
EVS29 Symposium

Montréal, Québec, Canada, June 19 - 29, 2016

Innovative practice of Medium-Light Electric Vehicles for regional delivery and sustainable urban E-mobility in China

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Summary

Adoption of Medium-light electric vehicles in regional delivery started from 2014 and exploded in the second half of 2015 due to fast growth of urban logistics driven by booming e-commerce as well as vigorous promotion and application of electric vehicles in China. This paper comprehensively summarizes latest status of logistics EVs' usage in regional delivery and its practice innovation in China. Based on analyzing life cycle cost, performance, policies and business model as well as challenges, suggestions will be provided on building smart ecosystem and operating EVs successfully for green delivery and sustainable urban mobility.

Keywords: medium - duty, EV, market, policy, China

1. Introduction

Electronic commerce and urban logistics industry emphasizing express delivery has become governments' focus as emerging economic growth point to support in China in recent years. Network of express delivery is usually a tertiary structure. Heavy duty trucks are mainly used for the first level among distribution centers to bear long-distance transport of goods. The second level is from distribution centers to delivery points, mainly using medium-light cargo vans and closed trucks. The third level is from delivery points to recipients often called as end of the delivery or the last mile of the delivery. Medium-light cargo vans and closed trucks together with motorcycles and electric tricycle are used in the third level delivery. Regarding medium-light trucks suitable for the second and third delivery level with shorter distance transportation of small goods which have been booming with fast increase of regional delivery in these two years, this paper focus on study issues of Medium-Light Duty -Electric Vehicles¹ adoption. Regional delivery in this paper refers to the second and third level of express delivery business operated by post EMS and all kinds of courier companies.

¹ Electric Vehicle refers to EV

The result is based on author's study from 2010 in Research Center of New Energy Vehicle industry at Tongji University, Shanghai, China, specifically on integration of electric bus, electric taxi, electric logistics and other special vehicles, car sharing as well as private cars etc., into sustainable low-carbon urban transportation system. In last 2 years, author's study focuses on the two fastest developing fields of EV application, EV-Carsharing and EV usage in regional delivery aiming at issues of 'last mile' of inner-city express.

Although logistics EVs' application started later than EV usage in other sectors of urban mobility in China, its explosive growth trend is much higher than EVs in other areas in 2015 and it is expected to have a more than 100,000 production and sales in 2016. This paper will comprehensively summarize latest status, driven power as well as key issues on adoption of Logistics EVs in regional delivery in Chinese urban mobility. Electric cargo vans and closed trucks are two main types of logistics EVs in delivery market currently. They will be chosen as representatives of medium and light logistics EVs to analyze. By conducting field investigation, data collection and analysis, as well as expert interview, etc., the paper will reveal practice innovation in China as a whole and different type of city cases. Based on analyzing advantages as well as disadvantages, successful experience as well as barriers, such as performance of logistics EVs, governments' policy and administration, business and operating models, suggestions will be provided on operating successful EV for green delivery industry and low - carbon urban mobility.

1.1 Production of logistics EVs blows up

China became the world's largest EV producer and sales market in 2015, surpassing the United States for the first time with an explosive development. EV production in 2015 is more than 330000 vehicles reaching 2.7 times of the total accumulated past production by 2014 which was about 120000 vehicles in China^[2]. Among the total 330000 Chinese EVs made in 2015, logistics EV production was just about 44000 accounting for 13.3% of the total EVs; but it increased faster than other kinds of EVs with a growth of higher than 12 times of accumulated past production by 2014.

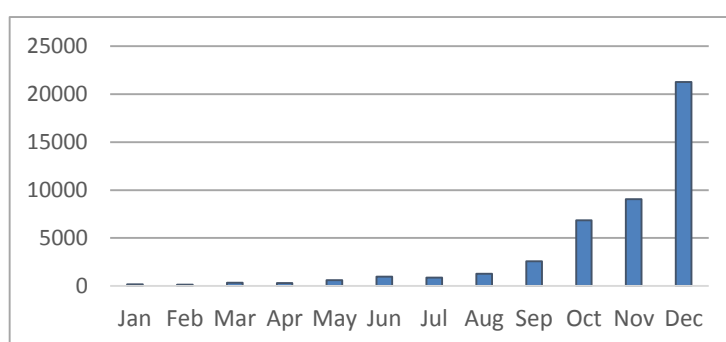


Figure 1: Distribution map of monthly logistics EV production in 2015, China

As shown in figure 1, Chinese logistics EVs' production blew up from the second half of 2015 and was predicted to exceed 100000 in 2016 by existing orders. Logistics EVs are also expected to become the new main part of the whole Chinese EV industry replacing the former, E-bus in 2016.

