EVS30 Symposium
Stuttgart, Germany, October 9 - 11, 2017

Development Mode for Integrating Electric car-sharing into Different Types of Chinese Cities

Xiaoyuan Wu[1], Baojiang Sun[2]

Automotive Studies, Tongji University

4800 Cao'an Road, Jiading District, Shanghai, China

E-mail: xywu@tongji.edu.cn

Summary

This paper studies suitable modes for Chinese cities to develop Electric car-sharing based on comparing its history, statistics and characteristics in China with that in Europe and America. By brief analysis on macro background for booming Electric car-sharing in China nationally and more detailed analysis on cities' mechanism locally, the paper aims to not only suggest best practical mode for Chinese cities but also facilitate the world's collaboration on greater success of Electric car-sharing in more regions' sustainable mobility with comprehensive understanding of Chinese NEV strategy, industry and application as well as cities' experience and obstacles of car-sharing.

Keywords：Research, Electronic drive, Car-sharing, Mobility as a service, Business models

1 Introduction

China has become the largest and most dynamic Electric car-sharing market from the end of 2015 in a shorter than 7 years history of development. While overall nationwide tendency is keeping hot, local operation is hard and development mode for integrating Electric car-sharing into different types of cities is one of the most pressing tasks regarding complicated local conditions and challenges for E-urban mobility in China.

1.1 Overview of booming Electric car-sharing in China

Car-sharing is usually called as 'Time-sharing' to highlight its distinctive features as sharing a car by minute or hour rather than by day or longer-time referring to traditional 'long-time' car-rental in China. Compared with nearly 70 years of European and worldwide car-sharing and its currents status, China's car-sharing presents 3 most obvious features as short history, rapid expansion and high proportion of EVs. Although starting later in 2011, Chinese Electric car-sharing had been growing rapidly into the largest market from the end of 2015 and grew much faster in recent 2 years. As compared in Table 1**,** more than 95% of the 40,000 sharing-cars are EVs in China by April 2017 when only 10.4% of 17,200 sharing- cars are EVs in Germany while even less EVs in America [1]. According to Chinese Ministry of Transportation (MOT)'s statistics in June 2017, among the 6,301 car-rental companies operating about 200,000 vehicles for car-rental at a yearly growth rate of 20%, there are 40 car-sharing operators possessing 40,000 vehicles in around 50 cities [2].

Table 1: Development and status of Electric car-sharing in China, Europe and America

Country	History	Operators and sharing-cars	Vehicle type	Car-sharing mode	Power complement mode	Electric car-sharing cities	Largest Electric car-sharing city	Largest operator
China	2011-2017	• Registered operators:>350 • 40 operators account for 95% +of the market • ~10 operators possess 1, 000+ EVs • EVs: :>95% of 40,000 sharing-cars	• Total types>20 • Types with largest amount: Lifan 330EV, Chery EQ, BAIC E160, Roewe E50, ZD D2, JAC iev4, Zotye Z100	• Round Trip (A-A): ~49% • One way(A-B):~50% • Free-floating:~1%	• Charging:~85% • Battery swap:~15%	• Total:~50 cities • With 1,000 EVs: ~10 cities	Shanghai: >5,500EVs	EVCARD: >9,500EVs
Canada	1994-2016	Main E car-sharing operators: Communauto, Zipcar, Evo, Modo	Nissan LEAF, Chevrolet VOLT, Ford Focus, Toyota Prius	• Round Trip (A-A) • One way(A-B) • Free-floating	Charging:100%	Montreal, Vancouver, Quebec City, Gatineau, Sherbrooke, etc.	Montreal: ~200 EVs	Communauto: ~200EVs
Germany	2011-2016	• Operators:>150 • Main E car-sharing operators: Car2go, Drivenow, Flinkster, stadtmobil, PSA • EVs: ~10.4% of 17,200 sharing-cars	Smartfortwo, BMW i3, BMW ActiveE, Citroen C-Zero	• One way(A-B) • Free-floating	Charging:100%	Stuttgart, Berlin, Hamburg, Munich, Düsseldorf, etc.	Stuttgart: ~600EVs	Drivenow: ~800EVs
France	2011-2016	• Main car-sharing operators：Autolib', Zipcar • Largest E car-sharing operator: Autolib'	Bollor éBluecar	• One way(A-B)	Charging:100%	Paris, Lyon, Bordeaux, etc.	Paris: ~4,000EVs	Autolib': >4,000EVs
USA	1999-2016	• 4 operators (Zipcar, Car2go, Enterprise CarShare, Hertz) account for 95%+ of the market • Main E car-sharing operators: Autolib', Reachnow • Zipcar has a few PHEVs • EVs:<1% of all sharing-cars	Bollor éBluecar, BMW i3 , Volkswagen Golf GTE, Chevrolet Volts, Toyota RAV4 EV	• Round Trip (A-A) • One way(A-B) • Free-floating	Charging:100%	Indianapolis, Boston , Seattle, Los Angeles, San Francisco, etc.	Indianapolis: ~230 EVs	Autolib' : ~300EVs
Brazil	No Electric car-sharing operated so far; Zazcar has 65+ ICEVs for car-sharing in 52 locations across S ão Paulo until Mar 2017							

