The Role of Electric Two-Wheelers in Sustainable Urban Transport in China:
Market analysis, trends, issues, policy options

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Abstract
As a synchronous happening of the expansive and deepening urbanization in China, motorization is increasingly challenging the country's traffic system, affecting the daily life of its urbanites through traffic congestion and air and noise pollution. Is electric motorization the answer? Probably, but yet to come, while electric two-wheelers are already serving as a better alternative to private car ownership (by being more affordable and less pollutive) and public transport system (by being more flexible and efficient for personal use and for the last mile transport). China, as the old day kingdom of bicycles, is today the world's largest manufacturer, exporter and market for electric two-wheelers, with the current ownership of about one electric two-wheeler for every 10 people. However, electric two-wheelers, as a competitive solution for fast and "green" transportation, are yet to be bettered off. Lead poisoning, traffic accidents, lacking of charging facilities in general are the elements that affect and restrain the further development of the market. Through extensive reviewing of academic papers, professional reports, news articles and blogs upon electric two-wheelers, this paper begins with a systematic introduction into China's electric two-wheeler system and pertaining laws and regulations, followed by a comprehensive analysis of China's current market and trends, especially the many existing issues, aiming to come up with sensible policy options to provide meaningful references to policy makers, industry regulators, relevant associations, manufacturers, two-wheeler drivers, market researchers and other interested stakeholders.

Keywords: China, urban transport, sustainability, electric two-wheelers (electric bicycles & electric scooters & electric motorcycles)

Contents:

1 Introduction

Two wheel vehicles, due to their low cost and easy operatability, especially in congested traffic, have traditionally been a very popular mode of transport in China, India and many other Association of Southeast Asian Nations (ASEAN), compared with other regions in the world. Besides mobilizing individual people, they are also used to carry additional people and cargo. China used to be the kingdom of bicycles, by end of 2011, the ownership of bicycles was 470 million.

Along with the arrival of electric vehicle age by and large, given the already deep penetration of traditional two wheel vehicles in these areas, electric two-wheelers, claimed to be "greener" and more sustainable transport option, find their rapid adoption and expansion in the region. Accelerating urbanization, increasing demand and income for transportation, traffic congestion and environmental pollution, sometimes underdeveloped public transport system are the main drives. Thus, emerging about a decade ago, the market and industry of electric two-wheelers have experienced a rapid growth ever since (Pike Research, 2012d).

Electric two-wheelers, by its swiftness and dexterity, easy operatability and easy maintainability, affordability and low pollution, are most welcome among city dwellers, short distance commuters and frequent road drivers and users of special needs. Besides personal use, electric two-wheelers also increasingly find their place in public service, such as urban sanitation and domestic and short distance patroling, in delivery service, etc.

1.1 Definition

Electric two-wheelers, as indicates itself, is electricity-powered two-wheelers. A battery pack and a motor are installed to store and transform the electricity. A user control is usually attached to the handle bar to brake and adjust the speed.

Under this abstract definition, a variety of types and styles are available to consumers in the market and still developing. This paper follows the mainstream definition and mainly focuses on the Chinese market.

1.2 Categorization

Having operating pedals or not divides electric two-wheelers into two categories, electric bicycles (e-bicycles) and electric scooters (e-scooters) or electric motorcycles (e-motorcycles). And, these two categories are also different in the defined top speed, in terms of which, legal definitions vary a lot among areas and countries, as shown in Table 1.1 and Table 1.2 in below.

1.2.1 Electric bicycles

By appearance, e-bicycles have pedals as traditional bicycles do, and have two types (Pike Research, 2012a):

- Pedal-assisted (or pedelec), which has a torque sensor that engages the motor without the driver operating a throttle.
- Throttle-controlled (or twist-and-go), which permits a driver to accelerate without having to pedal;

By top speed an e-bicycle is designed and could reach in real driving, different regulations exist:

Table 1.1 E-bicycle Definitions by Region, World Markets (Pike Research, 2013a)

