Chapter 2

The Electric Vehicle Industry in China and India: The Role of Governments for Industry Development

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1 Introduction

With the Copenhagen discussions recently taken place, it is fair to say that the acknowledgement of global warming as a potential threat to our planet has never been greater. Despite the lack of all-embracing, world-wide consensus, the trend is nevertheless going toward a situation with strengthened control and regulatory frameworks in order to reduce greenhouse gas emissions. Recently, the G8 countries signed a treaty to reduce average global temperature by two degrees centigrade until year 2050. However, this calls for a multilateral commitment at all levels of society – from the beginning of the supply chain starting with raw materials extractors, not ending at the final consumer, but also considering waste and disposal after consumption. Virtually all industries are affected and especially big emitters like the automotive industry.

Countries like China and India are here not exceptions, as they have both proclaimed far-reaching measures to address the global warming issue. Interestingly, whereas most Western countries have argued about pollution costs and consumer adoption, developing countries like China and India have embraced the current situation as an opportunity to turn greenhouse gas reduction into a business case and to take technological leadership in the field, focusing on the development of electric vehicles (EVs) and hybrids.

Due to the threat from global warming, China, among many other nations around the world, has committed itself to reduce emissions of greenhouse gases. Furthermore, with increasing local pollution levels, increased traffic congestion, and also an ever-increasing demand for natural resources, has made the Chinese central government implementing new tougher measures in order to mitigate the current situation. As the auto industry is responsible for a large share of local and global CO_2 emissions, it is one of the target industries for tighter regulatory control. The new emission standards to be put in place over the next years means that the whole auto industry have to adjust, in order to be compliant. There are many ways to achieve this, for example through more efficient engines, alternative fuels, or introduction of completely new power train technologies such as hybrid and electric vehicles.

Having said the above, the aim of this paper is to examine the role of the governments for the development of the electric vehicle industry in China and to a lesser extent India. For this paper, the primary focus is on passenger and commercial vehicles – electric motorbikes and electric vehicles that are not for public road transportation are beyond the scope of this paper. In this paper, the following research questions will be addressed, namely 1) what is the current state and developments of the electric vehicle industry in China?, 2) what measures has the Chinese government taken to promote growth and development in the electric vehicle industry?, and 3) how does China compare to India in terms of industry developments?

2 Research Design and Methodology

The unit of analysis of this research is the burgeoning Chinese electric vehicle industry. Due to the macro perspective of the study, it is not very suitable for research methodologies whereby survey techniques are applied. Furthermore, as the aim of the research is to conduct a descriptive analysis from a broader perspective rather than providing a snap-shot picture, the research was based on archival and secondary data research.

Although primary data was used for the pre-study of this chapter, it was not deemed as suitable as a primary source of data. It has indeed a reliability advantage in the sense that one can validate the accuracy and reliability of the data, but there are nevertheless several advantages to using secondary data in the case of this chapter. First, due to the inherent difficulties to collect empirical primary data in China, secondary data makes it possible to process larger amounts of information, which would not be feasible to do alone within a reasonable amount of time. Second, secondary data in China is not always highly reliable, but when sourced from multiple archives it is generally more objective than even primary data could be, since researcher and respondent bias is effectively cancelled out.

With this in mind, given the lack of prior academic research on the topic, a research design based on a combination of quantitative and qualitative methods of analysis using a mix of primary and secondary data was chosen. To overcome the main critique often mentioned about qualitative research in international business publications, namely the lack of methodological rigor (Yeung 1995), a triangulation approach was deployed. In line with Denzin (2006) triangulation for this particular study was carried out along the following dimensions, namely 1) data triangulation, 2) investigator triangulation, and 3) methodological triangulation.

Primary data was collected through semi-structured interviews in order to accomplish a certain degree of comparability while ensuring an unobstructed flow of narrations (Bryman 2004). The interviews were conducted during a period of one week in 2009, and each interview lasted two hours on average. The informants selected were senior managers from automotive firms, academics, and consultants, all of which usually have good insights in industry developments. In order to facilitate open communication with firms, anonymity of company sources were ensured in the report findings. Furthermore, for investigator triangulation purposes, the interviews were performed using multiple researchers, who independently took notes and analyzed the results afterwards. Since also a data triangulation approach was deployed for the research, the primary data collected through the case interviews was contrasted with secondary data from various sources such as industry journals, websites, independent consultant reports, government authorities, and press releases with relevance to the research. Whereas the case interviews served as data pre-study, the secondary data analysis served as the basis for the main research and generation of results and guidelines. For methodology triangulation, the primary data was analyzed through qualitative within- and cross-case analyses, whereas the secondary data was analyzed with quantitative forecasting techniques.

3 The Automotive Industry in China

The tremendous economic growth since the liberalization of the Chinese economy in 1978 has propelled China past the United States to become the largest automotive market in the world. Despite the explosion of domestic brands and manufacturers (currently more than eighty, depending on how one is counting), foreign OEMs such as Volkswagen and General Motors (together with their domestic joint venture partners) comprise the lion's share of 74 percent of total sales in 2008 in China (Xia 2009). We can see from Table 1 that on March 2009, only three pure domestic players made it to the top ten rankings, namely Chery, Geely and BYD.