1.2 Coexisting of macro leaping circumstance and micro tough reality

It is not accidental but inevitable that Chinese Electric car-sharing boomed in recent years. There are four main powerful macro driving forces forming strong base from increasing NEV industry, supporting policy, advancing technology and thickening sharing-economy nationwide.

In terms of micro level, cities (including counties) are landing destination for Electric car-sharing. Although most of Chinese cities also provide strong motivation to embrace Electric car-sharing valuing its great role in facilitating local economy, reducing emissions and congestion, as well as enhancing cities' image, it is beset with difficulties in almost all cities. The most obvious manifestation of these difficulties is that Electric car-sharing operators move forward harder in cities and basically unprofitable than expected.

1.3 Study Purpose and Methodology

A lot of studies often focus on whether operators' business model is suitable and their effort is good to profit earlier. Based on engagement in investigation and research of Electric car-sharing since its germination in China and comparison study with that aboard, the author finds that selecting suitable development mode for cities as a whole with adapted mechanism allocating and utilizing key elements is far more critical than only considering individual operator's model and efforts. This paper will focus on comprehensive understanding of key factors impacting cities' landing and suggest suitable development mode for facilitating Electric car-sharing successful in more cities for sustainable and low-carbon urban mobility.

Main work includes continuing survey, field investigation of the 8 cities possessing a fleet of over 1,000 sharing-EVs, expert interview, data collection, processing and analysis, etc. Case study, comparative analysis and other methods are combined quantitatively and qualitatively.

2 Macro background and main cities' portraits

Comprehensive understanding macro background and local factors for Electric car-sharing is helpful for analysis on its settle down in China.

2.1 Macro background accelerating Electric car-sharing cities' landing

As mentioned above, the rapid developing NEV industry, supporting policy from central governments, advancing mobile internet and payment technology as well as a bit overflowing sharing-economy are the four strongest power accelerating Electric car-sharing entering about 50 cities in China by the beginning of 2017 while more and more cities are under the way.

First, rapidly developing NEV industry in China lays the deepest and most important foundation for Electric car-sharing. Since the second half of 2015, China has become the largest country of NEV production and sales with the total amount approaching 1,150,000 units which accounts for more than 50% of the total in the world by May 2017. Among the total NEVs, passenger-car sales have been accounting for a high proportion around 70% in recent 5 years. As displayed in Figure 1, its annual sales increased rapidly from 10,000 units in 2012 to 336,000 units in 2016 while proportion in the first 5 months of 2017 rising much higher than 85%. In terms of pure electric passenger-cars (EVs) which are used as Chinese car-sharing's main transportation, both of EVs production and proportion in total NEVs will expand much faster driven by the national strategy of "Double Credits for Fuel and New Energy Vehicles" as well as "Strictly Control on New Capacity for ICEVs". Viewing planned yearly NEV production capacity of the 6 traditional giant Automotive Group, like BAIC, SAIC, etc., and the newly approved 15 New Energy passenger-car makers since 2016 in China, it will be more than 6,000,000 units in 2020 and far greater than central governments' expectation. Under this background, car-sharing has been put as the best way to promote the huge scale of EVs when private purchase blocked by anxious from short mileage and inconvenient charging. Moreover, car makers have viewed actively participation in car-sharing as most necessary choice to improve their core-competitiveness facing the era of sharing-economy. On the other hand, the huge NEV passenger-car production allows car-sharing operators more cost-effective vehicle

types to reduce costs while offers customers more economic and diversity travel selection. In addition, quick developing NEV industry makes product technology line more abundant and hence allows diversity for Electric car-sharing with unique large-scale battery-swap mode besides the common charging mode.