More and more car makers entered in logistics EVs industry and market. In 2015, among the total 160 new enterprises applying new energy vehicles directory, 99 new comers were for logistics EVs while in 2014 the number was just 50. Production capacity is of a high degree of concentration. The cumulative production of

8 car makers of the 99 accounted for 66% of the total production of logistics EVs. In particular, the big three companies, Dongfeng, Chongqing Ruichi, Shaanxi Tongjia, produced about 2 times logistics EVs of all others'. When analyzing yield structure of vehicle models, it is easy to find that medium-light e-cargo vans and e-closed trucks applicable to urban short distance express delivery accounts for the highest and main proportion of logistics EVs.

1.2 Cities accelerate application

Besides logistics EV makers' speeding production, cities actively implement local financial policies for purchasing subsidies and green traffic policies for preferential access and park to promote rapid application of logistics EVs. As of early 2015, there were 50 among the total 88 Chinese EV pilot cities set promotion plan and supporting policies. Most of cities require that new purchased logistics vehicles should be EVs at a rate of no less than 30%. Having promoted 8720 logistics EVs by the end of 2015, Shenzhen became the largest application market in China. The second largest application city is Chongqing which had promoted more than 1100 logistics EVs. Besides offering the same purchasing subsidies as Shenzhen at a level of 200 Yuan/per KWh higher than central governments' subsidies, Shanghai plans to give a special green pass to encourage at least 3000 logistics EVs' application in 2016 while logistics- ICEVs' traffic is limited. In addition to private courier companies, state-owned postal transport companies are also actively considering to adopt logistics EVs for express delivery.

2. Background of booming Logistics EV in China

Production and application of logistics EVs in China flourish for two main factors. One is rapid growth demand from booming delivery business while another is national strategy and local EV pilot cities strongly support EV promotion and application as well as develop EV industry.

2.1 Rapid growth of demand from booming delivery business

2.1.1 Booming delivery industry needs more green vehicles

In recent years, Chinese express delivery industry sustained rapid development at a rate around 50% of yearly growth both on amount of business income and business volume. China's express delivery business volume exceeded 20 billion units with business income of 276 billion Yuan in 2015, respectively increasing as 7.8 times and 3.8 times of those in 5 years ago. Due to significant contribution to reducing circulation cost, supporting e-commerce, and expanding channels of employment, regional delivery was highly valued by national government as an important part of modern service from March 2011. Since 2014, express delivery business in China exceeded that in the United States for the first time and kept as the No.1 in the world from then on reflected in table 1².

Table 1: Growth trend of express delivery business volume in China

Item	Year 2012	Year 2013	Year 2014	Year 2015
Total Business Volume (Billion Units)	57	92	140	207
Annual growth rate	33.7%	61.6%	51.9%	48%
Global ranking	No.2	No.2	No.1	No.1

² Data from China Post

Rapid growth of express delivery volume creates more demand for vehicles' usage. For example, in 2014, 560000 vehicles were needed to meet Chinese express delivery business volume of 140 billion pieces a year with an average of more than 0.56 billion pieces per day and a three wheeler's can averagely deliver 100 pieces with a day. If using medium-light cargo vans or closed trucks instead of all tricycle or two wheelers, 280000 vehicles are needed according to their average load is 200 pieces per day. Compared to that in 2014, demand in 2015 for new capacity of express delivery is 184000 tricycles and two wheelers or 92000 vehicles.

In some area with a higher growth of delivery business than average, such as Zhejiang province, demand of express delivery vehicles increases faster. For example, in a city named Huzhou in Zhejiang Province, 2015, its express delivery business volume is around 80 million pieces at an increase of higher than 50% yearly in city center area in past 3 years. According to author's survey, there are about 900 express logistics vehicles and 1500 three and two wheeled vehicles bearing the second and third level delivery while 200 heavy duty trucks for the first level distribution in the center city with an area of 1580 square kilometers and resident population of 1.2 million. Ignoring replacement of existing vehicles, 450 new vehicles as well as 750 three and two wheelers will be needed to undertake newly increased express delivery in 2016 according to the current growth rate of express business volume. As planned by the city, 40% of three or two wheelers will be replaced by vehicles operating for delivery business regarding three and two wheelers have flexibility in the third level delivery but are unsafe specifically in the second level delivery and detract city image. Considering the above factors and according to that medium-light truck's capacity is generally 2 times of a tricycle's, it needs to increase total 600 medium-light cargo vans and closed trucks for its express delivery capacity in central area in 2016. Rapid growth of e demand for express vehicles brings huge pressure on urban traffic congestion and emissions. According to that a gas vehicle's consumption is 10 liters fuel per 100 kilometers for express delivery and in China 1 liter 93# gasoline combustion produce 2.3kg of carbon dioxide, 600 E-cargo vans can reduce a total emission of 13800kg per day if every cargo van travel 100km within a day.

