Application of New Energy Logistics Vehicles in China: Evidence from Pilot City Surveys

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Abstract. In the urban delivery sector, expanding the use of new energy vehicles (NEVs) can have a considerable positive impact on low-carbon sustainable development. To promote the application of new energy vehicle in logistics industry, China's Ministry of Transport launched Green Urban Freight Pilot Program in 2017 and has been achieved with promising results. However, the program has also encountered various restrictions and obstacles. This study carried out local investigations in six pilot cities of the Green Urban Freight Pilot Program. Key challenges of new energy logistics vehicles (NELV) adoption such as insignificant road access privileges, low cost-effectiveness, insufficient charging facilities, etc., were further identified through field research, online interviews and panel discussions. Then, detailed policy suggestions and recommendations targeting to national level and local level are proposed to promoting NELVs development.

1 Introduction

The fast development of China's logistics and delivery sectors has increased demand for short-distance urban freight services greatly. Urban distribution has become an essential component of modern logistics, and the sector desperately needs more logistics vehicles. New Energy Vehicles offer a realistic approach for reducing carbon emissions in China's expanding logistics industry. [1]. Since 2017, Ministry of Transport (MoT) launched the Green Urban Freight Pilot Program for the purpose of promoting new energy logistics vehicles (NELV) in the Chinese urban delivery sector. A total of 46 urban green freight distribution pilot cities were included in the first two batches. The program has yielded excellent results, with over 460 thousand NELVs on the road by 2020, and the number of these cars is growing. [2]. However, the program has experienced a number of constraints and issues, such as insignificant road access privileges, low cost-effectiveness, insufficient charging facilities, etc. Field investigations were conducted in six pilot cities: Chengdu, Foshan, Shenzhen, Yinchuan, Zhengzhou and Zhangjiakou in order to acquire first-hand information on the overall implementation status in the pilot cities of the MoT's Green Urban Freight Pilot Program. This study highlighted effective promotion measures and the key challenges for NELVs promotion, based on a case study of six pilot cities. Particular policy implications for the further promotion of NELVs in China were also proposed.

1.1 NELV application in the urban delivery sector

China is currently the world's largest new energy logistics vehicle production and marketing countries. However, NELV sales have been declining for three years in a row, beginning in 2018 due to the phase-out of purchasing incentives. In 2021, Sales of new energy logistics vehicles in China reached 31,000, growing at a 25% average annual growth rate.[3]. China's NELVs vehicle ownership has now reached 532,000, accounting for 7% of the country's total NEV ownership [4] (Fig. 1). Urban logistics vehicles have favorable circumstances for widespread promotion of new energy vehicles since they are characterized by relatively fixed routes, short- and medium-distance range, high frequency of usage, centralized charging, etc. In terms of charging infrastructure, by the end of 2021, China has built 2.617 million charging piles and 1,298 power stations, forming the world's largest charging and replacing network. The majority of the charging infrastructure is centered in the provinces of Guangdong, Jiangsu, Shaanxi, and Sichuan, as well as Beijing. The infrastructure was built primarily to service public buses and passenger cars, rather than logistics vehicles and others [5].

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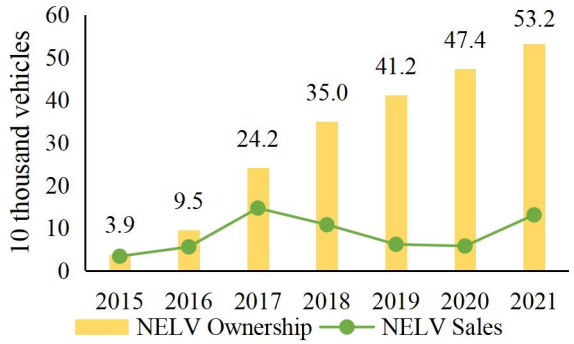

Fig. 1 Car Ownership and Sales of NELVs 2015-2021

1.2 NELV application scenario

NELVs are mostly used in three situations in the urban delivery sector: express deliveries, retailer supplies, and e-commerce sales, with top e-commerce firms typically owning their own fleet of logistics vehicles. However, due to several practical hurdles such as a lack of urban road connectivity, inadequate cost-effectiveness, and a lack of easy charging choices, the use of NELVs for personal delivery services is uncommon.

NELVs are primarily used for point-to-point express delivery within cities, but are rarely used for customised delivery services for individual end-users due to current technical limitations on travel ranges (how far vehicles can go on a single charge), recharging times and a lack of related infrastructure, and challenges with vehicle attendance rates and reliability.