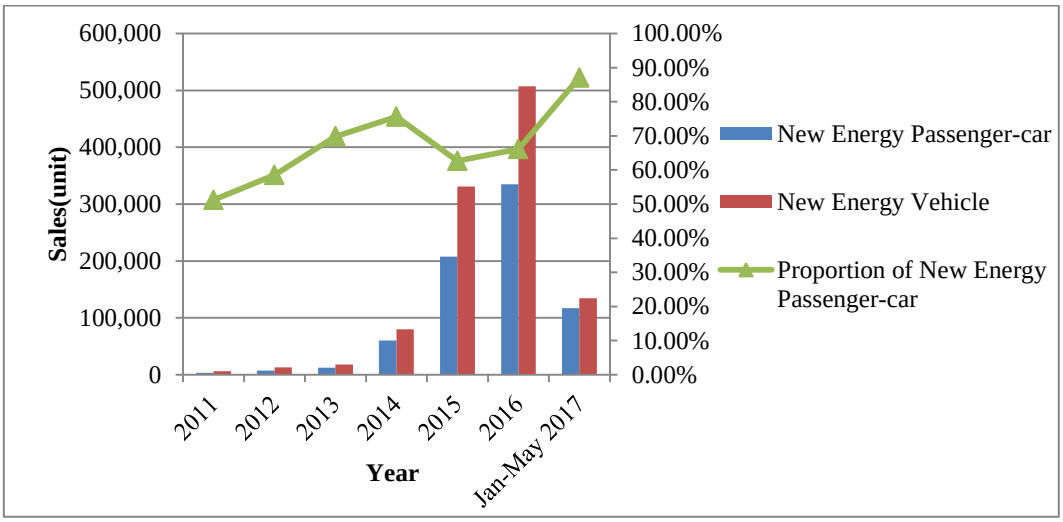

Figure1: Sales of New Energy Vehicles (NEVs) in China (2011-May 2017)

Second, strong political support for Chinese Electric car-sharing came from both central governments' industry policy and transport policy. In July 2014, time-sharing (car-sharing) was written for the first time into the State Council's Files as innovative business model encouraged for NEVs promotion. Besides this highest national-level industry policy, on June 1st, 2017, Chinese Ministry of Transportation (MOT) and the Ministry of Housing and Urban Rural Development (MOHURD) jointly issued 'the Guiding Opinions on Promoting Healthy Development for Car-rental Industry (Draft for Comment)' .Time-sharing was also for the first time defined as car-sharing and classified its role in Multimodal Mobility as innovation of traditional car-rental. In the two Ministries' new policy, position of car-sharing and its relationship with other mobility modes, including public transportation, taxi and net taxi(like Didi), car-rental, private-car and bike, was positively stated and clearly encouraged as "Car-sharing not only improves users' travel experience as a new choice of urban mobility but also helps to reduce cities' rapid growth trend of private-car purchase willingness and ownership capacity, hence resulting in less occupation of road and parking resources to some extent." Despite the nonexistence of accurate data, there have been preliminary data in some advanced Electric car-sharing Chinese cities (such as Shanghai, Chongqing and Wuhu) showing that more and more car-sharing users sell their cars in advance, forgo new car purchase or reduce usage of private-car for commuter.

Third, quickly advancing mobile internet and popularizing mobile payment technology in China improved the self-service capacity and operating efficiency greatly by O2O for Electric car-sharing companies as well as customers' usage. By only deploying APP on smartphones with no need of a card or the key anymore, customers can complete entire process by themselves easily, including access and registration, searching and booking EVs, open and lock the door, pick up and return, charging and parking, as well as the payment. More convenient service modes, like one-way (A-B) or free-floating, complete the early A to A mode and billing modes are varied by time or by time combined with by mileage.

Fourth as the final but not limited to this, fast growth of Electric car-sharing should thank to the overheated 'sharing-economy' in China represented by sharing-bike, sharing-basketball and even sharing-mini KTV, etc., which fast permeated daily lives from the end of 2015. It's easy to see customers' understanding and acceptance of Electric car-sharing are tremendously strengthened by the hot overall sharing atmosphere if only taking sharing-bike as an example. Only in recent 2 years, over 10 million bikes in China have been put for share by over 100 million usages.

