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Demand-oriented Innovation on Development Mode of Logistics Electric Vehicle

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Summary

In recent years, China's electric vehicles used in city logistics have been rapidly expanding, due to the country's strategy on emission reduction and the fast developing intelligent logistics market. However, the lack of high quality and suitable types of light-electric freight vehicles (L-EFV) seriously hampers the expected faster forward of the industry and market. Based on analysing demand of city logistics and its electrification status, studying existing development modes of the widely used L-EFVs, this paper suggests the innovative L-EFV development mode suitable for future market development and its implementation measures.

Keywords: BEV (battery electric vehicle), Market Development, Demand, Light vehicles, Freight transport

1 Introduction

City freight transport is an important contributor of pollutants and greenhouse gases emissions with it becoming a more frequent and necessary daily activity in and around urban areas [1]. China has been implementing stricter emission reduction requirements for urban freight transport besides passage transport in recent years. With the wide use of new energy freight vehicles in city logistics since 2015, China has rapidly developed into the world's largest light electric freight vehicle (referred to hereafter as "L-EFV") market. By 2018, China has a total of over 350,000 new energy freight vehicles and around 90% of which are L-EFVs in city logistics. However, the L-EFV adoption speed lags far behind the demand of the rapid growing logistics market and the governments' low-carbon requests. Besides the imperfect charging and maintenance service system, hurdle to L-EFV market penetration and performance mainly lies in the lack of high-quality and suitable vehicle products [2]. The key reason behind the lack of demand-adapted L-EFV exists in the vehicle development modes.

The research object of this paper is the development mode of this kind of L-EFV in China. The intent is to summarize the existing development modes, comparatively analyze their leading bodies, process characteristics, the impacting factors behind, advantages and disadvantages, etc. On this basis, we put forward innovative development mode and suggestions for its implementation. To motivate this work, we first review the China's city logistics market and its demand characteristics which affect the L-EFV development mode.

L-EFV in this paper refers to fully electric freight vehicle in China's city logistics with gross vehicle weight (GVW) up to 4.5 tons, load capacity from 0.5 to 2.5 tons, and cargo space from 3 to 18 m^3. Two main types of the L-EFVs are electric mini-cargo van and electric light-close truck. Table 1 illustrates the two type vehicles' battery capacity, load ability, main application scenarios and typical pictures. From the perspective of power technology, the 300,000 fully electric freight vehicles are dominant in China's new energy city logistics market while there are less than 500 fuel cell freight vehicles on the road and not any plug-in hybrid type.

In August 2018, China Federation of Logistics and Purchasing issued "Specification for Selection of Electric Vehicle Application in City Logistics". It defines the two types of L-EFVs and points out the key difference between the electric mini-cargo van and electric light-close truck. As Figure 1 illustrated, the body structure of the former is a whole closed compartment connecting the loading part with its driver's cab while the latter's loading part is a closed compartment independent of the cab.

A. mini-cargo van B. light-close truck

Figure1: Two main types of L-EFVs in China

Table1: L-EFVs in China city logistics market

Type	Load Capacity (ton)	Cargo Space (m^3)	Battery Capacity (kWh)	Application Scenarios	Vehicle Picture
E-mini-cargo van	0.5~1.5	3~15	30~70	Central city & the last mile delivery	
E-light-close truck	1.0~2.5	15~18	70~100	Suburban & special-line delivery	

2 City Logistics Electrification in China

China has both the world's largest logistics market and the fastest growth of its city logistics scale in recent 3 years. In 2016, the country's total cost of social logistics exceeded 11 trillion yuan and surpassed that of the United States for the first time. Due to rapid growth of e-commerce and consumption of organization and residents, growth rate of the total logistics value of organization and residents approached 30% and around 3 times of the overall logistics' in 2018. Improving quality and increasing efficiency as well as saving energy and reducing emission are the two most important tasks requested by the country to develop the huge and rapid growing urban road freight transport [3-5]. In this macro context, the use of electric vehicles in China's city logistics has tremendous power and pressure.