Region	Top Speed	Electric Motor Size	Other Requirements
United States	<20 mph (<32 kph)	Max 750W	Has operating pedals
Canada	<20 mph (<32 kph)	Max 500W	Vehicle weighs less than 120kg; has operating pedals
Western Europe	<15.5 mph (<25 kph)	Max 250W	Motor operates during pedaling only (Pedelecs)
Eastern Europe	<15.5 mph (<25 kph)	Max 250W	Has operating pedals; some markets require motors only operate during pedaling
China	≤12.4 mph (≤20 kph)	No limit	Has operating pedals; 40kg max weight
Rest of Asia Pacific	≤15.5 mph (≤25 kph)	Max 250W	Has operating pedals
Latin America	<15.5 mph (<25 kph)	Max 250W	Has operating pedals
Middle East	≤15.5 mph (≤25 kph)	No limit	Has operating pedals
Africa	≤15.5 mph (≤25 kph)	No limit	Has operating pedals

Note: According to *Electric bicycles - General Technical Requirements of People's Republic of China* (The National Standard GB17761-1999), the electric motor size in China should not surpass 240 W (Baidubaike, b).

1.2.2 Electric scooters (e-scooters) and electric motorcycles (e-motorcycles)

Wikipedia defines e-motorcycles and e-scooters as plug-in electric vehicles that can be recharged from any external source of electricity, and the electricity stored on board in a rechargeable battery powers one or more electric motors to attain locomotion. E-motorcycles, to distinguish from e-scooters, do not have a stop-through frame (Wikipedia, b). Besides, e-scooters have a floorboard designed to let the drivers put their feet on.

Like the case of electric bicycles, regions and states have different regulations on the top speed as in Table 1.2:

Table 1.2 Electric scooters and electric motorcycle definitions by region (Pike, 2012f)

Region	E-scooters	E-motorcycles
Nother America	**20 mph (32 kph) <Top speed ≤ 30 mph (48 kph)**	**Top speed >30 mph motor size >3 kw**
Western Europe	**15.5 mph (25 kph) <Top speed ≤ 28 mph (45 kph)**	**Top speed >28 mph**
Eastern Europe	**15.5 mph (25 kph) <Top speed ≤ 28 mph (45 kph)**	**Top speed >28 mph**
China	**12.4 mph (20 kph) <Top speed ≤ 31 mph (50 kph)** **40 kg (max weight)<Top speed ≤ 31 mph (50 kph)**	**Top speed >31 mph**
Rest of Asia Pacific	**15.5 mph (25 kph) <Top speed ≤ 31 mph (50 kph)** **Vehicle weight over 40 kg**	**Top speed >31 mph**
Middle East/Africa	**15.5 mph (25 kph) <Top speed** **Vehicle weight over 50 kg**	**Top speed >31 mph**

E-scooters and e-motorcycles belong to motorized vehicles, thus running on motorized lanes according to regulations on motorized vehicles.

1.2.3 Electric two-wheelers spectrum

These three types of electric two-wheelers can be illustrated at the spectrum below in terms of speed.

Table 1.3 Electric two-wheelers spectrum

E-bicycles low speed	E-scooters medium speed	E-motorcycles high speed
China	12.4 mph (20 kph)	31 mph (50 kph)
Europe	15.5 mph (25 kph)	28 mph (45 kph)
Rest of Asia Pacific, Middle East, Africa	15.5 mph (25 kph)	31 mph (50 kph)
North America	20 mph (32 kph)	30 mph (48 kph)

For e-bicycles, obviously, Western Europe and some Eastern Europe markets only allow pedelec type of e-bicycles, while other regions have the throttle-controlled type also. Among all regions, China sets the lowest top speed (equal or less than 20 kilometers per hour) and weight limit (max weight being 40kg), while an e-bicycle can drive on North American roads (United States and Canada) as fast as 32 kilometers per hour, and highest at 25 kilometers per hour in the rest of the world.

To note that e-bicycles belong to non-motorized vehicles in China. Hence, though the top speed limit for an e-bicycle in China is 20 kilometers per hour, when it runs on non-motorized lanes, the speed is limited to 15 kilometers per hour.

For e-scooters and e-motorcycles, to contrast, e-scooters in China have a wider speed range than that in other regions, and e-motorcycles are regulated and thus designed at a slightly higher speed, and both e-scooters and e-motorcycles belong to motorized vehicle.

Of note, this paper discusses electric two-wheelers in general, differentiations concerning respective type will only be mentioned when necessary, except that statistics is only available regarding certain type at the time of writing.

1.2.4 Electric two-wheelers and carbon emission reduction

According to the calculation of Bywin (a well-known Chinese manufacturer from Shandong Province), instead of riding on a gasoline motorcycle for one year, the carbon emission reduced by riding on an electric two-wheeler equals the cleansing effect of 12 trees. Given the current Bywin five million users worldwide, the carbon dioxide emission reduced in ten years surpasses the cleansing effect of 60 million trees (Peoplenet, 2013).