2.2 Cities' evolution and motivation for Electric car-sharing

Looking on Chinese cities' development progress of Electric car-sharing, it's easy to identify two different stages as incubation of 2011-2015 and rapid growth from the end of 2015. While just 15 cities had involved in Electric car-sharing by 2015 starting from 2011 when the only city, Hangzhou, probed car-sharing with 2 EVs, the total number of Electric car-sharing cities has exceeded 50 by May 2017. Over 95% of these cities are located in the 5 parts under the red line in Figure 2, Yangtze River Delta, Pearl River Delta, Region of Beijing, Tianjin and Hebei, as well as the Central and Southwest area. Although large cities including the first and second class cities as well as some capital of provinces are pioneers, the amount of middle and small-sized cities accounts for more than 50%.

Figure2: Distribution of regions operating Electric car-sharing in China

Some common motivation combined with different starting points because of locality drove cities speeding Electric car-sharing in recent 2 years. All kinds of cities face a common huge pressure between increasing intense traffic resources and residents' thirst demand for driving and parking with no private-car or parking lots. As show in Figure 3 and 4, the amount of private cars is far lower than that of drivers' license but far higher than parking facilities [3]. The emergence of Electric car-sharing was just the right time allowing access instead of ownership for those drivers and EVs' favour in cities with restriction on ICEV purchase and traffic. Some cities show special preference to facilitate Electric car-sharing for the pressing need to expand local NEV industry as well as application and tourism industry. In addition, Electric car-sharing has earned more local governments' support because it offers new and green options for official travel after general governments' fleet cut heavily in the public convoys' reform while helps local governments complete NEV promotion tasks.

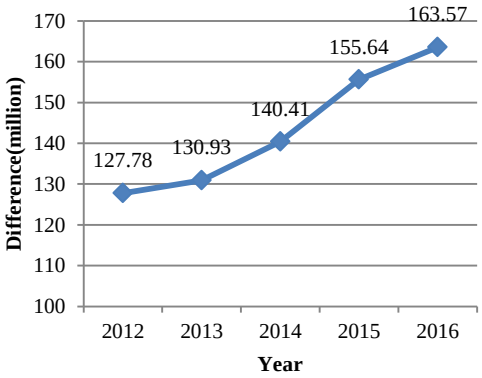

Figure3: Difference between amount of private-car and drive license

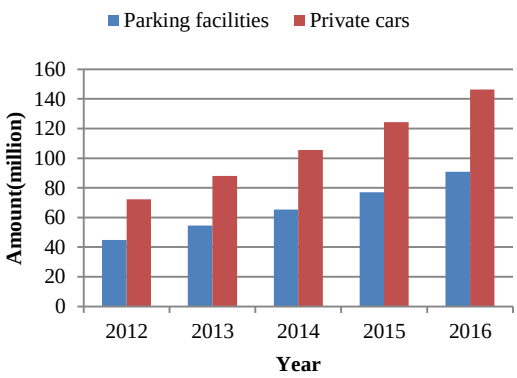

Figure4: Difference between amount of private-car and parking facility

2.3 Main Electric car-sharing cities' portraits and features

According to authors' survey and statistic, around 10 of the 50 Electric car-sharing cities possess more than 1,000 EVs for each so far. As shown in Table 2, the portraits list the 8 cities with the largest scale of sharing EVs for a simple comparison on cities' localities, like class, population, area, and Electric car-sharing

Table 2: Portraits of main Electric car-sharing cities with over 1,000 EVs operated for each in China （by May 2017）