2.1.2 Current situation of E-Cargo Van is suitable for service demand of express delivery business

As mentioned above, express delivery business is mainly operated by post EMS and all kinds of courier companies. General volume and weight of their goods delivered are small while requirement of timeliness is stronger and service quality is emphasized. One piece of goods is usually lighter than 20kg and one way of express delivery range from distribution centers to delivery points and from the points of delivery companies' network to recipients is not long because most of the companies have considerable network coverage. Total mileage of a delivery vehicle within a day is rarely higher than 100km, even in large cities like Shenzhen, Chongqing even in Beijing, Shanghai. Current mileage of E-Cargo Vans in China which is usually around 160km can meet demand of delivery vehicles' daily travel. Therefore, range anxiety which is the biggest barrier of EV application for taxi or private EV owners' travel is no longer an obstacle for E-Cargo Van used for delivery. Besides mileage capacity, E-Cargo Vans are welcome due to advantages of zero emissions and economic and so on.

2.2 Great development of new energy vehicle industry and application in China

2.2.1 Driven power from national strategy and EV pilot cities

Chinese central government determined new energy vehicles as the country's emerging strategic industry in

2010, and set a goal to promote and apply 500 thousand and 5 million new energy vehicles respectively by 2015 and 2020. Among the goal of each type of EVs in detail by 2020, specially-used EVs including logistics EV as the main are expected to be no less than 200 thousand by 2020.

Selected and encouraged by the central government, 25 cities from 2009 to 2012 and 88 cities from 2013 to 2015 respectively launched the first round and the second round project of EV pilot Cities. Compared to EVs application started early in bus and taxi from 2009, EVs usage for logistics and car-sharing started later from end of 2014 but developed faster from the second half of 2015. Many cities have begun to layout logistics EV industry while plan goal and supporting policies for promotion and application.

2.2.2 Promoted by state and local financial subsidies

Since 2009, Chinese central government implemented subsidy policy for new energy vehicles. In terms of logistics EVs, in 2015, central governments' subsidies are offered by battery capacity as 1800 Yuan per KWh but total of central and local subsidies should be no more than 135000 Yuan per vehicle. On April 29, 2015, the four ministries, the Ministry of finance, national development and Reform Commission, the Ministry of industry and Information Ministry and the Ministry of science and technology jointly issued a new round of 2016-2020 subsidy policy for new energy vehicles, clearing a backslide in the next 5 years. The four ministries specified that level of subsidies in 2016 will be kept unchanged as in 2015 but it will decline 20% during 2017-2018 and decline 40% during 2019-2020.

In addition to central government's financial subsidies, a lot of cities announced local subsidies at different standards in 2015. Subsidies in Shenzhen and Shanghai are the same and higher than the central standards at 2000 Yuan per KWh but total of central and local subsidies should be no more than 150000 Yuan per vehicle. Beijing, Tianjin, Chongqing, Xi'an, Wuhan implement subsidies at 1:1 with the central standards while Linyi offers subsidies at 1:0.3. Local subsidies for 2016 and later were not determined by March, 2016.

The two level financial subsidies greatly reduce the initial purchase cost of logistics EV and thus greatly promote its development. In addition to financial subsidies, unlimited purchase and priority of access and other policies also greatly promote development logistics EV.

3. Favorable features on life cycle costs and performance

Favorable feature on life cycle costs is the main reason for expanding Logistics EVs market besides zero carbon emissions and small noise. In addition, innovative business model plays another important role to drive the application.

There are many economic indicators to study EVs. This section focuses on comparison on life cycle cost between medium-light logistics EVs for express delivery and their similar type of internal combustion engine vehicles (Hereinafter referred to as ICEV)^[2].

When calculating life-cycle cost of vehicles, purchase prices, operating costs and maintenance cost will be the three main factors considered. That means the formula to calculate is life cycle cost = purchase cost + operation cost + maintenance cost and purchase cost = market sales price - central governments' subsidies - local subsidies. As mentioned above, the total subsidies should be no more than 135000 Yuan.