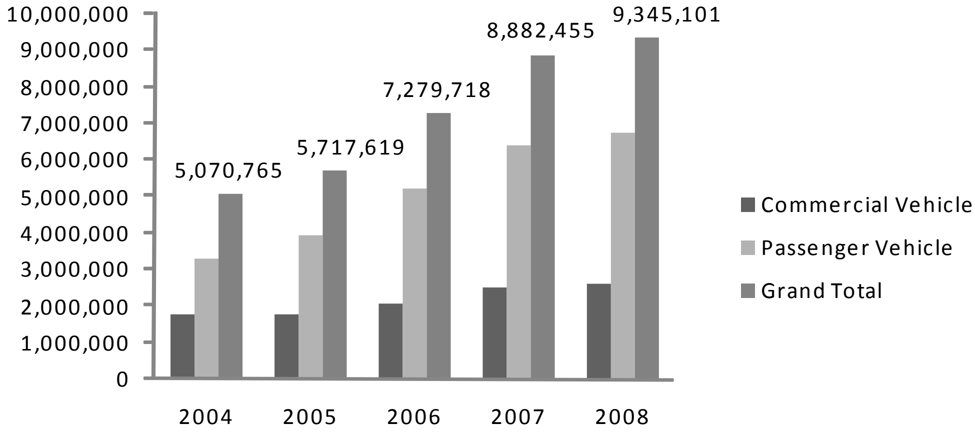
Table 1: Automotive sales in China March 2009 year-on-year

		March		Accumulated		
		Volume	±%	Volume	±%	Share,%
Rank	**Total**	528,115	26.56	1,318,900	-1.66	100
1	Shanghai-VW	46,523	8.61	125,712	-6.67	9.53
2	FAW-VW	54,752	75.98	119,159	-1.06	9.03
3	Beijing Hyundai	37,729	23.61	97,466	53.46	7.39
4	Chery Auto	34,035	20.31	86,908	-0.21	6.59
5	Shanghai GM	30,421	38.83	75,403	-2.3	5.72
6	Dongfeng Nissan	31,865	35.57	75,218	5.56	5.7
7	Geely Auto	24,662	12.11	65,973	1.14	5
8	BYD Auto	24,003	-8.4	64,895	123.34	4.92
9	Guangzhou Honda	26,482	47.19	63,693	-4.92	4.83
10	Changan Ford Mazda	22,734	41.21	52,330	-21.17	3.97
	Top 10	**63.09%**		**62.69%**		

Source: Ascendas Marketing Research (2009)

Passenger car sales in China have experienced spectacular growth in recent years, with demand driven by rising incomes and the fall in tariffs that followed China's accession to the World Trade Organization (WTO) in 2001, and lower prices helped by the emergence of low-cost domestic manufacturers. The rapid growth of the market in recent years has made China the world's largest automotive market and has created an increase interest from global car manufacturers, all of which have a presence in the country (Economist Intelligence Unit 2009). An overview of the output for the Chinese auto industry is shown in Figure 1.

Figure 1: Chinese automobile productive output from 2004-2008 (Units)



Source: Emerging Markets Information Service (2009)

Interestingly, Chinese manufacturers are also increasingly trying to enter the global marketplace, primarily through sales channels in Southeast Asia, Latin America and Middle East. This trend is confirmed by the fact that China became a net exporter rather than a net importer of cars in 2005 (Mcgregor 2006). In 2009, the country exported more than 330,000 vehicles (China Association of Automobile Manufacturers 2010). The bulk of the exports consist of local brands destined for developing countries as indicated above. Foreign OEMs, as they affected by their foreign joint venture partner's global strategy, their exportation from China has area restriction. Therefore the exportation of foreign OEMs only account for small proportion of total Chinese vehicle exportations. Normally foreign OEMs use China as a global production base for local consumptions.

Despite the lack of advanced technologies for the foreseeable future among domestic OEMs, the potential for CO_2 reduction still remain high, thanks to the currently low technological maturity level. Burke (2007) claimed that a 40 to 50 percent fuel economy is possible through "mild hybrid"[1] (Francis 2009) approach. A contributing driving force among domestic OEMs though is the fact that those who wish to enter the global marketplace have to adopt state-of-the-art product technologies. Interestingly, most

[1] A mild hybrid - sometimes called a power-assist hybrid. There's generally a bigger battery that can store plenty of charge from regenerative braking, and an electric motor that can use it to assist the car's engine when needed. Mild hybrids save fuel because energy that would be lost to braking is "re-used" to help accelerate. Most importantly, a mild hybrid can't run on its electric motor alone for zero-emission low speed motoring.

Chinese OEMs have product and technology development programs in place for electric and hybrid vehicles as can be seen in Table 2.