City	Starting time	Local conditions					Policies		EVs			Operators	
		City class	Population* (million)	Built-up area* （million km^2）	Car ownership (million)	Number of NEV OEMs/largest NEV OEM	Admittance (approve or register, quota)	Right (traffic, purchase, parking)	Amount of EVs (unit)	Average (unit/per million people)	Main vehicle type	Number of operators/ main operators	Largest operator
Hangzhou	Mar.2011	2nd class	9.01	5.06	2.29	5 / GEELY	register, quota	traffic and purchase restriction on ICEV	2,500	222	KANDI, Lifan, BAIC, CHANGAN	4/Microcity, PAND-AUTO, iblue, Chefenxiang	Microcity/ 2,000 EVs
Beijing	Mar.2013	1st class Capital	21.73	14.01	5.44	5 / BAIC	approve, quota	traffic and purchase restriction on ICEV	3,200	138	BAIC, JAC, Chery, GEELY	About 100 registered and 10 in large-scale/ Beijing travel, Gofun, Youche, YIDU, Greengo, YIKAZC	Beijing travel/ 2,000 EVs
Shanghai	Oct. 2014	1st class	24.19	15.63	3.02	1 / SAIC	approve, quota	traffic and purchase restriction on ICEV	5,500	227	SAIC, BAIC, JAC, KANDI, Chery, BMW	3/EVCARD, Microcity, Auto-Green	EVCARD/ 5,200EVs
Wuhu	Jul. 2015	3rd class	3.67	1.65	0.47	1 / Chery	register, no quota	parking benefit and operating subsidy	1,200	545	Chery	1/EAKAY	EAKAY/ 1,200 EVs
Chongqing	Nov. 2015	2nd class	18.38	13.29	3.04	3 / Lifan	register, no quota	parking benefit	3,500	190	Lifan, CHANGAN, Chery, SAIC	3/PAND-AUTO, CHANGAN, EVCARD	PAND-AUTO /3,200 EVs
Ninghai	Dec. 2015	County	0.65	0.36	0.13	1 / ZD	approve, no quota	parking benefit	1,100	1,692	ZD	1/SHARE'N GO	SHARE'N GO/ 1,100 EVs
Guanghzou	Jul. 2016	Provincial capital	14.04	12.37	2.33	1 / GAC	register, no quota	traffic and purchase restriction on ICEV	3,000	207	ZD, Chery, SAIC, BAIC	9/DINGDONGCHUXING, JIABE, EVCARD, YIDU…	DINGDONGCHUXING/ 1,000EVs
Chengdu	Aug. 2016	Provincial capital	15.91	6.15	3.89	1/ Yema	register, no quota	traffic restriction on ICEV	1,000	63	Lifan, Chery, SAIC, BMW	>7/PAND-AUTO、EVCARD, Gofun, Soda	PAND-AUTO/ 800 EVs

* Population data is of 2016; built-up area data is of 2015; number of NEV OEMs only counts NEV of passenger-cars

operating status as well as local policy, etc. The amount of EVs shared in these 8 cities accounted for over 50% of all in China.

Further inspecting the 8 cities' localities and development course, the largest 8 Electric car-sharing cities are also the most representative cities reflecting almost all Chinese cities' development mode and path. The 8 cities covers all kinds of city-class, from the first class, like Beijing, to even a small county, like Ninghai, while include cities with typical different local NEV industry base or other characteristics. Some cities' respective characteristics deserve briefly highlighted as follows besides listed in Table 2 because some features are also key points of the typical development modes which will be extracted later.

As mentioned above, Hangzhou was the first Electric car-sharing city in China but not the strongest one yet.

Beijing is the second early city next to Hangzhou with the largest number of operators but scale of sharing-EV fleet is not as large as expected.

The largest Chinese Electric car-sharing city, Shanghai, with over 5,000 sharing EVs, edging out Paris with 4,000 units, also became the global largest Electric car-sharing city for the first time since 2016. Instead of having many operators, there are only 3 in Shanghai and the leading operator is very strong and open enough to integrate city resources more efficiently. In addition, Shanghai is the first Chinese city issuing the city-level comprehensive policy and plan for Electric car-sharing in March 2016.

Chongqing is the earliest and the largest city operating 3,200 EVs for car-sharing in unique battery-swap mode in the world. In addition, Chongqing is also the only Chinese city with overseas car-sharing project, Car2go launching from April 2016.

Located in Anhui Province and as a third-class and inner-land city in China, Wuhu stood out for possessing the largest Electric car-sharing fleet in the medium-sized and small cities with only one operator but a complete and efficient operating business chain.

As a county in even lower city class, Ninghai in Zhejiang Province is another typical case of small cities similar to Wuhu with only 1 operator but over 1,000 sharing EVs.

Compared with the above cities in Table 2, Chengdu and Guangzhou have something in common. Although they both are large local capital cities with strong traditional ICEV industry (not NEV), they are the last cities to kick off Electric car-sharing. Another common feature is that although they started late they both gathered the largest number of operators in a short span of 1 year. Taking Guangzhou as the example, it has near 10 Electric car-sharing operators so far in less than 1 year from its first operator's birth in July 2016. In terms of local policy, though started late, Guangzhou established the first Chinese city-level official association and issued the first introduction of development norms for car-sharing industry.

3 Development modes in different types of cities

Typical development mode for large or medium and small-sized cities respectively will be analysed for better performance considering more detailed in key factors' framework both about cities' 'Locality' and 'Ability'.