2.1 Demand of City Logistics Market in China

City logistics in China mainly refers to "distribution services in and around urban areas" but also includes cold-chain transportation, municipal sanitation, and other special logistics etc. in its broader meaning. Road freight transport is the main mode of city logistics transport and automobile is the mainly used vehicle accordingly. In 2017, the proportion of the road transport freight volume was 96%, 82%, 79%, 66%, 64% and 41% in the 6 major cities with the highest freight volume respectively. By 2017, there were about 13 million freight drivers and nearly 20 million freight vehicles working in city logistics.

Application scenarios of China's city logistics are diverse and complex. The demand for vehicles and their usage varies greatly in different market segments. As shown in Figure 2, a variety of electric vehicles(EV) with different weights and transport service functions as well as electric two-wheelers and tricycles have been widely used in different segments of city logistics. The two main vehicle electrification segments are express and city delivery in city distribution and most of the EVs used are the L-EFVs, including E-mini-cargo vans and E-light-close trucks. The rapid expansion of L-EFVs in the two segments of city logistics is mainly related to the characteristics of freight transport business and the policy requirements on emission and congestion. The two types of logistics mainly serve the central city area, with higher frequencies of transport, lighter goods to be delivered, and relatively fixed routes of shorter than 100km range. Meanwhile, most of local governments have high requirements on lower emission and restrictions of traffic and parking for medium-or-heavy duty freight vehicles in central urban areas. Light logistics vehicles with GVW less than 4.5 tons begun to enjoy the convenience of no need to register for operation permit as in the past since 2018. These demand characteristics make cleaner and smaller freight vehicles, especially those L-EFVs with GVW of under 4.5 tons and body length less than 6 meters, more preferred for the market. In addition, more than 500 cities in China have been speeding up their smart city strategy from 2015 and have more urgent demand for EFVs which are easier to integrate smart logistics technology.

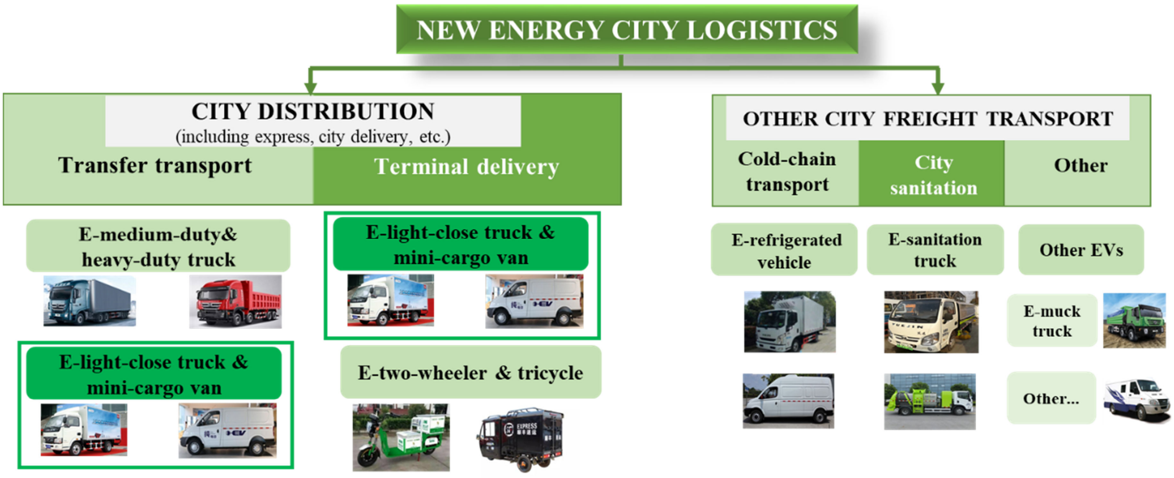

Figure2: Application scenarios of new energy city logistics in China

2.2 Status of City Logistics Electrification

The number of L-EFVs in China has exceeded 10,000 for the first time from the second half of 2015. Since then, the total number has been increasing quickly to over 300,000 by the end of 2018, and is expected to reach 1 million by 2020 [6]. Figure 3 illustrates the past 4 years' annual sales of EFVs in China. The regional market of L-EFVs is unbalanced. The large scale of application is concentrated in a few cities with supportive policies and strong operators. Only each of the 6 cities, Shenzhen, Beijing, Chengdu, Shanghai, Tianjin and Xi'an, has promoted over 10,000 L-EFVs respectively by 2018. Shenzhen is far ahead of all Chinese cities with a total number of over 60,000 and has become the city with most registered L-EFVs in the world for 4 consecutive years.