At the Nanjing Forum on Electric Bicycles Consumption themed “Environmental friendly, healthy and safe driving” this year publicized the latest statistics of the environmental contribution of electric vehicles. It is estimated that every 10 thousand kilometers an e-bicycle covers, if in place of bus, saves the energy generated by 137 kilograms of standard coal, if in place of motorcycles, reduced carbon dioxide emission of 479 kilograms, if in place of private cars, saves electricity of 1380 degrees. The total energy reduction of 150 million electric two-wheelers in China within one year equals the power generation of four Qinshan Nuclear Power Station (Dayoonet, 2013).

1.2.5 Charging infrastructure

In general, charging infrastructure consists of four elements, charging piles, concentrator, battery management system and charging management and service platform.
Several Chinese cities have initiated building up charging stations since 2006.

Table 1.4 Charging infrastructure development in China (Baidubaike, c)

Year	City	Infrastructure

2006	Shenzhen	BYD[1] built up the first charging stations for electric cars;
2008	Beijing	Setting up the first domestic centralized charging station for the Olympics, which can provide charging for 50 pure electric buses;
2009	Shanghai	Shanghai Power Company invested the first commercial charging station in China.
2009	Beijing	The first demonstration charging station project which has the complete intelligent control system;
2009	Shenzhen	2 charging stations with 134 charging piles in operation;
2010	Tangshan	The State Grid sets up its first modelling charging station, which can charge 10 electric cars, in two models: fast charging and slow charging.

However, these charging stations are mostly for electric cars and bicycles. Most electric two-wheelers are charged either at home or at the workplace.

2 Market analysis

2.1 World market at a glance

In 2012, more than 30 million units of electric two-wheelers are sold worldwide, generating a revenue of $6.9 billion. If the compound annual growth rate (CAGR) maintains 7.5 percent between 2012 and 2018 as predicted by Pike Research, the global sales in 2018 will reach 47 million units and $11.9 billion revenue (Pike Research, 2012d).

Consumers' demographic features vary a lot among different regions. drivers from Europe and North America tend to see electric two-wheelers more as a lifestyle or style choice (being green and fitness workout), while those from Asia Pacific, Middle East, Africa and Latin America use electric two-wheelers more as a practical transportation means. In terms of age group, North American consumers are around 45 ~ 65 and affluent, while consumers from other regions tend to be younger and working (Pike research, 2010).

Outside Asia, Europe has the biggest market for e-bicycles, currently containing 1.94 million e-bicycles and a CAGR of 17.3 percent between 2009 and 2016. However, e-bicycles sold at Western Europe market shows a significant higher price per unit compared with at Asian market. Such disproportion leads to a 3.4 percent market share of West Europe but 12 percent revenue contribution to the global market. North America possesses the same feature but at a lesser degree (Pike Research, 2012a).

A well established traditional two-wheeler market in Asia Pacific countries, such as in China, Japan, India, South Korea, Indonesia, Taiwan, Vietnam, Thailand, Malaysia, etc., are passing on the market share to electric two-wheelers. India and Indonesia are the two emerging markets following China. In the case of India, widely available and already existing electricity net, popularity density and rapid urbanization are making India ready for an exciting transformation to the age of electric two-wheelers (Pike Research, 2012b).

[1] BYD is the world well-known Chinese electric vehicle manufacturer and exporter. Website: http://www.byd.com.cn/views/home/indexe.htm

Table 2.1 Major market comparison of electric bicycles

	Asia Pacific / China	West Europe	North America
General description	-The biggest & most concentrated area for manufacture, distribution & market; -Fragmented marketplace; -Low-cost products and batteries, sealed lead acid battery as the mainstream;	High-cost, high-quality;	Underperformance Mergers and acquisitions;
Estimate sales in 2012 / global share	28 million / 92%	782,512	105,682
Anticipated sales in 2018 / global share	42.4 million / 89%	1.5 million	342,526
Average cost	$167	$1,546	$815
Lithium ion (Li-ion) battery penetration	4%	65%	56%

(Source/based on Pike Research, 2012a; Pike Research, 2012c)

Three major markets show distinct contrasts. But in general, sales in Asia Pacific market will grow by 50 percent reaching 2018, still maintaining the absolute domination of the electric two-wheelers. Sales in West Europe will double while sales in North America will thrice in 2018.
Currently, e-bicycles sold in Asia Pacific region is at a price on average almost one-tenth of that in West Europe and one-fifth of that in North America. Lithium ion (Li-ion) battery sees a much higher adoption, more than half, in West Europe and North America, while in Asia Pacific where consumers are more price sensitive, it is only 4 percent at the time being.