3.1 Typical development modes and framework of key factors

Although development modes of the 8 most representative Electric car-sharing cities vary with their different local conditions, it is not difficult to find a basic common point of development modes among different cities. In the two smaller cities, Wuhu and Ninghai, there is only 1 operator each while multiple operators in each of other 6 large cities. When further reviewing all 50 Chinese Electric car-sharing cities, the same result is clearer that large cities have several operators in each while medium-sized and small cities have only 1. To study the two typical development modes better on their similarities and differences, effect and applicability for cities, it can simply and reasonably put aside other classification features but divide different types of Electric car-sharing cities into two categories, large cities as well as medium and small-sized cities. In general, large cities include the first-second class and most of local capital cities while medium and small-sized cities refer to those in the third and flowing class as well as smaller counties in China. Furthermore, each of the two types of cities respectively has strong commonalities in key factors

that influence their development modes when observing their clustering characteristics in a view of the key factors' framework for Chinese Electric car-sharing cities. The so called 'three horizontal-three vertical' framework was extracted by the author from her team's continuing study and widely recognized practical by the industry to analyse cities' Electric car-sharing[4]. In brief, layering and refining in AHP method, the author summarized local factors influencing development of Electric car-sharing in cities into 6 dimensions in three horizontals and three verticals. As illustrated in Figure 5, the three horizontals are referred collectively to 'Locality' while the three verticals called as a whole of 'Ability' for cities' Electric car-sharing success. The 3 horizontals factors, transport, parking and policy of car-sharing quota, dispersed in the three categories of local conditions, are viewed as the most critical 'Locality' factors as highlighted in red. Residents' travel modes differ a lot among different types of cities. For example, when the proportion of travel by bus in Shanghai is over 23%, non-motorized travel mode in Changxin (a county similar to Ninghai in Zhejiang Province) is dominant at a proportion of 64.8% while bus travel proportion is accounting for 7.9% and car trips up to 21.7%.[5] In terms of 'Ability', the collaborative ability among all operators, including several car-sharing operators and other resource operating companies, like charging providers, is usually viewed more important than the other two abilities.

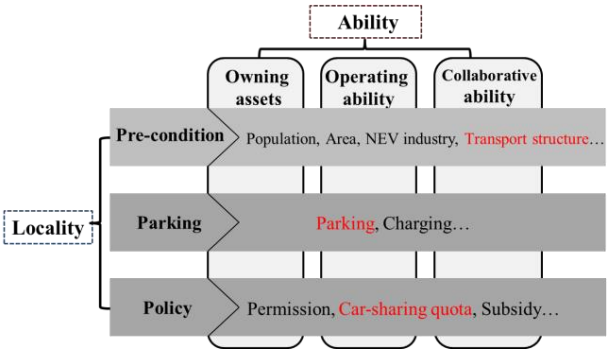

Figure5: Local factors' framework influencing development of cities' Electric car-sharing

3.2 Development mode for large cities

The above preliminary idea that large cities' Electric car-sharing development mode symbolized in common as having several operators also consists with general logic that a large city needs a large scale of EVs and station network in reasonable density. It needs more than one operator to undertake the heavy burden in capital and service for a certain scale of Electric car-sharing especially in the early stage. Meanwhile, having more than one operator is conducive to moderate competition and encourage operators' better and diversified EV sharing service. After this point is clear, the next question may arise naturally as how many operators is suitable or whether the more operators the better for a large city.

Looking at Table 2 again, the number of operators in the 6 large cities differs obviously and is not positively related to cities' performance. When reviewing quantities or effects of the overall scale of EV fleet and membership, members' activity and satisfaction, operation efficiency of EVs integrated with power complement and parking, Shanghai and Chongqing are widely recognized as the two best cities on Electric car-sharing development. The number of operators in the two best practice megacities is only 3 for each, much less than the other large cities'.

In contrast, starting Electric car-sharing earlier with strong support from both the central and local governments as well as capital market, Beijing has the largest number of over 20 operators. However, Beijing moved on more difficultly with poorer performance on Electric car-sharing. One of the most fatal points is that excessive number of operators makes the city's overall shortage resources, like license quota, parking networks and charging facilities, dispersed at lower efficiency. It is difficult for each operator to form the necessary large-scale of EV fleet and station network when resources decentralized and operation islanded. As a typical failure case, in March 2017, an Electric car-sharing company with small size but strong operation and service ability in Beijing went bankrupt as the first closed Electric car-sharing case in China.