3.1 Medium E-closed trucks

As for medium trucks' life-cycle cost, the length of whole life cycle is set as 10 years according to China 'Vehicle scrapping standards'.

The typical medium-sized electric closed truck selected to analyze is the best-selling model in Chinese market, Dongfeng EQ5070XXYTBEV (Hereinafter referred to as 'Dongfeng EV-truck') which has been sold out more than 2000 vehicles by 2015. Comparative study of selected similar ICEV type of Dongfeng EV-truck is Dongfeng DFA1081S39D8 (Hereinafter referred to as 'Dongfeng ICEV-truck') and both of their full capacity is 3000kg.



Figure 2: Dongfeng EQ5070XXYTBEV

Part of Dongfeng EQ5070XXYTBEV's parameters is as follows. Its self-weight is 3000kg, equipped with 75 KWh lithium-ion ferrous phosphate battery at a continuing mileage of 150 km. The length, width and height of vehicle shape is 6110*2200*2860mm while cargo compartment size is 4150 * 2050 * 1900mm. Driving a mileage of 100km consumes around 60 KWh power energy with full load.

Table 2 shows that Dongfeng EV-truck's life cycle cost is lower than Dongfeng ICEV-truck's in a 10 years life.

Table 2: Comparison on life-cycle cost of E-closed truck and ICE- closed truck

Items / Units	EV-closed truck (EQ5070XXYTBEV)	ICEV-closed truck (DFA1081S39D8)
(1) Purchasing price(after subsidies)/Yuan	235000 ³	88000
(2) Energy consumption /Yuan/100km	50	150
(3) Full life mileage /100km	4000	4000
(4)life cycle operation cost/ Yuan (4)=(2)*(3)	200000	600000
(5) maintenance cost/ Yuan /year	3000	10000
(6)life length/ year	10	10
(7) life cycle maintenance cost/ Yuan (7)=(5)*(6)	30000	100000
(8)life cycle cost/ Yuan (8)=(1)+(4)+(7)	465000	788000

³ 250000 Yuan=370000 Yuan (Official guidance price) - 135000 Yuan(central governments' subsidies
=75KWh*18000yuan/KWh)

3.2 Light E-cargo vans

Medium-sized E-closed trucks relatively is still relatively uncommon in the market because light E-cargo vans are cheaper than 50000 Yuan and are very suitable for intra city express transport.

In terms of light E-cargo vans' life-cycle cost, 5 years and 100000km is a generally standard for quality assurance.

Chongqing Ruichi EK05 is the most popular light E-cargo vans in China with a sale of more than 1500 in Shenzhen and more than 300 in Chongqing. It is analyzed as the typical light E-cargo vans compared with its original ICEV model, Dongfeng XiaokangK07. Both of their full capacity is 450kg while self-weight is 1950kg.



Figure 3: Ruichi EK05

Chongqing Ruichi EK05 is equipped with 25.92KWh lithium-ion ferrous phosphate, Lithium manganate or three elements battery at a continuing mileage of 150 km. The length, width and height of vehicle shape is 3795*1560*1925 mm. Driving 100km consumes about 18KWh power energy with full load. Table 3 shows that Chongqing RuichiEK05's life cycle cost is also lower than its ICEV version in a 5 years life.

Table 3: Comparison on life-cycle cost of E-cargo van and ICE- cargo van

Items / Units	EV (Chongqing RuichiEK05)	ICEV (Dongfeng XiaokangK07)
(a)Official guidance price/Yuan	135000	35000
(b)Central governments' subsidies (25.92KWh*1800Yuan/KWh)	46656	0
(c) Subsidies in Shenzhen ⁴ (25.92KWh*2000Yuan/KWh)	51840	0
(1) Purchasing price(after subsidies)/Yuan (1)=(a)-(b)-(c)	36504	35000
(2) Energy consumption /Yuan/100km	25	70
(3) Full life mileage /100km	1000	1000
(4)life cycle operation cost/ Yuan (4)=(2)*(3)	25000	70000

⁴ As mentioned before, local subsidies are different in different cities while power price is also different in different area.

(5) maintenance cost/ Yuan /per time per 5000km	80	450
(6)life length/ year	5	5
(7) life cycle maintenance cost/ Yuan (7)=(5)*20times	1600	9000
(8)life cycle cost/ Yuan (8)=(1)+(4)+(7)	63104	114000

Shown as in table 2 and table 3, both E-closed trucks and E-cargo vans' life cycle cost are lower than their ICEV types. Subsidies to purchase of EVs, cheaper consumption of electricity power and lower maintenance cost for EVs without engine allow logistics EV very competitive in the market.