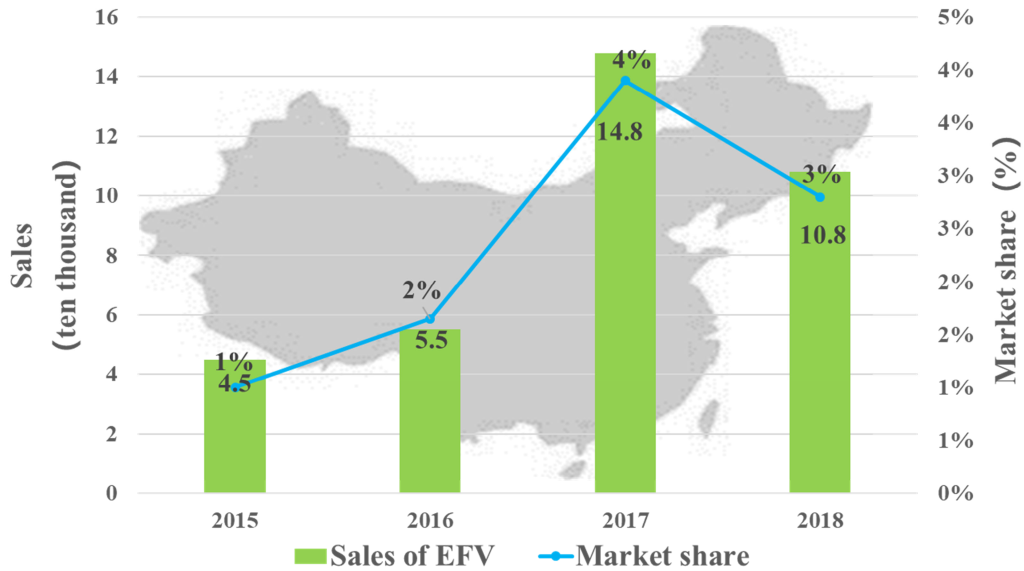

Figure3: EFV annual sales and market share in China (2015-2018) [7]

There are a large number of EFV manufacturers as well as a large number of vehicle models in China. Market concentration is not high with many new entrants, especially those who purchase vehicle chassis for refitting. In 2018, there were more than 130 EFV manufacturers in China, declaring more than 800 L-EFVs models to be marketable and subsidized. Market concentration CR5 is only 37% while CR10 is 60.33% in 2018 [8]. Only two of the automakers' annual sales number of L-EFVs reached 10,000 while more than 100 automakers' each is under 1,000. Taking Shenzhen market as an example, the number of brand names of the 24,669 newly registered L-EFVs in 2018 reached 68, which is 20 more than that in 2017. In the relatively decentralized industry structure, most of the automakers' R&D is not strong enough to form a positive development capability suitable for L-EFV in a short time. Meanwhile, customers usually view L-EFVs as a kind of means for production and are highly sensitive to price, which also leads to the unreasonable but cheaper development modes taken by automakers.

3 L-EFV Development Modes in China

Although the above-mentioned L-EFVs are produced by automakers, the vehicle development leading force are not only the automakers but also other players in the city logistics market. Relevant to this, the development processes led by different subjects are quite different. This section compares and analyzes several typical development modes, focusing on the characteristics of their leading force, the differences in development processes, and their respective advantages as well as disadvantages. Development processes generally include positive process and reverse process. Leading forces are simply classified as automakers and non-automakers, in which core parts companies, freight operators and L-EFV operators are included.

3.1 Difference in the Development Processes

As illustrated in Figure 4, reverse development process refers to obtaining a digital model based on the measurement data of an existing vehicle prototype first and then testing and producing L-EFV. Different from the reverse process, the positive development process makes a design plan first rather than deploying an existing vehicle prototype. Vehicles developed through positive process, in comparison with those under reverse process, are more stable and can be easier designed for new functions, but have a longer development cycle and higher R&D costs. For L-EFVs, redesign, especially that of electric power system through positive process, is the basis for ensuring safety, higher quality and other better market adaptability.