Current total number of operators in Chengdu and Guangzhou is not too more with less than 10 in each city. However, regarding the two cities' rapid increasing trend in a short span, the momentum of having excessive number of operators has begun to appear. These two cities are worth learning from Beijing's lessons and avoiding difficulty from blind development for too many operators.

Going back to the two better models of city cases, Shanghai and Chongqing have another common point on possessing only 1 major leading Electric car-sharing operator among the three in each besides each has the relatively suitable number (such as 3) of operators. Reviewing practical results of all large cities, it shows more good than harm for a large city to have 1 leading operators. It is helpful for maintaining the appropriate cooperation and competition among multiple operators, such as facilitating share of parking and charging resources. It is necessary for improving cities' overall operating capacity by integrating multiple operators' ability so as to allow the whole city with healthy development on Electric car-sharing.

Table3: Comparison of leading operators' development and mode in Shanghai and Chongqing

Item	EVCARD in Shanghai	PAND-AUTO in Chongqing
Scale of EV fleet(units)	5,200	3,200
Power supplement model	Charge	Battery swap
Compatibility of platform (number of OEMs/Vehicle types)	5/8	1/1
Openness (open to number of facility operators)	>5	1

Further comparing modes of the two best practice cities' leading operators is helpful to figure out which is more suitable for other large cities with more universal significance. In Table 3, EVCARD in Shanghai and PAND-AUTO in Chongqing are simply compared as the two cities leading operators. In addition to basic statistic data, such as scale of EV fleet and number of vehicle patterns, mode of power supplement, platform compatibility for the number of OEMs and vehicle types, and openness of operation system for the number of power suppliers, are compared as more important factors related to development mode. The most obvious difference is that EVCARD deploys the most popular charging mode while PAND-AUTO uses unique battery swap mode. Regarding that shortage of widely distributed charging piles attached to parking space is the biggest obstacle for all cities' Electric car-sharing operation, the advantages of battery swap mode is obvious as only a few large swap stations or moving trams with batteries can give consumers convenient energy supplement in short time. The operator also benefits more operating time and higher efficiency from the swap mode. However, the fatal drawback of using swap mode is that the operator should be only completely attached to one OEM's EVs and cannot share resources from other infrastructure operators. In contrast, although charging mode for EVCARD in Shanghai suffers from long charging-time and hard access of parking space with charging resources, it allows EVCARD high compatibility and openness to gain more resources from multiple OEMs, facility operators as well as local governments. In fact, by May 2017, EVCARD possesses a fleet of over 9,500 EVs located in 24 cities while PAND-AUTO possesses 7,000 EVs in 6 cities. Comprehensively thinking, charging mode is more suitable for leading Electric car-sharing operator to expand to more cities with more healthy development in the current developing stage.

3.3 Development mode for medium and small-sized cities

Viewing that parking spaces are easier to plan and cheaper to obtain while average travel distance is shorter, it is more suitable for medium and small-sized cities to develop Electric car-sharing than aforementioned large cities. However, also for the similar reasons that traffic congestion and parking shortage are not as severe as in large cities, enthusiasm and urgency of Electric car-sharing development for medium and small-sized cities are relatively lower.

The exception exists in medium and small-sized cities with strong EV industry, like Wuhu and Ninghai as mentioned above. The two cities started early with high enthusiasm in Electric car-sharing mainly due to each has a strong EV maker producing large scale of compact EVs, the right vehicle types for car-sharing. These cities' governments usually have greater motivation and ability in mobilizing public resources to support local operator working closely with local EV maker and growing rapidly as strong leading car-sharing operator. The basically current practice shows an obvious path that only 1 strong local Electric car-sharing operator is more preferred as suitable mode for medium and small-sized cities with EV industry in the early developing stage. Careful analysis on development mode of the only operator EAKAY in Wuhu and that in Ninghai, Share'ngo, comes out a little bit of big difference. EAKAY mode is a kind of full close chain to construct and operate stations with parking and charging piles by itself while Share'ngo is a kind of open mode to cooperate with other infrastructure providers. From the two cities' overall propulsion and performance on Electric car-sharing, the fully enclosed operation mode is more suitable for medium and small-sized cities in the early rapid progress.

In addition, medium and small-sized cities without EV industry bases should also be mentioned because a lot of these types of cities started already or are under the way and development modes for Electric car-sharing in these cities differ from those cities with EV industry to some extent. In general, Electric car-sharing in these cities is mostly operated by the local former leading car-dealers independently or together with nonlocal strong operators entered.

