

Research on Innovative Urban Green Delivery Models under the Low-carbon Background

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Abstract:

Driven by low-carbon strategic goals, urban logistics delivery, as a major source of carbon emissions, urgently requires a green transformation. Research indicates that traditional delivery models are characterized by high energy consumption, high emissions, and limited efficiency, thereby constraining sustainable urban development. In recent years, innovative models such as new energy vehicles, green warehouse-distribution integration, joint distribution and shared logistics, as well as intelligent and digital delivery, have emerged, injecting new momentum into the delivery system. This paper analyzes the current situation of energy consumption and carbon emissions in urban delivery, outlines the theoretical foundations and driving factors of green delivery, and proposes diversified innovative pathways while drawing on typical case studies. Based on this analysis, optimization strategies and implementation suggestions are put forward, aiming to provide valuable insights for building a low-carbon and efficient urban logistics system.

Keywords:

Low-carbon Background, Urban Delivery, Green Logistics, Model Innovation, Sustainable Development

1. Introduction

Driven by the national “dual-carbon” strategy, urban logistics delivery, as a key sector of energy consumption and carbon emissions, is under increasing pressure for transformation. With the rapid growth of e-commerce and the diversification of urban consumer demands, delivery volumes continue to surge, leading to high-frequency vehicle operations and the expansion of last-mile networks, which impose significant environmental burdens. The limitations of traditional delivery models—such as high energy consumption, excessive emissions, and insufficient efficiency—have become increasingly prominent, making green transformation an inevitable trend. Emerging technologies and models, including new energy vehicles, digital platforms, intelligent scheduling, and shared logistics, provide innovative momentum for urban green delivery, yet challenges remain in policy support, cost control, and large-scale

implementation. Therefore, exploring innovative urban green delivery models under the low-carbon background is crucial for optimizing logistics systems, reducing emissions, and supporting sustainable urban development and greener lifestyles.

2. Current Situation of Urban Delivery under the Low-Carbon Background

2.1. Energy consumption and carbon emissions in urban delivery

With the rapid development of e-commerce and on-demand delivery, the number of urban logistics vehicles has grown significantly, leading to rising energy consumption and carbon emissions. The extensive use of conventional fuel-powered vans and trucks not only results in high energy consumption per unit of cargo but also exacerbates air pollution and traffic congestion in urban areas. Studies show that carbon emissions from urban logistics account for a considerable proportion of the transport sector, making it a critical challenge in achieving low-carbon goals. In particular, during the “last-mile” delivery stage, due to small delivery volumes and high frequency, energy efficiency remains low, thereby amplifying carbon emission pressures.

2.2. Existing green delivery models and their applications

In recent years, various green delivery models have been gradually explored in urban logistics, such as replacing fuel-powered vehicles with electric vans, promoting bicycle couriers, integrating green warehousing with delivery, and adopting joint distribution. These models have been piloted in certain cities—for example, express companies have launched new energy delivery fleets, and some communities have introduced parcel lockers and centralized delivery points to reduce repeated trips and empty runs. Meanwhile, the rise of smart logistics platforms has enabled more scientific route planning and vehicle scheduling, helping reduce unnecessary energy consumption. However, the adoption of these green models remains largely concentrated in pilot cities and demonstration zones, with limited overall penetration, making it difficult to replace traditional modes on a large scale in the short term.

2.3. Main problems and constraints

Although green delivery models show great potential, their promotion still faces multiple constraints. First, the high cost of new energy vehicles and insufficient charging infrastructure increase operational burdens for enterprises. Second, some green models face limitations in delivery efficiency and service coverage, making it difficult to meet the demands of high-density and fast-paced urban environments. Third, the lack of collaboration and information sharing among logistics enterprises slows down the development of joint distribution. Finally, the implementation of policies and the standardization of regulations are still incomplete, leaving gaps in institutional support. Overall, green delivery has yet to establish a mature and stable operating mechanism, requiring coordinated efforts from policy, technology, and market stakeholders.

3. Theoretical Basis and Driving Factors of Urban Green Delivery Models

3.1. Theoretical Basis

The proposal of urban green delivery models is grounded in the guidance of low-carbon economy and sustainable development theories. The low-carbon economy highlights the reduction of energy consumption and carbon emissions throughout production, distribution, and consumption processes, aiming for coordinated growth between economic development and environmental protection. Within this context, logistics—being a sector of concentrated resource use and emissions—must undergo a green transformation in transport modes, energy structures, and organizational models. At the same time, the concept of a circular economy provides new insights for green delivery, emphasizing efficient resource utilization and waste recycling throughout the logistics chain to minimize environmental burdens. Moreover, ecological systems theory and sustainable urban development theory also support green delivery, underscoring the need to balance economic benefits, environmental protection, and social responsibility in logistics system design to achieve harmony between human activities and nature.

3.2. Driving Factors

The innovation of urban green delivery models is driven by diverse forces. Technological progress serves as the most direct driver, with applications such as new energy vehicles, intelligent scheduling systems, the Internet of Things, and big data platforms making energy-saving and route optimization feasible in practice. In addition, policy guidance and institutional support act as powerful external drivers, as governments encourage green transformation through subsidies, standard-setting, and regulatory frameworks. Moreover, market demand and social pressure also play a key role. With rising environmental awareness, consumers are increasingly inclined to choose low-carbon and eco-friendly delivery services, prompting enterprises to adopt green logistics to enhance brand image and competitiveness. Finally, industry collaboration and the growth of the sharing economy provide favorable conditions for joint distribution and multi-party cooperation, helping improve overall efficiency, reduce costs, and accelerate the innovation and implementation of green delivery models.