2.2 Chinese market

China, as the world largest electric two-wheeler manufacturer and exporter, accounts for 92 percentage of the global market in 2012 (Pike Research, 2012e). Though as No.1 exporter, China itself digests the vast majority of its output. In 2012, the output is 35 million, with the annual growth of 26.3 percent. The export in 2012 is 1.29 million, taking up 2.5% in the total output. The major export destinations are Netherlands (USD 60.5 million), Germany (USD 46.2 million), US (USD 41.7 million), Italy, Bangladesh, Japan, Belgium, Brazil, UK and Spain. Netherlands is currently the largest export destination, taking up 14.2% of the total export of China.

According to MA Zhongchao, chairman of China Bicycle Association, the number of e-bicycles in use in China now reaches 142 million (Xinhuanet, a). To note that these figures have not count those converted ones, which are normal bicycles by adding a battery pack and a motor, either by the consumers themselves or by some specialists.

After a highway developing period, the CAGR slows down since 2011 with a growth rate slipping by 28 percent compared with the previous year, but able to sustain a moderate and stable growth at an annual growth rate of 6.6 percent until 2018 (China Electric Bicycle Industry Report 2012-2015, 2012; Pike Research, 2012b).

2.2.1 Affordability

For initial purchase, battery and motor are the two major determiners, especially for low and middle end market, while high end consumers demand more on vehicle design and style. Latest statistics show that low end electric two-wheelers are sold at 1400 ~ 1800 RMB (≈228 ~ 294 USD) in China, while high end electric two-wheelers could be sold as high as 4000 RMB (≈652 USD) (Taobao, 2013). Li-on electric two-wheelers cost on average 1000 RMB (≈160 USD) more than the sealed lead acid (SLA) electric two-wheelers. Other factors affecting sales price also includes motor size, quality warranty and after sale service.

Usually, the total cost of ownership (TCO) of electric two-wheelers sees payback on the vehicle with a year or two of purchase. Hence, a continuing growth in individual and household income will contribute substantially to the sales growth, especially in Asia Pacific region.

2.2.2 Manufacturers and distributors

Manufacturing companies are divided mainly between those making whole vehicles through their own production lines and the component companies (original equipment manufacturers-OEMs) which produce parts and components of electric two-wheelers for domestic and international markets and which have successfully lowered the entry threshold for new comers (Pike Research, 2012e).

By end of 2011, there are approximately 2,600 licensed whole-vehicle manufacturers and assemblers, among which, 800 are of high productivity, among which, up to 50 percent of the total output comes from 50 manufacturers (Baiduwenku, undated).

The geographic distribution of the manufacturers and distributers coincides with China's three strategic economic zones, Yangtze River Delta, Bohai Economic Rim and Pearl River Delta, while several cities are the most concentrated area as the manufacturing bases. They are: Tianjin, Wuxi, Shanghai, Shenzhen, etc. By the end of 2012, Tianjin, as the traditional bicycle production center, locating 9 special industry parks of 9.58 million annual output, becomes world No.1 production base and market distribution center for electric two-wheelers by (China Bicycle Association, 2012).
Exporter manufacturers are mainly located in Jiangsu (39.64%), Zhejiang (30.46%) and Guangdong (10.28%), with the premium suppliers come from Changzhou, Jinhua, Ningbo and Wuxi. Some of the main manufacturers are listed in Table 2.2.