4 Conclusion and discussion

To summarize, cities are the most import destination for Chinese Electric car-sharing to settle down. In the early developing stage from present to 2020, selecting suitable development mode for a city as a whole will be still critical for advancement and success. To select suitable development mode for cities' Electric car-sharing needs basic understanding on both the whole country's car-sharing's characteristics, development status, future trend and mechanism at a macro level and cities' best practice as well as failure lessons related to their locality at a micro level.

Besides obvious features differing Chinese car-sharing from that in the world, such as late start, rapid growth and EV based, cities' large difference on locality should be pay more attention to. In terms of developing process, although China has become the largest Electric car-sharing market globally, it still will be in the early growing stage with more and more cities' jump in.

Some principles for cities selecting Electric car-sharing development mode should be insisted on. Firstly, a city should do well comprehensive top-level design for the whole city. Especially for a new developed city, proper scale of Electric car-sharing as well as number and distribution of charging stations should be planned to facilitate Electric car-sharing sustainably integrated into low-carbon urban mobility. It means cities' Electric car-sharing should target at proving the lower carbon travel mode, including public transport, bicycle and pedestrian, while reducing not low-carbon travel by private-car. Secondly, cities' development mode should plan proper amount of operators, foster leading operator as well as guide its proper business model, and encourage coordination among operators by a set of policy based on full consideration of local conditions. Third, development mode should keep pace with the times. Full attention should be given to the integrated innovation of technology, business models and policy at different development stages.

As the focus of this paper, development modes of cities' Electric car-sharing under the current early and rapid growing stage from present to 2020 are suggested for different types of cities. The Shanghai mode which encourages order competition and is characterized by allowing multiple but not too many operators (such as around 3), fostering and promoting leading operator full coordination with other operators, and guiding the leading operator, EVCARD's business model marked by open ecological cooperation, is suggested for large cities. The Wuhu mode, a typical PPP mode by implementing exclusive operating franchise together with the only operator, EAKAY' s business model characterized by running key resources in a full close chain is recommended for medium and small-sized cities with strong local EV industry. As for medium and small-sized cities without EV industry, development mode can be selected as supporting local-dealers or car-rental enterprises to operate Electric car-sharing by stimulating their potential enthusiasm in alternating rent for sale or introducing nonlocal mature and powerful operators.

At last, briefly looking at the future shows a greater development of Chinese Electric car-sharing regarding encouraging policy, advancing NEV industry and technology, as well as improving consumption circumstance. According to the author's interview, the scale of Chinese Electric car-sharing in the next 10 years only regarding domestic OEM's current plan will be over 1,000,000 units, far more than 600,000 in 2025 as predicted by Roland Berger in April 2017[6]. Of course, some new factors, including time window of policy (such as the Central governments' subsidies will completely fall off after 2020) and new technologies (such as integration of autonomous technology with electrification) should be seriously considered ahead for more suitable Electric car-sharing development mode.

References

[1] http://mp.weixin.qq.com/s/zQVMLPKx_0Hz60pVaS03fg

[2] http://mp.weixin.qq.com/s/YJZ-q74x1N_edCbvXquj7Q

[3] http://www.mps.gov.cn/n2255040/n4908728/c5682934/content.html

[4] http://www.evpartner.com/news/27/detail-24450.html

[5] Wang Yuji, Cheng Long, et. *Analysis of the difference of travel characteristics in small and medium-sized cities, take Changxing county , Zhejiang province as an example,* Urban Transport of China Vol.13 No.2 March 2015

[6] *How Does Car-sharing Succeed in China*, Roland Berger, https://www.rolandberger.com/publications/publication_pdf/tab_car_sharing_china_cn.pdf

Acknowledgment

Survey on Chinese cities' Electric car-sharing obtained help from CEOs of the following operators, Shanghai EVCARD, Wuhu EAKAY, Chongqing PAND-AUTO, Ninghai Share'ngo, Hangzhou Microcity, Beijing Greengo, Chengdu EVCARD, Guangzhou DINGDONGCHUXING. Appreciation should be given for their information.

Authors

Xiaoyuan(sally) Wu, associate professor, Deputy director of Center for NEV Industrialization, Automotive studies, Tongji University. With strong ability and abundant experience in survey and assessment of EV industry and E-urban mobility, she has been researching on EV industry, policy, business model and customers' acceptance for cities mechanism of EV application, etc.

Baojiang Sun, Master degree candidate, Automotive studies, Tongji University. Study NEV industry and application under Xiaoyuan Wu's guidance.