Urban retail supply is also a major scenario for the application of new energy logistics vehicles. As new retail channels emerged, urban convenience stores such as Suning and T-mall began to grow on a big scale. Because urban convenience shops, franchise bakeries, and other urban merchants have set delivery hours, product kinds, and routes, urban retail delivery for these increasing services will remain an essential function that battery-electric logistics trucks may play.

In terms of self-built logistics transportation for e-commerce businesses, The features of logistical needs have changed to include deliveries across a variety of ranges, tiny quantities of items, many batches of units being sent over various periods, and short cycles of delivery traffic as a result of changes in urban inhabitants' consumption habits. Due to present urban traffic regulations and the fact that e-commerce businesses place a high value on time efficiency, it is challenging for conventional gasoline logistics trucks to keep up with the rising logistical needs of e-commerce.

Large-scale e-commerce companies like Alibaba and JD have started using NELVs in their urban delivery transport in response to new energy-saving and emission-reduction policies. JD had accomplished its pledge to replace 100% of its own conventional fuel logistics vehicles with electric vehicles in Beijing by January 2018. [6].

2 Survey

2.1 Survey in six pilot cities

In order to acquire first-hand data, this study conducted field investigation in six pilot cities: Chengdu, Foshan, Shenzhen, Yinchuan, Zhengzhou and Zhangjiakou (Fig. 2). The case cities were chosen for their unique characteristics. Chengdu and Shenzhen are two notable examples of NELV application in the transportation sector. Differences in geographic location, economy and climate of the regions are taken into account (such as Chengdu in the West, Zhengzhou in the central East, Yinchuan in the Northwest, Shenzhen and Foshan in the South). Differences in the types of new energy sources available, related policies and the implementation of supported energy systems were also taken into account (such as Zhangjiakou and Foshan).

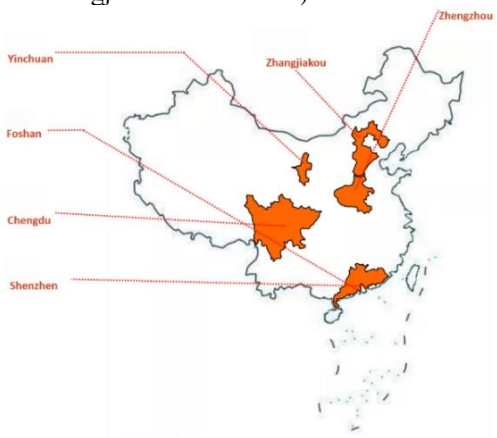

Fig. 2 Pilot Cities Investigation Map

Four of the six pilot cities focus on battery electric vehicles promotion, with the other two, Zhangjiakou and Foshan, promoting both battery electric vehicles and fuel-cell electric vehicles (FCEVs). As its hydrogen supplies are produced using green power from nearby wind farms, Zhangjiakou is encouraging FCEVs. Additionally, the city advocated hydrogen as a green transportation choice for the 2022 Winter Olympic Games and offers geographical advantages for green hydrogen. Foshan has been presenting itself as the hydrogen capital of China since 2010, so the technology route for new energy vehicles in Foshan was focused on BELVs and FCEVs. This study analyzed the overall development in the urban delivery sector in the investigated cities by field investigations with local transportation authorities, relevant departments, and transportation enterprises.

The progress in NELV development between cities varies due to different emphasis and effort used within common measures such as through providing financial subsidies, right of way privileges, and support for the new energy infrastructure. There are also individual local measures being implemented, such as formulating relevant standards, building information platforms, optimising the approval process for the new energy infrastructure, and raising public awareness, which impact how the vehicles are being rolled out. A summary

of the key characteristics of each case city are presented in Table 1.