Table 2.2: List of selected electric two-wheeler manufacturers and distributers in China (by alphabetic order)

List & profiles of selected electric two wheeler manufacturers and distributers in China (In English) **6**

Item-Brand-Comapny-Headquarter			
1.	**AIMA**	AIMA Hi-tech	Tianjin
2.	**AUCMA**	Qingdao AUCMA Electric S&T Co.,Ltd.	Qingdao, Shandong
3.	**BYVIN**	Shandong Bidewen Power Technology Co., Ltd.	Weifang, Shandong
4.	**CRANES**	Shanghai CRANES Electric Vehicles Co., Ltd.	Shanghai
5.	**DALUGE**	Nanjing Daluge Hi-Tech Stock Co., Ltd.	Nanjing, Jiangsu
6.	**FOREVER**	Zhonglu Co., Ltd.	Shanghai
7.	**GEOBY**	GEOBY Electric Vehicle Co., Ltd.	Changzhou, Jiangsu
8.	**Giant**	Giant (China) Co., Ltd., Giant Electric Vehicle	Kunshan, Jiangsu
9.	**Lima**	Shanghai Lima Electric Vehicle Manufacturing Co., Ltd.	Shanghai
10.	**Luyuan**	Zhejiang Luyuan Electric Vehicle Co., Ltd.	Jinhua, Zhejiang
11.	**Lvneng**	Lvneng Electric Bicycle Technology Development CO., LTD	Changzhou, Jiangsu
12.	**PHOENIX**	Shanghai Phoenix E-bicycle Wuxi Co., Ltd.	Wuxi, Jiangsu
13.	**Schwinn, Diamondback, Specialized, Scott, MBK, Repco, Apollo, Hodaka and Deki**		
		Shenzhen China Bicycle Company (Holdings) Limited	Shenzhen
14.	**SUNRA**	Jiangsu Xinri E-Vehicle Co., Ltd.	Wuxi, Jiangsu
15.	**Yadea**	Jiangsu Yadea Technical Development Co., Ltd.	Wuxi, Jiangsu

Among the manufacturers, some are traditional world famous bicycle manufacturers, like Forever, Phoenix, some are battery makers, while some are totally new entrants. Brand like Giant and Merida originate in Taiwan, meaning investment comes from Taiwan and design in Taiwan but manufactured in mainland.

2.2.3 Battery technology

In China, as in many other Asia Pacific countries, lead-acid batteries, much cheaper than Li-ion batteries, occupy the vast majority battery market for electric two-wheelers. However, Li-ion, cleaner, much lighter and of longer life circle, is predicted to represent 10 percent adoption in e-scooters and 15 percent in e-motorcycles in 2018 along with the gradual declining cost and large scale production of Li-ion cells (Pike Research, 2012b).

Table 2.3 Contrast of Li-on batteries and SLA batteries

	Merits	**Defects**
Sealed lead acid batteries	Low cost;	Heavy, short durability (approx. 300 cycle times, long charging time (6~8 h), lead poisoning, poor performance in low temperature;
Lithium batteries	Light, larger capacity, long durability (Lithium iron as much as 2000 cycle times), fast charging (2~3 h), clean in production & use;	Low stability;

3 Market trend

3.1 Down-slowed growth, and demand for industry transformation

The domestic market shows homogeneous competition, more emphasis on price instead of product design, feature, etc. Both the market demand and output began to slow down since 2011, while the trend of enhanced sales revenue and added-value is nonetheless visible. The whole industry points to upgrade their product to be healthier and more fuel-efficient. Meanwhile, product customization and stronger distribution networks are increasingly the urgent need challenging domestic manufacturers.

3.2 Domestic relocation

Instead of focusing on the almost saturated markets in Yangtze River Delta and Bahai Economic Rim - the more developed east, north and south urban and semi urban areas, main market players begin to relocate their bases and distribution network into central regions to develop new markets. Furthermore, deeper and greener urbanization will also generate continuous huge market demand for electric two-wheelers, especially in areas in transformation.

The status quo of the market reveals a lower penetration rates of electric two-wheelers in rural areas than in urban areas. Though urban and semi-urban middle income classes are still the main targeted consumers, potential users in rural areas are now also drawing the market attention.

Another innegligible factor is the overseas market, with a upgraded product and distribution channel, sales in overseas market will also grow in both quantities and average vehicle price.

3.3 Acceleration of industry consolidation, with market fragmentation.

The concentrative crack down of sealed lead acid manufacturing facilities in 2011 shut down about 80 percent of SLA battery makers, with many others suspended. This left the major players stronger and ready for industry upgrade and consolidation to further expand their market, while small firms increasingly face stricter check, thus merger or bankruptcy.

3.4 Battery materials from SLA to Li-ion

According to Pike Research, the global penetration of Li-ion battery will grow from the current 6% to 12% in 2018. Though the current Li-ion battery penetration in Chinese market only takes up 4%, far less than in the West European and North American markets, it is expected to have 10% e-scooters and 15% e-motorcycles using Li-ion battery in 2018 along with the reduced cost of Li-ion in the near future and large scale of production (Pike Research, 2012b).