Table 2: Chinese OEMs involved in EV development

Company Name	Model Name	Type	Battery	Range	Max Speed
BYD AUTO Build Your Dreams	F3DM/F6DM	Dual Mode	ET-POWER Fe battery[1]	400 km (dual mode)	160 km/h
	E6	PEV	ET-POWER Fe battery	400 km	160 km/h
吉利控股集团 GEELY HOLDING GROUP	Panda EK-1	PEV	Lithium Ion battery[2]	80 km	65 km/h
	Panda EK-2	PEV	Lithium Ion battery	180 km	150km/h
CHERY	S18	PEV	LiFePO4 battery[3]	120-150 km	120km/h
	M1-EV	PEV	LiFePO4 battery	100 km	120km/h
	Tiggo3-EV	PEV	Lithium Ion battery	150 km	135 km/h
CHANA 长安汽车	Jiexun HEV	HEV	-	-	160 km/h
长城汽车	GWKULLA	PEV	Lithium Ion battery	160 km	130 km/h
	GWPERI	PEV	Lithium Ion battery	180 km	130 km/h
SAIC MOTOR	Roewe750-FCV	FCV	Fuel cell battery[4]	500 km	205 km/h
	Shanghai	FCV	Fuel cell battery	319 km	150 km/h
哈飞汽车	Saibao	PEV	lithium ion battery	160 km	130 km/h

Notes: (1) ET-POWER Fe battery is invented by BYD with the characteristics of low cost, long cycle life and high energy density is widely adopted for BYD's electric vehicle. Battery charging cycles reached 2000 times and mileage life achieved 60,000 km. (2) Lithium Ion battery has high charging/discharging efficiency but produce relatively little heat, so a simple cooling system is adequate. A high single-cell voltage means the number of cells in a battery can be relatively small, the state of charge (SOC) can be sensed easily, so charging durations can be managed and driving ranges can be accurately predicted. But the high price of cobalt makes it too costly for the large batteries used in vehicles. Currently it is suitable for EV and HEV. (3) LiFePO4 battery--Lithium Iron Phosphate battery has High Performance, extremely Safe/Stable Chemistry High intrinsic safety, high Rate Capability For all high power output application, long cycle life best can up to 2000 cycle life, high flexibility both in terms of battery application and cell design, does not contain any heavy metals and does not exhibit the "memory effect". It is widely used for EV and HEV. (4) Fuel cell battery use hydrogen fuel and oxygen from the air to produce electricity. The application of fuel cell battery for vehicle can reduce greenhouse gas emissions and air pollutants, improve the economy of fuel. However, onboard hydrogen storage, vehicle cost, fuel cell durability and reliability and safety issues are the challenges that fuel cell battery need to overtake. Therefore it is not the first choice for EV and HEV.

Source: Autohome (2009)

4 Environmental Policy

Environmental policy refers to actions deliberately taken to influence human activities with the aim to prevent, reduce, or mitigate harmful effects on nature and natural resources. Furthermore, it also implies ensuring that man-made changes to the environment do not have harmful effects on humans. The rationale for governmental involvement in the environment is market failure in the form of externalities, such the free rider problem and the tragedy of the commons (Hardin 1968).[2]

In contrast to governments in other market economies, the Chinese central government still retains relatively strong administrative power due to the long history of central planning and China's authoritarian political system. China's national government can still play an important role in promoting issues that carry social and environmental benefits. The rapid move to unleaded gasoline was also made possible by the strong support of local governments. Great public pressure to deal with heavy air pollution in Beijing and Shanghai has provided political and economic incentives for local governments to move forward quickly. For example, it took the U.S. Environmental Protection Agency from 1970 to 1996 to phase out lead in gasoline, whereas it took China less than ten years, from 2000 to 2009 (Oil China 2009). The rapid move to unleaded gasoline demonstrates the strong leadership role the central government can play in pollution control.

As of today, China does not have any plans for a carbon tax system. Nevertheless, the central government has acknowledged the importance of getting up to par with international standards in terms of technology in order to strengthen the competitiveness of domestic players and facilitate global market entry. Today, the existing Chinese taxation system is based on engine volume, which only has an indirect influence on CO_2 emission levels. Interestingly, in a recent taxation scheme promulgated in 2008, tax on vehicles with an engine volume less than one liter were lowered from three to one percent, whereas the tax on vehicles larger than three liters was raised from 25 to 40 percent.

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[2] An example of an externality is a factory that engages in water pollution in a river. The cost of such action is paid by society in general, when they must clean the water before drinking it and is external to the costs of the factory. The "free rider problem" is a situation when the private marginal cost of taking action to protect the environment is greater than the private marginal benefit, but the social marginal cost is less than the social marginal benefit. The "tragedy of the commons" is the problem that arises due to the fact that no specific person owns the commons, implying that each individual has an incentive to utilize common resources as much as possible. Without governmental involvement, the commons is overused.

Vast efforts have been made since the late 1990s to control vehicle emissions in China (see Table 3), even though the first national vehicle emission standards were issued in 1983. The government reform in 1998 gave the State Environmental Protection Administration (SEPA) the exclusive responsibility for vehicle emission control and monitoring. The 2000 revision to the Air Pollution Prevention and Control Law added a new chapter on vehicle emission control, including specific penalty measures. This led to the phase out of leaded gasoline, the introduction of European emission standards, the promotion of alternative fuel vehicles, the implementation of fuel economy standards, and the development of an R&D program for advanced clean vehicle technologies, such as electric battery vehicles, hybrid vehicles, and fuel cell vehicles.