Table 1 NELV Promotion Status among Investigated Cities in 2021

City	Number of NELVs	Infrastructure	Authorities	Subsidy Policy	Access Priority
Yinchuan	3000 BEVs	1,067 charging piles planned for 2022	Business Bureau	Vehicle acquisition link with national subsidies, local subsidies	NELVs are completely unlimited, and fuel logistics vehicles are restricted during some hours in the Xinhua business district
Zhengzhou	15000 BEVs	More than 20,000 charging piles	Transportation Bureau	National subsidies for vehicle acquisition, local subsidies for infrastructure construction, and local subsidies for operation	Differential traffic management measures are implemented for NEVs with green number plates, and the classification management system for NELVs is improved to facilitate the road passage of qualified van-type logistics vehicles. In the third ring, NEVs are not restricted except in the morning and evening rush hours. New energy trucks cannot drive into elevated roads.
Chengdu	30000 BEVs 100 FCEVs	23,700 charging piles	Department of Transportation Port and Logistics Office	Vehicle acquisition link with state subsidies	Allows NELVs (BEVs) to pass through urban areas for the full time and not subject to tail number restrictions; In 2020 and subsequent years, there will be no longer issue entry permissions for fuel logistics vehicles (except those that are determined to be necessary to retain)
Shenzhen	25208 BEVs	60,953 charging piles	Transportation Bureau	There are national and local subsidies for the acquisition and use of vehicles	Battery electric light and micro trucks that have completed electronic filing and are subject to supervision are allowed to drive on the rest of the roads in Shenzhen, except for that is prohibited from 7:30 to 21:00 from Monday to Friday; medium BEVS and heavy trucks that are subject to supervision and whose body length does not exceed 6 metres are allowed to drive on the sections and times where ordinary large trucks are restricted the section of Shennan Avenue
Foshan	448 FCEVs	16 hydrogen refuelling stations, 6,109 charging posts	Transportation Bureau	There are national and local subsidies for the acquisition and use of vehicles	Except for the morning rush hour from 7:00 to 9:00, the evening rush hour from 17:00 to 19:00, and the road sections around government agencies, schools and bridges that do not meet the conditions of height and weight restrictions, all other time periods and road sections in Foshan City have been abolished for medium-sized vehicles with an authorised load capacity of less than 5 tons (including) with new energy plates at the provincial level.
Zhangjiakou	5 FCEVs	Over 5,600 charging piles; 4 hydrogen refuelling stations	No	There are national and local subsidies for the acquisition and use of vehicles	No special access priority

3. Findings and discussions

Through field research, online interviews and panel discussions with municipal transport authorities, relevant departments and enterprises, best practice and key challenges of NELV promotion were further identified.

3.1 Effective policies and measures for NELV promotion

Policies and measures for NELV's include priority right of way planning, parking conveniences, industrial management support and related plans are issued locally and nationally to promote the use of NELVs in the urban delivery sector. Some pioneer cities like Shenzhen, Chengdu, and Zhengzhou have earned valuable experience and learnt lessons in these processes, and therefore serve as examples and references for the better promotion and adoption of NELVs in the future.

3.1.1 Implementation of preferential policies for NEVs

To maintain the momentum of new energy development, national purchase subsidies for NEVs, as well as purchase tax exemption policies have been extended to the end of 2022. Locally, subsidies for the purchase of NEVs have been replaced by financial and operational support for vehicle use and operation, in accordance with the national policy, with a view to promote them in an orderly manner. For example, NEVs are provided with special license plates by local governments as an incentive policy, with which they are permitted to access low emission zones. These measures are adopted to cushion the impact caused by cancelling the preferential purchase policy.

3.1.2 Improvement of integrated and specialised planning to enhance NELV's guiding and leading roles

Integrated NEV promotion plans and specialised plans for developing charging facilities have been issued at provincial and municipal levels, supporting the industry's development. Cities such as Shenzhen have integrated plans for the building of charging stations into their city planning, for example, by reserving space for charging piles in NELV drivers' residential compounds. Some cities, like Zhengzhou, have formulated specialised plans for the promotion of NEVs and the construction of charging facilities, and have set goals for supporting the use of NELVs in city planning. These plans have provided the foundation for the development of plans to use NELVs, and tackled problems that operators of the vehicles might face, such as insufficient power capacity without changing facilities, and the lack of standardised charging service fees.

3.1.3 Promotion of preferential right of way for NELVs

The provision of right of way privileges, or priority access to areas of the city at different times for NELVS, hold the key for the vehicles to be seen as a preferred method of transport and distribution for delivery vehicles in urban areas. Therefore to promote the role of NEVs in urban transportation and delivery, Chengdu has clarified their policy relating to the road privileges of different types of vehicles, and imposed no restrictions on the passage of NELVs in urban areas. Shenzhen, Chengdu, and Zhengzhou have completed digital registrations for the right of way of BELVs, with which the normal admittance certificate is not required before they can operate on roads within the cities, except for roads under special regulations.