4 Issues

4.1 Ambiguity existing in regulations

Ambiguity and contradiction exist in the national standard and the national law on road traffic

safety. According to China's *Law on Road Traffic Safety* (2004), e-bicycles in China belong to non-motorized vehicles, and the top speed limit for non-motorized lanes is 15 kilometer per hour. Given that the national standard prescribes that the top speed of an e-bicycle be 20 kilometers per hour, it is very likely that an e-bicycle could easily surpass the top limit of the non-motorized lanes. Such ambiguity and contradiction tempts e-bicycle drivers to break the traffic rule "unconsciously". This also makes the implementation and monitoring of observance of the traffic rule in real roads more difficult.

Furthermore, by definition, e-scooters belong to motorized vehicles and can run much faster. But in China, e-scooters are always sold as e-bicycles. Thus, it is very possible that uninformed e-scooter drivers, consciously or unconsciously, take the advantage of such ambiguity to drive their vehicles however fast and convenient at real roads, leaving the traffic situation in potentially dangerous complication.

4.2 Law and rule violations as the common practice

However, neither "top speed limit" would effectively limit the speed of e-bicycles on real roads. In China, it is not an uncommon nor an unknown practice that originally many manufacturers design and make the motor of an e-bicycle to run at a higher, if not much higher, speed than the claimed speed on *Product Description* or *User Instruction Brochure*. By cutting the speed limiter, as many dealers might wish to inform their willingly clients, an e-bicycle could run much faster than the top speed. Many e-bicycles can run as fast as 35 kilometers per hour on Chinese roads, to know that during traffic congestion, even cars can only move at a speed of 15~30 kilometers in the inner city area. This well explains the reason why e-bicycles got the nickname of "road killer" in recent years, notorious for the drivers' careless driving behavior and high incidences of traffic accidents (Baidubaike, a).

4.3 Electric two-wheeler safety and regulation

In recent years, Chinese governments at different levels are increasingly tightening up surveillance, site check and punishment to motor vehicle violations of the road traffic safety law due to the increasing traffic congestion and pertaining issues. However, less attention and administrative resources are given to electric two-wheelers, thus leaving the monitoring and management of electric two-wheelers a "gray area".

E-bicycles driving at motorized lanes, or driving beyond the speed limit of non-motorized lanes are the common violations. Driving at an excessive speed poses danger to motor vehicles, bicycles and sometimes pedestrians, and eventually to the two-wheeler drivers themselves. It is the actual speed capacity of an e-bicycle and the drivers' willingness to drive faster that cause that electric two-wheeler drivers tend to violate traffic rules more often than traditional two wheel drivers do. Noiseless during driving makes electric two-wheelers less noticeable to bicycles drivers and pedestrians when they get close and pass by. Even a horn or pre alarm is sounded, there is usually not enough time for bicycle drivers and pedestrians to make way or shun away.

In China, no horn, front, rear or turning lights are mandatory in electric bicycles. Crossroads, intersection of motorized and non-motorized lanes, especially during evening and night time, are areas of high traffic incidence. The casualties caused by electric two-wheeler involved accidents increase year by year. In 2007, 2,500 people died of such accidents, and more than 3,600 died in 2009, which is 6 times more than the number in 2004 (Baidubaike a). What's worse, since no registration nor driving license nor insurance is required in China for electric two-wheelers, when such accidents happen, the compensation is either not guaranteed or not available (KnowledgeWharton, 2011).

From August 2002 to January 2006, electric bicycles were banned in some areas of Beijing due to the concerns over environment, safety and city image issues. Beijing had re-allowed use of approved electric bicycles as of January 4, 2006, while some cities in China still ban electric bikes (Wikipedia, a).

The recent decade has seen a fast growth of private car ownership in China, especially in large cities, which far outpassed the development of its traffic system and infrastructure, parking, as well as the management and monitor system. It is quite often the case that parking cars take up most space of non-motorized lanes, which forced non-motorized vehicles running into motorized lanes. What worsen the real road situation further is that the increasingly narrowed pedestrian lanes also forces pedestrians to walk on non-motorized lanes. Hence, pedestrians, bicycles and electric bicycles can be found to coexist and move on non-motorized lanes, and electric bicycles running in motorized lanes, leaving the road traffic in disorder and raising traffic accident risks.

