli, A., Righini, G. A route-based algorithm for the electric vehicle routing problem with multiple technologies [J]. Transportation Research Part C: Emerging Technologies, 2023, 157: 104374.

[11] Kullman, N. D., Goodson, J. C., Mendoza, J. E. Electric Vehicle Routing with Public Charging Stations [J]. Transportation Science, 2021, 55(3): 637-659.