3.1.4 Innovative operation models to drive NELV application

Cities like Shenzhen and Chengdu are actively exploring innovative operation and management models for promoting and adopting NEVs in their urban delivery sectors. Several cities, such as Shenzhen, have launched the 'Internet + new energy freight transportation' model, helping to reduce information gaps in the freight and logistics sectors by providing information on where and how NELVS can and may operate, such as through programs like the 'Green Truck Taxi', a platform similar to passenger ride-hailing business models and created by Green Wheel Electric Vehicle Co. Ltd. In addition, a considerable number of NELVs are employed in such freight transportation apps as Lalamove and GoGoVaN, providing new opportunities for sharing information about NELVs in operation.

3.2 Main obstacles and challenges for promoting NELVs in China

The study discovered the following constraints and difficulties for the development of NELVs in China through pilot city investigations.

Many cities lack right-of-way policies for new energy logistics vehicles. In comparison to traditional gasoline logistics trucks, most NELVs do not get a priority right of way when it comes to receiving traffic permits to enter urban areas.

Logistics vehicles powered by new energy have no cost advantage. NELVs and its essential components, such battery packs and other equipment, are substantially more expensive to acquire than traditional petroleum logistics Vehicles. Only when leased, NELVsmay match the total cost of ownership of traditional fuel cars. [7].

The existing deployment of public charging facilities, both in terms of their number and geographic distribution, is insufficient to fulfill the needs of NELVs for either immediate or future development.

Inadequate standardisation of NELV manufacture and operation has resulted in a lack of acceptable business management and maintenance procedures, as well as barriers to the successful execution of legislative incentives, such as subsidy allocation.

For NELVs at their after-sales stage, insufficient after-sales services have resulted in inconveniently lengthy maintenance procedures and excessive expenses. The number of after-sales service centers continues to fall short of demand, and there are also shortages of skilled professionals, uniformed quality assurance procedures, and rules for spare component replacement.

With China committing to carbon peaking by 2030 and carbon neutrality by 2060, there will be increased investment in new energy R&D, particularly in BEVs and FCEVs. The analysis demonstrates that for the majority of NELV application scenarios, BELVs can currently satisfy urban transit and delivery needs. However, Cold-chain (refrigerated) delivery is an exception, as existing BELVs cannot match its high-power consumption needs for temperature control during cargo transit. An exception to this is cold-chain (refrigerated) delivery, as existing BELVs cannot match its high-power consumption needs for temperature control during goods transit [8]. Given that cold-chain deliveries often service high-value commodities,

somewhat expensive FCEVs may nevertheless be employed more cost-effectively for high-value cold-chain delivery.

4 Policy implications

4.1 Recommendations at the national level

Develop a policy agenda for NELV promotion. With the purpose to accelerate the promotion of NELVs, the purchase cost can be reduced through fiscal policies. Purchase subsidy policies for NELVs should be explored when the existing NEV purchase incentives are phased down. Governments at all levels should develop policies to subsidise the replacement of high emission vehicles of the China III and China IV emission standards with those of China VI and with vehicles powered by natural gas, electricity, and hydrogen. It is important to provide preferential tax policies for replacing and discarding older cars, and to keep in place the NELV vehicle purchase tax exemption.

The operational cost of NELVs could also be reduced through fiscal subsidies. An operation subsidy for NELVs based on their operation mileage should be developed and/or enhanced. The government should also formulate charging subsidy policies (for both the construction and operation of these services). In addition, more R&D funds should be planned to curb technological bottlenecks such as the development of high-performance batteries, the improvement of battery energy density, the upgrading of thermal management systems, the increase of range per charge, and the reduction of fuel cost.

The development and implementation of a New Energy Vehicle Credits (NEVC) mandate for commercial vehicles should be accelerated. Studies should be carried out on conventional commercial vehicles and new energy commercial vehicle manufacturers to understand the characteristics of commercial vehicles under various types, uses, scenarios, users, and regional conditions, as well as the progress and difficulties of the new energy transformation of commercial vehicles. With the consideration of technology and market factors, NEVC regulation for commercial vehicles should be grounded by phases based on different implementation regions, vehicle models, and application scenarios. In addition, the introduction of the NEVC system should consider how to be better at seamlessly transforming from the phasing out progress of subsidy policies to sustaining market momentum.

It is critical to have complete guidelines and standards for NELVs. Authorities should speed up the development of standards for NELVs and its main components and parts. A timetable and roadmap of standardisation for batteries, essential parts and charging facilities should be studied and put forward. Standards for vehicle battery reuse/recycling should be developed as soon as possible. This includes clarifying a unified process and the responsibility and cost allocation among all stakeholders. Through regulations and standards ensuring the vehicle quality of the original OEM, normalising vehicle operation, and controlling the vehicle scrapping process, resource recycling and subsequent effects on environmental protection could be maximised. It is necessary to create a thorough standard for handling NELVs during their whole life cycle. R&D, production, after-sale maintenance, administration of operations, scrapping and recycling are all included in this.