Given the traffic congestion during peak hours and Chinese urbanites' comparatively low awareness of traffic safety, together these elements further degrade the driving environment for electric two-wheelers in China.

4.4 Lead poisoning, battery recycling and the environmental concern

Large scale of SLA battery application in electric two-wheelers, the production and recycling of these batteries had become a high public health concern for long. Frequent accidents of lead poisoning forced Chinese government to launce a nation wide crack down of sealed lead acid (SLA) manufacturing facilities in 2011. Significant number of small and medium-sized battery manufacturers were shut down or production suspended during this period. By the end of July of 2011, it is estimated that about 80 percent of the 1930 registered SLA production, assembling and recycling companies in China were closed (Sina news, 2011).

Currently, in spite of explicit regulations on SLA battery disposal and recycling, illegal recycling and disposing of SLA batteries widely exist in China. One reason is that the entrant threshold for companies qualified for SLA battery recycling and disposal is comparatively high in China. By August of 2011, there is only one qualified company in Beijing for SLA battery recycling and disposal.

Given the short life circle of SLA batteries, one or two years' use before replacement, together with SLA battery's vast application in electric two-wheelers, an estimate of 30,000 ~ 50,000 ton SLA batteries need to be recycled and processed in Beijing every year. However, due to the high profit of lead recycling, severe price competition, and lack of effective monitoring system for illegal recycling, only very few goes to qualified companies, which hardly covers the cost of the equipment operation. Instead, the illegal chain or workshops absorbed most of the waste SLA batteries. In Beijing in 2011, estimated 80 percent of the recyclable SLA batteries went to illegal channel (Sina news, 2011). Besides lack of competitive recycling price, lack of wide spread recycling channels is the other main cause for the underperformance of licensed recyclers.

Hence, the illegal recycling and disposal of waste SLA batteries is still a severe concerns, continuously raising issues of public health and environment if not checked and regulated.

4.5 Health risks and protection

Like in the case of motorcycles, health risks also exist in electric two-wheeler driving. When driving too fast and frequently, especially in windy and cold weathers, without protection, arthritis and headaches might be caused at a later stage. In China, helmet is mandatory for motorcycle drivers but not for electric two-wheelers yet. Hence, in China, many drivers drive without helmets or other necessary protection.

4.6 Lack of a well established distribution channel

According to many manufacturers, finding a combination of independent dealers, mass retailers, and online sales that will together provide an effective marketing, delivery and after sale service has long been one of the key barriers both in domestic and abroad market (Pike Research, 2012b).

4.7 Charging facilities needs to be fastly developed

Though more and more cities begin to build up the charging piles or stations for electric vehicles, the charging facilities is still lacking at large and lagging far behind the actual demand from electric two-wheeler owners.

5 Policy options

5.1 More reality-sensible and meaningful regulation on e-bicycles and e-scooters

The long expected new national standard on e-bicycles is said to come out this year. In the new standard, the top speed of e-bicycles is lifted up to 26 kilometer per hour. The change is deemed to better reflect the actual driving need of drivers and the driving capacity of current e-bicycles, given the traffic congestion and road condition in China (Xinhuanet, undated).

Besides, the weight limit of e-bicycles in current standard also seldom finds its application in reality. Thus, the new standard redefines the weight limit by types and by road conditions. In rural areas, electric two-wheelers are allowed a higher speed and a heavier weight given the road condition and less traffic, as well as the comparative long distance commute which needs a larger battery. Other major modifications can be found in Table 3.1.

Table 5.1 Current national standard vs. The new standard (Xinhuanet, undated).

	The current national standard	**The new standard**
Year of effect	1999	2013 (provisional)
Top speed	20 kph	26 kph
Speed limiter	Have but dismountable;	Indismountable speed sensor to cut off the electricity if beyond the limit;
Sub-categorization	None, top speed ≤ 20 kph, max weight: 40kg	Into three types: Intelligent, pedelec and pure electronic type based on road condition and locations;
Number of technical terms	34	54 with more terms addressing safety.