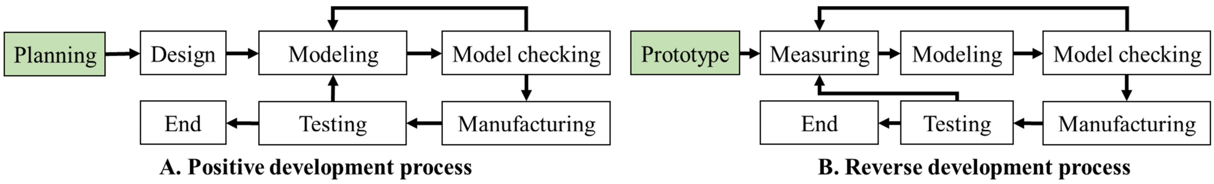

Figure4: Positive and reverse development process

3.2 Development Mode Led by Automakers

Development mode led by automakers is still the mainstream in China, and the two kind of vehicle development processes are both adopted by the leading force.

3.2.1 Traditional Reverse Development Mode

At present, most of China's L-EFV development mode led by automakers is the reverse mode, which is commonly known as the "gasoline-to-electricity" mode. Under this mode, the key parts, such as the engine and the gearbox, in the traditional gasoline vehicle prototype are simply removed and replaced with batteries and motors for a new L-EFV type.

Typical L-EFVs developed under this mode in the market include E-mini-cargo van EM80 and H9. Their manufacturers are those automakers who have the experience of R&D and manufacturing of gasoline logistics vehicles and hope to occupy the emerging L-EFV market as soon as possible. To shorten the development cycle and to reduce investment are the two main driven power.

According to the survey of main new energy vehicle (NEV) operators, although the purchasing price of these "gasoline-to-electricity" style L-EFVs is relatively low, the failure rate is high and the load capacity is poor. In addition, some operators also complain that these L-EFVs exist some big safety problems. The main reason is that this simple modified-style development mode cannot meet the requirements for safety and other functions. Besides, some L-EFVs have defects in the design of safety warning systems.

3.2.2 Positive Development Mode

Positive mode is generally adopted to develop L-EFVs from the beginning by NEV manufacturers which have no traditional gasoline vehicle production basis. BYD E-light-close truck T5 (BYD T5) can be analyzed as a representative vehicle model under this mode. Based on the new designed power system deploying liquid cooling technology, the BYD T5 has been well recognized by the market with a long range. However, the BYD T5 market sales are not high because its price is about 1.6 times that of the reverse-developed similar E-light-close truck.

Driven by demand for high quality growth of city logistics, positive development mode is now more actively taken by the traditional automakers that initially adopted the reverse "gasoline-to-electricity" development mode. For example, SAIC MAXUS Automotive Co., Ltd. (SAIC MAXUS), firstly developed EV80 under the "gasoline-to-electricity" mode by using the gasoline vehicle prototype V80 from 2016 for the fast growing city logistics market. To overcome the weakness of the early modified-developed EV80, including weak load ability and insufficient intelligent function, etc., SAIC MAXUS introduced a newly positive-developed L-EFV EV30 in 2018 to implement its deeper electrification transformation strategy. The EV30 has been positively designed more market-adaptable with charging time shortened from 1.8 hours of EV80 to 0.75 hours, range increased from 290 km of EV80 to 400 km [9]. In addition, the EV30's configuration can be customized for L-EFV users based on big-data technology.