NELV after-sales service systems improvement. After-sale services for NELVs should be regulated, including clarification of responsibilities in maintenance, vehicle recall and replacement, after-sale dispute resolution, battery recycling and safety risk control. Customer convenience should be considered when planning after-sale service networks. The service scope should consider covering businesses along the NEV industrial chain, such as battery recycling, second-hand vehicle trade, and other related services. A standard service procedure needs to be established, including a service hotline for consultation and complaints, and the timely processing of customer requirement should be assured. To satisfy the growing demand for high-skilled workers, a training/education system for highly qualified professionals in after-sale technical services and management on NELVs should be built. Consultation and technical training should be conducted for freight companies to increase their understanding of NELV operation and troubleshooting for higher vehicle utilisation efficiency.

4.2 Recommendations at the local level

Continuous implementation of NELV road privileges. New city admittance permits should only be granted to NELVs. The existing permits currently used by conventional fuel vehicles could thereby only be kept if the vehicle is replaced by a NELV.

Policies on NELV parking privileges for loading/unloading should be implemented while also considering the road share of public bus lanes. Preferential measures on roadside parking should be put into practice. A feasibility study on sharing bus lanes with NELVs during certain periods should also be conducted.

Road priority for NELVs should be maximised. Fossil fuel-related emissions might be further decreased by creating green logistics zones and placing limits on conventional fuel logistics trucks in central areas. Fines should be increased, and road access restriction should be enforced for illegally retrofitted freight delivery purposes passenger vans to avoid harmful competition for freight companies.

Accelerating the construction of the charging facilities. It is important to optimize charging facility layout planning. Based on the analysis of the data from vehicle operation platforms and heat maps of urban logistics vehicles, relevant authorities should better plan

the layout of charging stations geographically to match with NELV operation areas and speed up the improvement of charging networks. The service radius of the supporting infrastructure should be reduced.

To speed up the construction of charging infrastructure, the following measures should be adopted. It is important to research and develop fiscal subsidy policies for the development and operation of infrastructure for battery charging, battery swapping, and hydrogen refuelling. It is necessary to give financial support proportionally to the construction of charging piles. Market-oriented development should be encouraged and freed, attracting investments of multiple parties for the construction and operation of charging piles. The construction of the NELV charging network should be prioritised in places like logistics parks, urban hubs and arterial roads.

Fostering of innovative NELV application and organisation models. The viability of battery switching should be investigated further in order to develop a business model that separates car and battery sales (for example, introducing models like Battery-as-a-Service). New vehicle models should be developed based on practical real-world demand. In addition, power packs for battery-swapping vehicles should be standardised, the responsibility of battery safety should be clarified, and pilot programmes of battery-swapping models should be launched as soon as possible. Innovative collaboration strategies between NELV operators and finance institutions should be promoted. The government should play a coordinating role of connecting financing institutions with operators to strengthen their credit and loan support for NELV programmes, and to establish dedicated capital and innovation funds to attract and leverage more investment for industrial development. New technologies, such as Internet+, and cloud computing, should be employed to help establish a smart NELV operation platform for freight efficiency optimisation via big data analysis. The cumulative NELV operation data could then support the selection and customisation of NELV models to better serve various application scenarios, as well as to better improving the administration of urban logistics fleets, and to improve the efficiency of transportation organisations, thus making NELVs stand out in market competition.

5 Conclusion

The study reviewed the development of NELV application in the urban delivery sector. Key challenges and effective measures of NELV adoption in China were identified. The study also presents a complete set of policy suggestions for promoting NELVs to support the growth of a low-carbon urban delivery sector. Recommendations for different types of city can be drawn. Firstly, cities with a developed economy and good financial foundation can learn from Zhengzhou's financial measures to provide financial subsidies for NELVs and the required new energy infrastructure, mainly by means of capital subsidies. Zhengzhou offered additional local subsidies, in addition to national subsidies, for infrastructure construction and operation. Secondly, cities with a less developed economy and weaker financial foundation, but with room for innovation to roll out preferential vehicle right of way policies can learn from the right of way policy of Chengdu, to allow NELVs to maximise their use of right of way privileges and gain a clearer advantage over fuel vehicles. Thirdly, cities with a developed economy and room for innovation in right of way policies, can learn from Shenzhen's example and promote NELVs through the combined efforts of financial subsidies and right of way planning.

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