4. Innovative Pathways of Urban Green Delivery Models

4.1. Delivery models based on new energy vehicles

Driven by low-carbon strategies, new energy vehicles (NEVs) have gradually become a crucial support for urban green delivery. The widespread use of electric vans, hydrogen fuel cell vehicles, and new energy tricycles significantly reduces carbon emissions and exhaust pollution compared to conventional fuel-powered vehicles. NEVs not only achieve zero or low emissions during operation but also offer advantages in noise reduction and lower maintenance costs. At present, many cities have accelerated the adoption of NEVs for delivery through policy subsidies, traffic priority measures, and charging infrastructure construction. For instance, some express delivery companies have deployed electric vans and new energy two-wheelers in central urban areas to realize greener “last-mile” services. However, the large-scale promotion of this model is still constrained by factors such as limited driving range, uneven distribution of charging facilities, and relatively high purchase costs. Therefore, future efforts should focus on improving infrastructure, standardizing vehicle models, and enhancing battery recycling systems, in order to establish a sustainable operation mechanism for NEV-based delivery.

4.2. Green warehouse-distribution integrated model

The green warehouse-distribution integrated model emphasizes incorporating low-carbon concepts into both warehousing and delivery processes to achieve overall energy conservation and emission reduction across the logistics system. Specifically, green warehousing reduces energy consumption and carbon emissions through measures such as intelligent warehouse management systems, energy-efficient lighting, solar power generation, and eco-friendly building materials. On the delivery side, warehouse-distribution integration optimizes inventory layout, shortens transport distances, and improves vehicle load rates to minimize unnecessary transportation costs. For example, some e-commerce companies have established green front warehouses on the outskirts of cities, using big data analysis for demand forecasting to enable fast and efficient “warehouse-to-terminal” delivery while reducing transfer steps and empty runs. This model not only improves logistics efficiency but also effectively reduces the overall carbon footprint. However, its wider application is still constrained by high construction costs, the need for advanced technological integration, and complex system coordination. Therefore, supportive measures such as government incentives, land-use policies, and green certification standards are essential to promote its large-scale adoption.

4.3. Joint distribution and shared logistics model

The joint distribution and shared logistics model aims to reduce redundant transportation and empty runs in urban delivery by integrating resources and fostering multi-party collaboration, thereby improving overall efficiency and reducing carbon emissions. Under this model, goods from different companies are consolidated at a common distribution center, with unified vehicles and personnel responsible for last-mile delivery, thus providing “one-for-all” distribution services. This not only alleviates urban traffic congestion but also reduces the number of vehicles in use and overall energy consumption. At the same time, leveraging the concept of the sharing economy, logistics enterprises and third-party platforms share data and consolidate orders to achieve the joint use of warehousing facilities, transport vehicles, and distribution networks, thereby enhancing resource efficiency. For example, some cities have established unified community delivery platforms, where packages from multiple courier companies are coordinated for centralized delivery, avoiding multiple vehicles entering the same area and causing additional energy consumption and emissions. Nevertheless, the promotion of this model is still constrained by imperfect benefit-sharing mechanisms, insufficient willingness for cooperation among enterprises, and underdeveloped information platforms. Further improvements in policy support and industry collaboration are necessary to advance its development.

4.4. Intelligent and digital delivery model

The intelligent and digital delivery model is driven by technologies such as big data, the Internet of Things (IoT), artificial intelligence (AI), and cloud computing, which enhance refined management in urban logistics through digital means. In terms of route planning, intelligent scheduling systems can automatically generate optimal delivery routes based on real-time traffic and order distribution, thereby reducing empty runs and energy consumption. In capacity management, digital platforms dynamically match orders with delivery resources, improving the utilization of transport vehicles. At the last-mile service level, the use of smart lockers, autonomous delivery vehicles, and drones minimizes repeated deliveries by humans and vehicles,

effectively relieving last-mile delivery pressure. For example, some e-commerce enterprises use big data to forecast consumer demand, pre-positioning goods in front warehouses and enabling on-demand delivery, which shortens delivery times and reduces overall energy consumption. This model not only improves delivery efficiency and service quality but also provides strong support for achieving low-carbon goals. However, its development in practice is still constrained by insufficient data sharing, high technological investment costs, and cybersecurity risks. Thus, further advancement requires the establishment of industry standards and the improvement of data governance systems.

5. Conclusions

Under the background of low-carbon development strategies, the green transformation of urban delivery systems has become an irreversible trend. Research shows that the exploration and application of models such as new energy vehicles, green warehouse-distribution integration, joint distribution and shared logistics, and intelligent digital delivery provide effective pathways to reduce energy consumption and carbon emissions. Although these models still face constraints in terms of cost, technology, policy, and collaborative mechanisms during large-scale implementation, their development direction aligns with the intrinsic needs of sustainable urban development and green consumption. In the future, the advancement of urban green delivery requires joint efforts in policy incentives, technological innovation, industry collaboration, and public participation to establish a diversified, intelligent, and low-carbon modern delivery system. By continuously improving and promoting green delivery models, not only can the “dual-carbon” goals be achieved, but urban logistics can also evolve towards efficiency, environmental friendliness, and sustainability, thus laying a solid foundation for building green cities and enhancing residents’ quality of life.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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