Karry new energy automobile Co., Ltd. (Karry) can be analyzed as another traditional automaker case of the development mode transformation. Karry is the Chinese champion in total sales of L-EFVs in 2018 with a total number of L-EFV sales of 19,900 and the share of the whole country's market over 18%. Karry is also transferring from an automaker that uses the "gasoline-to-electricity" development mode to seize the market, to a company that uses positive development mode for high performance and quality of L-EFVs. Karry also has the country's best-selling model, Karry Youyou EV (Youyou), with a sales of 16,000 only in a single vehicle model. However, regarding the Youyou EV's current cheapness advantage introduced by its reverse development mode cannot maintain long-term competitiveness, Karry are preparing a new positive-developed E-mini-cargo van in 2019. New electric chassis, model platform and structure are designed for the new EV while deploying lightweight technology. Compared with the reverse-developed Youyou, the new L-EFV's battery capacity can be increased from 34kWh to 45kWh, cargo space increased from 4.7 m^3 to 5-7 m^3, and load capacity increased from 0.5 tons to 1.5 tons because of the more reasonable space layout.

3.3 Development Mode Led by non-Automakers

China's L-EFV market with great change of pattern made the leading force in the development of L-EFV shift from automakers to other diverse force which is closer to the market.

3.3.1 Development Mode Led by Core Parts Company

The core parts company mainly refers to the power battery company. Looking at that the threshold of L-EFV manufacturing is relatively low and battery cost accounts about 35% that of the whole vehicle [10], battery companies urgently want to more directly compete into the logistics electric vehicle market rather than just act as a parts supplier. Joint efforts with automakers to develop L-EFVs has become a shortcut for battery companies to reduce the risk of excess battery production, to expand their battery sales, or to extend their industrial and service chain. Most of the battery companies may simply adopt the reverse-mode for more sales of battery by the mutual purchase with automakers. But some battery companies would like to set up a new subsidiary company with automakers to positively-develop L-EFV to expand new market with new products, business models and services. Dingfeng E-light-close truck (Dingfeng) is the typical L-EFVs developed by Pulangte, a subsidiary company led and jointly set up by the strong battery company, Chilwee Group with an automaker. By deploying the positive-mode, the Dingfeng has a high range of 320km and a strong regenerative braking system [11].

3.3.2 Development Mode Led by Freight Operator

In recent years, main freight operators, including express delivery companies, city distribution companies, and e-commerce companies have gradually become big users of L-EFVs. They are speeding up cooperation with automakers to develop L-EFVs more suitable for their large-scale usage and freight transport. The leading E-commerce company, JD.com Inc. (JD) in conjunction with the automaker, Zhuhai Yinlong, developed an E-mini-cargo van in 2018. GVW of this L-EFV is only 2.7 tons, but load capacity can reach 1.5 tons and cargo space reaches 13.9m^3[12]. Fast charging and other functions for stability are also specially designed for the large logistics customers. Similar to the big user's choice, another main city distribution provider, Juma Group, also announced in August 2018 that it will jointly establish a truck company with GLP Inc. (logistics company), and WM Motor (automaker), etc., to jointly positively-develop a new electric "smart truck".

3.3.3 Development Mode Led by Operator Company

There are two main types of L-EFV operators in China. One is the integrated operators who buy L-EFVs and build operation platform to provide vehicle rental as well as charging and maintenance services for the L-EFV users. Another is the "Domestic Transportation Management (DTM)" platform operator, which only provides information matching and transaction matching service without any L-EFV purchased or rented. Comparatively speaking, the integrated operators have the advantage of more understanding L-EFV market demands in the process of serving large-scale vehicle users, and gradually become the new leading force in the development of L-EFVs. For example, Panda New Energy (operator) led and coalesced Aojie Design Co., Ltd. (design company) and HIGER (automaker) to develop a customized new E-mini-cargo van (LEV5) for several express company through positive-mode. The LEV5 adopted de-redundant design in 10 aspects with 8 kinds of new technologies deployed, such as lightweight and intelligent technology integrated. Compared to similar L-EFVs, the GVW of LEV5 is reduced by about 20% while cargo space increased by about 15%. Besides, it has nearly 20 new functions for express logistics, including a small table for the courier to fill out the receipt. [13] In addition, the LEV5 is more popular with the young-generation freight drivers' aesthetic and psychological needs in current city logistics because of LEV5's more technological-sense and fashionable appearance.

Unlike just providing O2O services in the past, city logistics platform operators, such as Lalamove, are gradually shifting to provide offline vehicle rental and freight service using their self-purchased L-EFVs. In the future, they may become the leading force in the development of L-EFVs with the advantage of having big data of L-EFVs operation. At the end of 2018, Lalamove started its purchase of 500 L-EFVs for providing rental service and transport service based on its operation platform with 15,000 L- EFVs registered.