Table 3: China Emission Standards

Standard	Reference	Date	Region
National Standard I	Euro 1	01/1999	Nationwide
National Standard II	Euro 2	07/2004	Nationwide
National Standard III	Euro 3	01/2006	Beijing
		07/2006	Shanghai
		09/2006	Guangzhou
		07/2007	Nationwide
National Standard IV	Euro 4	03/2008	Beijing
		11/2009	Shanghai
		2010	Nationwide
National Standard V	Euro 4	2012	Beijing
	Euro 4	2013	Nationwide

Note: Only applies to four-wheel Vehicles.

Source: Chinaen (2008)

As of today, the Chinese domestic automotive industry is not yet globally competitive in terms of ICE technologies (Tao 2008); most proprietary technologies originate from the foreign partners of the various joint ventures partners such as Volkswagen, GM, BMW, Toyota, etc. (Medhi 2006). In order to give domestic market players a fair chance to compete, the government's emission targets are less stringent than compared to the West. Fortunately, the central government has acknowledged the long-term need to reduce its dependency on oil as a natural resource. As shown in Table 3, developed areas like Beijing, Shanghai always take the lead in implementing new national standard and followed by the rest of the regions. Implementation plan is different from province to province and city to city. Most small-sized passenger vehicles like VW Polo or Chevrolet Spark already fulfill this target today, so this objective is by no means impossible to accomplish. However, the effectiveness of any such targets hinge upon the stringency on implementation and penalties.

More stringent emission targets in the coming years are likely, however, as the oil price in China is controlled by the state (currently around US$0.94/liter), oil companies have little incentives to upgrade refining technology. Furthermore, the below-market price of fuel also means that the opportunity cost of using alternative energy sources is higher compared to Europe and other advanced economies. Nevertheless, as domestic OEMs start to enter the global marketplace; these have to comply with the more stringent local regulations overseas, thus further accelerating domestic technology development in China.

4.1 Vehicle Emission Control Standards

Emissions standards are requirements that set specific limits to the amount of pollutants that can be released into the environment. Many emissions standards focus on regulating pollutants released by automobiles and other vehicles but they can also regulate emissions from industry, power plants, small equipment such as lawn mowers and diesel generators. Frequent policy alternatives to emissions standards are technology standards and emission trading. Standards generally regulate the emissions of nitrogen oxides (NOx), sulfur oxides, particulate matter (PM) or soot, carbon monoxide (CO), or volatile hydrocarbons (see carbon dioxide equivalent).

China started to implement emission controls regulations in year 2000, adopting National Standard (NS) I emission standards (equivalent to Euro I standards) countrywide. In 2004, China increased regulations by moving to NS II emissions. In 2008, when the country hosted the Olympic Games, the Chinese government further enhanced the move toward stringent emission control standards for better air quality, driving the implementation of NS IV in Beijing and NS III across the rest of China. China plans to adopt NS IV emission standards countrywide by 2010, and move to NS V (equivalent to Euro V) in 2013, thus eliminating the gap with European norms in just four years. By moving from NS II to NS III, emission limits for nitrogen oxides (NOx) were reduced by 29 percent and particular matter (PM) by 33 percent. Furthermore, the implementation of NS IV standards will reduce the emission of NOx and PM by 30 percent and 80 percent respectively, as compared to NS III standards. In sum, the government intends to accelerate the implementation of tighter standards for emissions to catch up with those of North American and European countries.

4.2 Alternative Fuel Vehicle Program

In order to further lower emissions from vehicles and reduce oil dependency, twelve Chinese cities began participating in the program "National Clean Vehicle Action" in April 1999. This program introduced alternative fuels, in particular compressed natural gas (CNG) and liquefied petroleum gas (LPG). By 2002, the Ministry of Science and Technology had invested RMB 50 million (US$6.1 million), and local governments and enterprises had invested billions more RMB in the program (Zhang, 2002).

CNG and LPG vehicles and stations increased rapidly in some demonstration cities (see Figure 2). By the end of 2002, the number of CNG and LPG vehicles increased to 153,000 and refueling stations reached 486 in twelve demonstration cities (China Automotive Technology & Research Center 2003). Eight other cities joined the program and had 12,500 CNG and LPG vehicles in 2002. More than 80 percent of taxis in Shanghai and 50 percent of buses in Beijing can use CNG/LPG (Hou 2002). However, the CNG/LPG technology is relatively primitive. The majority of China's alternative vehicles are retrofitted; in 2002 only 16 percent were new vehicles (Zhang 2002).

Figure 2: First batch of the demonstration cities

Source: Economic Observer (2009)

China also has promoted ethanol-based and methanol-based fuel vehicles on a pilot basis in several cities. China is demonstrating ethanol-based fuel vehicles in Henan, Jilin, Heilongjiang, Anhui and Liaoning five provinces which rich in corn production, a move designed to create a new market for surplus grain and to reduce consumption of petroleum (Wu 2006). Three plants producing denatured fuel ethanol from corn are being constructed. The demonstration of methanol-fueled vehicles is occurring in Shanxi Province, which is rich in coal resources. 260 methanol-fueled mid-size vehicles have participated the demonstration of methanol fuel utilization and owned 7000 different type of methanol vehicles by the end of 2008. Shanxi currently possesses 15 methanol engine patents and one methanol production patent (Zhang 2009).