Note: Three types of e-bicycles as categorized in the new standard are:

1. An intelligent e-bicycle (max weight 40kg) needs pedaling first to start the motor to move the wheels. This type is greener and more environmental friendly, and could better suit the comparatively narrow roads in cities;
2. A pedal-assisted e-bicycle (or pedelec, max weight 50 kg) is flexible to pedal or electric, which enables commute in small cities or urban-rural transfer;
3. A pure e-bicycle (max weight 55kg) better suites rural areas where the road condition is good and the distance is bigger.

However, in the case of inner city driving, the same ambiguity still exists, namely, with the speed limit of 15 kilometer per hour at the non-motorized lanes, it is still difficult for actual implementation and monitoring of observance.

Policy makers, industry regulators and other authorities in concern are expected to figure out effective management to put a stricter industry supervision for the manufacturing process and product check, as well as limit speed of e-bicycles on real roads. Meanwhile, for e-bicycles beyond

standard, some suggest that they be registered as motor vehicles. Plates application and registration is necessary before driving on roads. When e-bicycle involved accidents take place, they be treated as other motor vehicles. It is also suggested that dedicated insurance be applied to e-bicycles (Xinhuanet, undated).

5.2 Effective management system

It is advisable that license and registration system be introduced into electric two-wheeler management. This is good for: (1) Collecting information of electric two-wheelers, including vehicle numbers, vehicle conditions, and various indications of consumption market to better inform management and the industry at large; (2) Bonding drivers to their vehicles, thus effectively holding them responsible for their driving behavior, especially when accidents happen; (3) Monitoring the vehicle using and battery recycling.

This might involve setting up ad hoc agencies at different levels, as well as install necessary monitoring system on roads. Further more, concepts of safety, in terms of mechanical safety, electricity safety, and driving safety, should also be introduced by policy makers and industry regulators in making industry regulation and road traffic laws. Drivers of better awareness of safety and traffic rule observance are especially crucial to reduce traffic accidents. Thus, it is highly recommended that besides mandatory requirements and punishment to rule breakers, public promotion and educational programmes be initiated by the management authority or associations in concern to enhance the awareness of driving safety and responsible driving behavior.

5.3 Establishing effective monitor system to regulate battery recycle and disposal

Illegal SLA battery recyclers usually offer higher prices than the registered and qualified recyclers. To address this, besides exerting strict control and punishment to the illegal recycling market, management authorities are advised to subsidize qualified recyclers through tax relief or special fund support to enhance their competition in price. Since SLA will continuously account for the major battery technology in electric vehicles in the next few years, it is also necessary to effectively lower the entry threshold for recycling and disposal companies.

Like in many other countries, environmental tax could be adopted to encourage and motivate manufacturers or retailers to recycle SLA batteries. This well solves the lack of recycling channel for that manufacturers and retailers have wide spread retailing network available to consumers, which could be used as recycling channel.

Besides, management authority could also designate licensed agents or organizations to collect used SLA batteries, and send them to the qualified recyclers collectively. Similarly, it is highly recommended that management authorities and associations in concern initiate public promotion and educational programmes to enhance the awareness of solid waste poisoning and promote environmental responsible behaviors.

5.4 Battery and motor improvement

Li-ion batteries, as the trend indicates, will find larger application in China in the years to come. Besides the price, li-ion battery technology also needs to enhance the stability and safety to enable better endurability in extreme weathers. Furthermore, manufacturers are also encouraged to explore new internal components for Li-ion batteries like Lithium iron or fuel batteries to enable an early adoption, thus upgrading the industry to be more competitive and greener.

5.5 Electricity supplying infrastructure

An available and convenient charging network will determine to a large degree the sales of electric vehicles in the near future. Such charging facilities could be designed at parking lots, commercial areas, office buildings, recreational sites, etc. Urban planner and the land developer are advised to

design the charging facilities in the initial land developing stage, or they are advised to make use of the available facilities and transforming them into charging resources. The investment and management of such facilities could well involve multiple stakeholders.

5.6 Electric two-wheelers and public renting system

Electric two-wheelers could also be involved in public transportation system. Wuhan municipality announced that 100 electric bicycles will be available for renting by end of June. Cities like Chongqing, Hangzhou also began their trials recently.

Combination of e-bicycles and public renting system will further amplify the positive environmental effect of electric two-wheelers and better solve the traffic congestion and pollution issues in cities.

In such public renting system, e-bicycles of li-ion battery can have a better promotion through the initiative adoption by and in the public transport sector. Such renting system could also be jointly invested by local governments, electric two-wheeler manufacturers, as well as interested private companies and individuals.

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