3.4 Comparative Analysis of Development Modes

Figure 5 compares and helps better understanding of the relationships among the leading force and other companies under different L-EFV development modes.

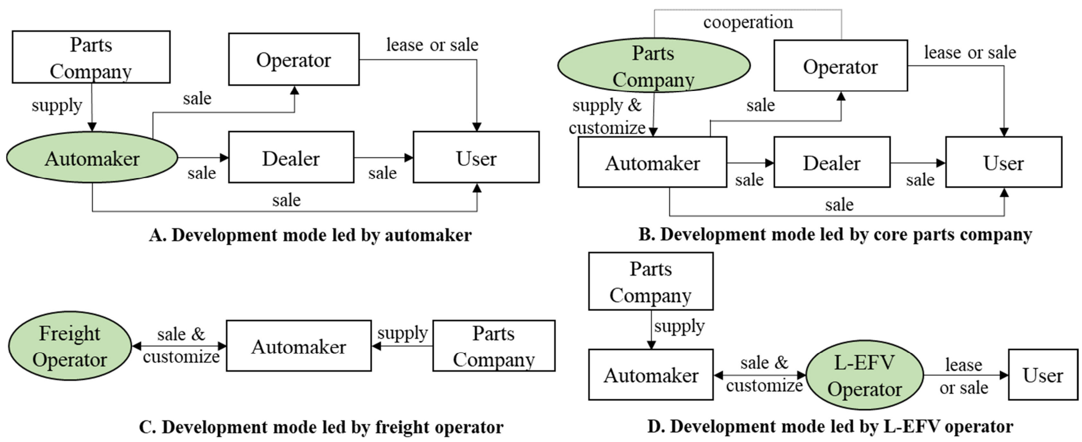

Figure5: Leading force relationships of different development modes

Table 2 shows an evaluation of the market demand adaptability of the L-EFVs under different development modes. The result is from 20 experts based on the Delphi method. "C", "B" and "A" in Table 2 respectively refers to the poor, ordinary and good of the corresponding market demand adaptability.

Table2: Development mode of L-EFVs and market demand adaptability evaluation

Leading Force	Development Process	Low Cost	Good Load Ability	Long Range	Good Maintenance	Total
Automaker	reverse	A	C	C	B	C
	positive	C	B	B	A	B
Parts (battery) Company	reverse	A	C	C	B	C
	positive	C	B	A	A	B
Freight Operator	reverse	A	C	C	B	C
	positive	C	A	B	B	B
Operator	positive	A	B	A	A	A

4 Suggestions for New Development Mode of L-EFVs

As analyzed above, each development mode has advantages and disadvantages. Comprehensively regarding the cost, load ability, charging and maintenance, L-EFVs made by the positive-mode led by the integrated operators are relatively closer to the market demand. However, existing integrated operators of L-EFVs mainly focusing on vehicle rental and sales, they still lack of more comprehensive understanding of the demand of city logistics. The requirements of deep understanding in hardware and software technology for intelligent logistics and smart L-EFVs as well as the reutilization of batteries, etc., may exceed the current operators' capabilities.

In order to develop cheaper and better L-EFVs with battery life cycle reutilization, this paper proposes innovative development mode based on integrating the advantages of existing development modes.

Figure 6 shows a rough framework of the innovative mode which is expected more suitable for China's city logistics market in the present and the near future. Two key points should be guaranteed. One is to cultivate and strengthen the innovative integrated operators and take them as the leading force. The other is to build an ecosystem that supports the production and application of L-EFVs.

The new integrated operator refers to those operators that have intelligent platform for matching information of people, vehicles and goods, can provide not only vehicle rental and sales but also freight services. Comprehensive services of charging, maintenance, battery reutilization, and other services of L-EFVs are integrated in their business. At present, there are few this kind of mature and innovative operators. But some existing large and strong L-EFV operators and automakers, presented by Dishangtie (the largest Chinese L-EFV integrated operator), Lalamove (the main Internet logistics platform) and SAIC MAXUS (the traditional and strong L-EFV automaker), have been speeding up their transition to the innovative L-EFV operators. For example, SAIC MAXUS has been building its own intelligent logistics platform and operating L-EFVs by integrating its own SAIC Anji logistics with the acquired Hoau logistics business besides developing and producing L-EFVs.