4.3 Alternative Fuel Vehicle Program

The Chinese government started to support R&D on electric vehicles in the early 1990s, and initiated a comprehensive electric vehicle program under the National High-Tech R&D Program for China's Tenth Five-Year Plan period (2001-2005). Through this program, the Chinese government hopes that the country can leapfrog conventional vehicle technology and enhance the ability of China's auto industry to compete internationally (Wang 2006).

Major auto producers are leading R&D on electric vehicles. The Shanghai Automotive Industry Corporation (SAIC) will invest RMB 6 billion to develop new energy vehicles and plan to launch a hybrid vehicle that with save 20-30 percent fuel in 2010 (Lin 2009). Beijing, Wuhan, Hefei, and ten other cities are listed as demonstration cities for battery electric vehicles and Beijing will build a world-class electric vehicle R & D center within three years (Zhang 2009).

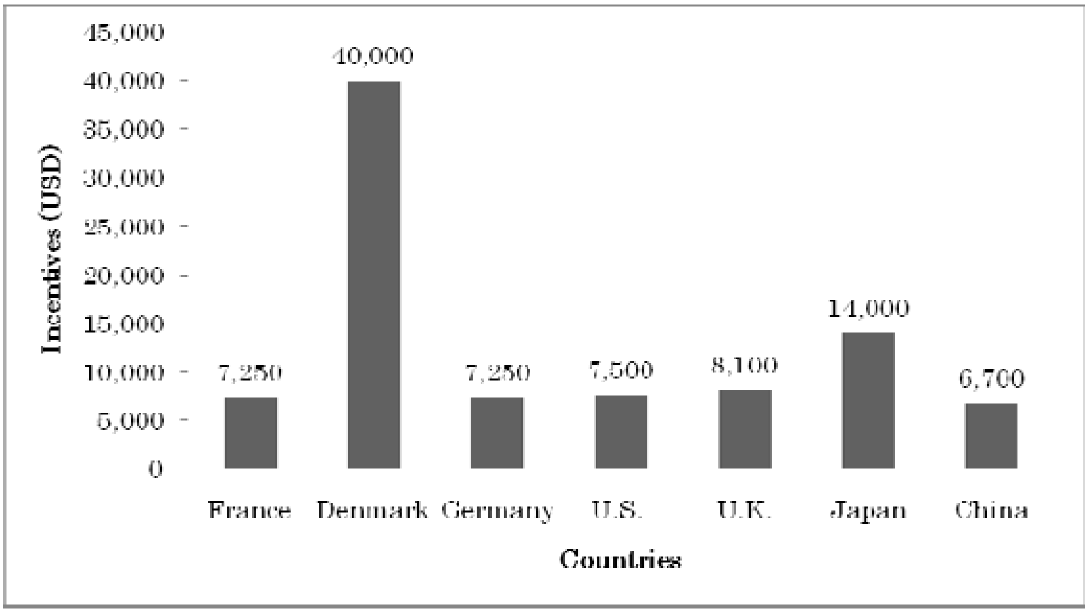
5 Government Support

Regarding subsidies, China is among one of the most progressive countries in the world. To date, the Chinese government has invested at least RMB 880 million (US$129 million) (Cropper 2002) in developing three kinds of clean vehicle technologies: commercialization of battery electric vehicles, large-scale production of hybrid vehicles, and R&D on fuel cell prototypes. EV-oriented automakers, now only in a very small number, are required to reach the annual capacity of 500 new-energy vehicles by late 2009 and their total annual output should achieve 10,000 units by 2010 for each of the designated cities to have enough EVs for trial operation. At the same time, the vehicle standards, quality and stability will be strictly controlled to meet the new requirements for city-use EVs. The role of large state-owned enterprises is helping to catalyze this development. BYD Auto, Wanxiang Group, Shenzhen Wuzhoulong Motors are speeding up their EV production and also urging the related infrastructure construction.

In June 2007 the State Power Grid Corporation issued a plan that provided for the conversion of a certain number of public transportation vehicles, taxis, waste disposal trucks, among others, to EVs on a trial basis in certain cities and provinces. The plan also included the development of a nationwide network of charging stations

Since EVs is one of the cornerstones of the future Chinese automotive industry, the government focuses heavily on the industrialization of EVs/PHEVs and corresponding key components. The central government will also provide more than RMB 10 billion (US$1.47 billion) for research in power train technologies. In order to promote the adoption of EVs, the government offers subsidies of RMB 60,000 (US$ 8,800) for the purchase of public EVs, such as taxis and buses. Table 3 shows current economic incentives for EVs in key automotive markets

Figure 3: Benefits on acquisition and ownership taxes for EVs include annual benefits over three years and one-time benefit



Note: Germany: Can only receive the subsidy between 2012 and 2014. France: Free parking and charging. UK: 96% discount on London parking; No annual Vehicle Excise Duty; Exemption from London Congestion Charge. China: Difference city has different incentive polices like tax and toll exemption

Source: Newswire Today (2009)

5.1 Central Government Support

Recently, National Development and Reform Commission automobile team leader Wang Shulin said the “New energy vehicle development program” has been submitted to the State Council and may formally promulgated in March 2010. The relevant state departments will also launch five supporting measures for development of new energy vehicles next year which will follow-up of the new energy automotive industry policies include the private consumers could get subsidies for purchasing new energy vehicles and map out the infrastructure planning. The introduction of these two policies are targeted to solve the consumption and the application bottlenecks, but also as the precondition for broad application of new energy vehicles (CCSTOCK 2009).