Besides advantages of lower life cycle cost, driving logistics EVs is comfort and drivers' satisfaction is high. Logistics EVs are suitable for express delivery business usage, including fixed line, daily mileage no longer than 100km, work during the day and EVs can be charged in night at distribution outlets which is easier to settle down charging infrastructure.

In addition, some emerging third-party leasing operators and service providers initiated innovative business model to reduce purchasing and using cost while providing more professional maintenance for logistics EV users, the express delivery companies. It is also very helpful for promotion of logistics EVs.

4. Challenges and Suggestions

An integrative trend formed by EV makers and governments' active support as well as urgent need from blowing up express industry and low-carbon urban mobility, logistics EVs are embracing great opportunities of development and application. At least 100000 logistics EVs are expected to be produced in 2016. Rapid expansion of logistics EVs also faces big challenges. Indicated as a survey on 'EV Resource Network'^[3], main factors affecting development of logistics EVs in field of express delivery include convenience, cost, as well as safety and reliability as shown in Table 4.

Table 4: Factors affecting development of logistics EVs in express delivery

Factors	safety and reliability	convenience	cost	performance	appearance
%	31	27	23	14	5

Considering currents status of logistics EVs' application and challenges, the following measures are suggested to take for integrating them into green express delivery and sustainable urban mobility.

4.1 Enhance research and development to improve EV quality

Safety and reliability is the biggest concern for using logistics EVs. Customers mainly worried about battery quality, system design and maturity of the whole vehicle technology. Most of current logistics EVs in the market are basically modified models of their original ICEV types, there is little dedicated to positive research and development. Unstable performance and potential risk of battery safety is the biggest obstacle for

expansive acceptance. Therefore, car makers should invest more on research and development to improve products' quality, specifically on battery and the whole vehicle.

4.2 Accelerate construction of charging facilities and maintenance system

Convenience of logistics EV usage includes convenience of charging and maintenance services. According to author's survey, there is a big security risk from current charging mode although it seems basically 'convenient'. Most logistics EVs charge by improved ordinary civilian power lines and wiring board but rather depend on specifically constructed charging piles. Main challenges are that cities public charging facilities is underdeveloped and it is difficult for express companies to self - built special facilities. Although express companies have allocation of space for centralized installing charge piles, to increase power capacity is expensive and its process is complex. Cities' government should accelerate public charging network and issue policies to encourage express companies constructing charging piles in their distribution center.

Maintenance system for logistics EV is also weak to follow the requirements. Less maintenance outlets and corresponding professionals, less service for battery and BMS, and poor emergency system are main challenges. City governments and logistics industry association should help enhance efficient maintenance system for logistics EV.

4.3 Improve incentive policy

Current incentive policies mainly provide financial subsidies for purchasing logistics EVs as well as installation of charging facilities. With purchasing and constructing subsidy back slope in the future, policies should focus more on non-financial encouragement for usage of logistics EVs. More effective measures include subsidies for charging cost, reduction of insurance, green credit policy and priority access, etc.

4.4 Integrate innovation of technology and business model to build smart ecosystem

Logistics EVs are not only vehicles for green express industry and low carbon transportation but also important carriers to improve standardization and intelligence level of express industry. Logistics EV is a good platform to integrate big data, Internet of things, cloud computing, mobile applications and other technologies and provide best intelligent solution for the last mile distribution and delivery. Real time updated route planning can greatly shorten driving distance and hence save time and improve work efficiency. Meanwhile, vehicle synchronous positioning system can help senders, recipients and vehicles with goods reduce waiting time and allow them a good way to find each other by client terminals and vehicle mounted terminal. Innovative technology combined with innovative business models based on logistics EVs not only accelerate delivery industry but also contribute significantly to improvement of professional dignity of rapidly expanding workers. It creates smart ecosystem and provides new engine of industrial upgrading for express delivery. Governments and operators should collaborate with all other stakeholders, including EV suppliers, delivery companies, employers in the industry and consumers to construct a friend environment and ecosystem circle for logistics EVs application and achieve greater success.

Acknowledgments

Survey on case of Chinese logistics EVs obtained help from CEO Fuhong Bi of Shenzhen Luzhou Electric Vehicle Co. Ltd. and CEO Liyong Hu of Chongqing Ruikang New Energy Automobile Co. Ltd. Economic Information Committee of Huzhou city and Shenzhen 'EV Resource Network' are also helpful for the paper.

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