To build an ecosystem that supports the innovation of L-EFV development mode, the key is to strengthen the coordination of governments, industry, and research institution. In addition to the collaborative innovation of the leading L-EFVs companies, policy support is still the main power to facilitate the emerging L-EFV market and thereafter to improve the L-EFV development mode. Favorite policies of traffic and parking rights as well as operation subsidies for L-EFVs in city logistics should be implemented in cities from the current less than 100 cities with the rights of passage and the 2 cities with operation subsidy.

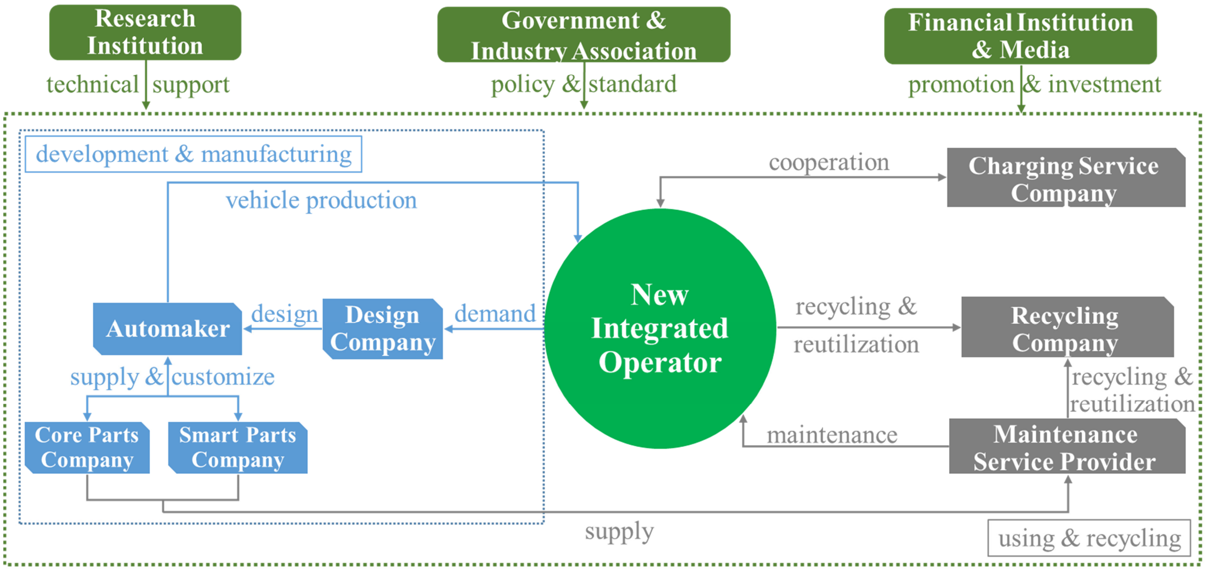

Figure6: Innovative development mode under the ecosystem of L-EFVs

5 Conclusion

To innovate L-EFV development mode is a complex issue. The selection and optimization of vehicle development mode is not a simple product technology problem, nor a problem that can be solved independently by automakers or operators. It is necessary to transfer from products thinking to comprehensive construction of innovative ecology that can integrate L-EFV technology, policy, industry as well as market, and improve their synergies. L-EFV development mode innovation should also keep up with the future. It is key to seize the strategic opportunities of the Chinese Government's Struggle to Prevent Pollution and the market opportunities to customize, develop and verify L-EFVs development mode in the national project of 22 Pilot Cities with Green Distribution. In addition, both of the latest intelligent city logistics technology, such as UAV and AI, unmanned warehouses, smart robots, etc., and the life cycle utilization of power batteries should be integrated with the L-EFVs development. The preliminary explored L-EFVs sharing and joint distribution model should also be considered to facilitate the innovation of development mode for low-carbon and more sustainable city logistics.

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