Furthermore, in February 2006, the State Council released documents that supported the development of new energy vehicles. In the “National Guidelines on Medium- and Long-term Program for Science and Technology Development” (2006-2020), the State Council listed “low-energy consumption and new energy vehicles” as a priority topic and “hydrogen and fuel cell technologies” as frontier technologies (Xinhua News 2006). In November 2007, the National Development and Reform Commission formulated the Rules on the Production Admission Administration of New Energy Automobiles. Moreover, The State Council issued a plan in March 2009 aimed at turning China into a global leader in new energy cars, including electric ones, by 2011 with an annual production capacity of 500,000 units (Long 2008). In the meantime, the Chinese government's RMB 4 trillion (US$585 billion) stimulus package puts strong emphasis on clean energy development and is backed by many new regulations and policies focused on increasing the uptake of low carbon technologies (Lei 2009). Table 4 and Table 5 show the subsidies from Chinese government to passenger vehicles (PVs), light commercial vehicles (LCVs) and city buses.

Table 4: Subsidy to public use of PV and LCV (RMB)

Vehicle type	Fuel saving rate	Max. Electric power rate			
		BSG	10%-20%	20%-30%	30%-100%
Hybrid vehicle	5%-10%	-	-	-	-
	10%-20%	4,000	28,000	32,000	-
	20%-30%	-	32,000	36,000	42,000
	30%-40%	-	-	42,000	45,000
	>40%	-	-	-	50,000
Pure EV	100%	-	-	-	60,000
Fuel cell vehicle	100%	-	-	-	250,000

Note: The subsidy standard for HEV with max. Electric Power rate over 30% applies to plug-in BSG (Belt-Starter-Generator system, a start-stop system).

Source: Ministry Of Finance (2009)

Table 5: Subsidy to public city bus over 10 meters

Energy saving& new energy vehicle type	Fuel saving rate	Using Lead Acid Battery	Using Nickel-Metal hybrid battery, Lithium-Ion battery and super-capacity hybrid	
			Max. Electric power rate: 20%-50%	Max. Electric power rate: >50%
Hybrid vehicle	10%-20%	5	200,000	-
	20%-30%	7	250,000	300,000
	30%-40%	8	300,000	360,000
	>40%	-	350,000	420,000
Pure EV	100%	-	-	500,000
Fuel cell vehicle	100%	-	-	600,000

Source: Ministry Of Finance (2009)

Another interesting feature of the Chinese EV industry is the so called "863 Program" or State High-Tech Development Plan, which is a program funded and administered by the central government of the People's Republic of China intended to stimulate the development of advanced technologies in a wide range of fields for the purpose of rendering China independent of financial obligations for foreign technologies (Hequan 2000). The name "863" comes from the fact that the program was created in March 1986, and from this date picking the two last digits of the year and the month number (March is the 3rd month of the year). It was proposed in a letter to the Chinese central government by the engineers Wang Ganchang, Wang Dayan, Yang Jiachi and Chen Fangyun and endorsed by Deng Xiaoping (Feigenbaum 2003).

In August 2008, Prof. Wan Gang, the Chairman of the Ministry of Science and Technology stated that the Ministry would develop a large-scale pilot project in ten or more cities to put 1,000 hybrid, fuel-cell and all-electric vehicles on the roads in each of those cities and provide the necessary infrastructure for the project within a three year-period. This project is called "Ten Cities, One Thousand Cars" and aims at facilitating adoption of energy-efficient vehicles in urban environments. The first batch of Chinese cities for the EV operation include Dalian, Shanghai, Wuhan, Shenzhen, Chongqing, Changsha, Jinan, with Beijing, Tianjin and Hangzhou as the immediate candidates..These cities will have the large-scale trial run of EVs and hybrid-powered vehicles in the next few years (Zou 2008).

5.2 Local Government Support

Rapid demand growth creates an urgent imperative to accelerate the development of electric vehicles (EVs), fuel-cell vehicles and other forms of low carbon transport. Because the active participation of some cities, the list for the project “Ten Cities, One Thousand Cars” has been extended to thirteen cities, now also including Hefei, Kunming and Nanchang in addition. Most of these thirteen cities are located in Central and Eastern China, the distribution is relative balance. An overview of the first batch of pilot cities on government policies and planned measures is provided in Table 6 and the volume of new energy vehicles these cities will have by 2012 is showed in Figure 44.

Table 6: The detail supports from partial "Ten Cities, One Thousand Cars" local governments

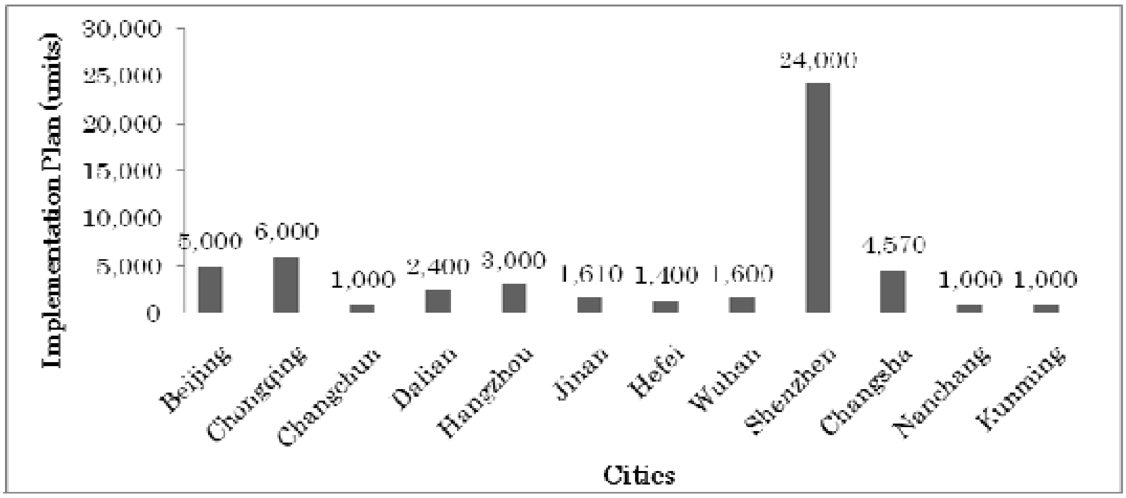
City	Measures Taken
Shanghai	1. Shanghai will formally introduce the new energy vehicle license fee exemption policy next year, and the amount of 15 percent or more fuel-efficient types of new energy vehicles will all be beneficiaries. 2. Meanwhile, new energy vehicles and key components industry bases with investment of RMB 3 billion (US$440 million) is under construction. According to the plan, by 2012, the scale of Shanghai new energy automobile industry is estimated to RMB 90 billion (US$13.2 billion).
Beijing	1. In early 2009, an alliance of new energy automotives was founded in Beijing with the aim of promoting the research and development of the vehicles. 2. On November 20^{th}, 2009, Beijing officially introduced new energy industrial revitalization plan and now studying the policies which encourage individuals and organizations to use and purchase electric vehicles, introducing financial subsidies or tax relief, including a series of measures.
Shenzhen	1. In March 2009, Shenzhen carried out a typical electric vehicle operational technology assessment research project. With the implementation of energy-saving and new energy vehicles projects in order to get more experience of new energy vehicle promotion nationwide. 2. In accordance with the targets of the project, Shenzhen will invest more than RMB 50 million (US$7.3 million), planning three bus lines and put 10 hybrid buses in each line. Furthermore, the city will also put 20 pure electric vehicles within the city, set up a corresponding charging and testing facilities, making management standard and evaluation method to complete the assessment of business operations environment.

Table 7: The detail supports from partial "Ten Cities, One Thousand Cars" local governments (Continued)

Zhuzhou	1. Zhuzhou has launched three-year action plan of energy-saving and new energy vehicle demonstration and extension. Now they have put 120 electric buses on the main road in the city. 2. They plan to replace existing 627 city buses by electric or hybrid vehicles from 2009 to 2011. 3. The Department of Finance will also provide bus companies a three-year car allowance, loan interest subsidies, advance disposal of the vehicle loss of subsidies, etc. total up to RMB 60 million (US$7.8 million).
Tianjin	1. According to Tianjin Municipal Science & Technology Commission, this city has created a complete industrial chain, developing electric vehicles, including whole-vehicle production, key spare parts manufacturing and standards setting. 2. Since Tianjin was authorized in August, 2002 as one of pilot cities in China for the use of electric vehicles, the city has successfully put electric vehicles into use as taxi, police cars and cars for official business, with the total driving distance exceeding 100,000 kilometers. 3. Three routes with electric vehicles in operation exclusively have been launched before the2008 Beijing Olympics.
Chongqing	1. As one of the first thirteen national demonstrations and popularization of new energy vehicles pilot cities, Chongqing Municipality will promote 1,150 energy-saving and new energy vehicles before the end of 2011. 2. In order to alleviate the cost pressure of new energy vehicles early promotion, Chongqing government will introduce financial assistance policies to encourage the energy-saving and new energy application in public transport, rental, service and other public services area. 3. In addition to the regulation of new energy official car, new energy taxi and new energy bus can enjoy the local financial subsidies, policy also clearly specifies the amount of subsidies that individuals can enjoy: the government specified Integrated Starter Generator (ISG) mild hybrid vehicle could get RMB 3, 600 (US$523) subsidies and one-time toll charges RMB 6,900 (US$1,000) subsidies, quantity is limited to one hundred.
Nanchang	1. Until 2012, Nanchang will promote 1,000 energy-saving and new energy vehicles in public domain and will establish support system for new energy automobile production and product after-sales service; build three electric vehicle charging stations (battery exchange stations) and 150 pure electric vehicle charging column (cabinet); set up 15 energy-saving and new energy vehicle maintenance service networks, and gradually build electric car fast charging network. 2. Nanchang government will actively promote the autonomous R&D and industrialization of key components for new energy vehicles and key components, trying to reach an annual output of 10,000 units of new energy automotive industry scale to achieve innovation and development of the automobile industry

Source: Automotive and Parts(2009)

Figure 4: The "Ten Cities, One Thousand Cars" implementation plan for new energy vehicle in 2012



Source: Xinhua News (2009)

Overall, the aim is to leverage the automotive industry in order to sustain continued economic growth in the country. Since the country historically has been a technology laggard, the central government sees the EV industry as an opportunity to gain technological leadership. Moreover, leadership in production and use of clean energy sources is also a powerful means to improve the environmental image of the country in a global context. Without doubt, fuel efficient vehicles are therefore the key in order to accomplish economic and political targets. Priority will be given to facilitating the research and development of electric and hybrid vehicles as well as alternate fuel vehicles, especially CNG /LNG.

6 Barriers to EV Adoption

Although the Chinese central and local governments continue to encourage the electric vehicle industrialization and commercialization, there are still many obstacles that stand in the way. In the following section, the key barriers are discussed.

6.1 Consumer Acceptance

According to the survey conducted by Horizon Research (2010) recently showed that that 29.7 percent of Chinese consumers are not familiar with EVs in general and the consequences are that these consumers will not buy any new energy vehicles. As one of the interviewees stated:

> "What we find out from our study is that 10.15 percent said they were willing to pay more for such a car, because they expected that they can save more fuel during the usage period, and then they think it is worthy. But here is a problem, for the first time buyers, especially in the young and immature market, people do not know much about hybrid. Two-thirds of people know about hybrids, but fifty percent of people tell you that they only have heard of it. So when it comes to how well people know about it, it's just a very small portion."
>
> (Source: anonymous interviewee, 01/09/2009)

Another issue stated was that consumers have fears for a lack of technology performance and after-sales service. Furthermore, most respondents claimed that Chinese consumers generally do not consider life cycle costs when considering purchasing a product, but rather primarily consider purchase price. Consequently, EVs, with its higher price tag but lower operating costs might appear unattractive to the Chinese consumer at a first glance. Finally, from a producer's point of view, trying to sell EVs is hazardous, as many consumers are first-time buyers. As they currently haven't built any brand loyalty, there is a risk that disgruntled consumers abandon brands for a long time to come.

6.2 Cost of Ownership

Currently, the price of EVs is too high for most of the population, mainly due to the high cost of the battery technology. As of today, only Toyota Prius is commercially available, and retails for roughly RMB 300,000 (US$38,000), which is about sixty percent more than the price of a Prius in the United States (Gallagher 2006). BYD has a hybrid ("F3DM") and a FEV ("e6"), but these are not yet commercially available for end-customers according to the pre-study respondents. According to the respondents of our empirical pre-study, most Chinese consumers believe this price is too high. A recent survey (Horizon Research 2010) also showed that 24.8 percent of the respondents are not willing to buy the new energy vehicles due to the high purchase price and maintenance costs. One of our interviewees described:

> "So people will wonder whether it worth the money or not and hesitate to buy them. A few months ago, it still costs RMB 400,000 (US$58,600), now I think it comes down to about RMB 300,000 (US$43,970), but I think it is way too expensive. Even BYD sell it for about RMB 170,000 (US$24,900), which is actually speaking not a large amount of money. But if compared to the conventional F3, which costs RMB 78,000 (US$11,400), it doubles the price. In this target group, they are not will to pay twice as much to get a hybrid car. I think the car manufacturers need to bring the costs down."
>
> (Source: anonymous interviewee, 02/09/2009)

A comparison of gasoline prices among various countries indicates that the current low fuel prices capped by the government in China is a major roadblock against EV adoption; a liter of unleaded gasoline was retailing for RMB 6.45 (US$0.94) in China, compared to an average price GBP 1.12 (US$ 1.79) in the UK, EUR 1.48 (US$ 2.07) in Norway, and EUR 1.18 (US$ 1.65) in Hungary. Moreover, the milage cost with EVs become less the longer travel distance, as the purchase price can then be distributed over a bigger number of miles. Consequently, the commercial viability of EVs is greater for commercial vehicles such as buses and taxis, due to the longer travel distance during the product life cycle (usually 100,000 km/year). For example, if the fuel price was RMB 10 per liter (US$1.47/liter) and the additional cost for a full hybrid was RMB 64,000 (US$8,000), this cost could be recovered within two years for a taxi being driven 100,000 km per year with a fuel economy of 50 percent (Gallagher 2006).

6.3 Technology and Technical Capabilities

According to the Horizon report (2010), 18.1 percent of the respondents believed that the lack of domestic technical capabilities to develop and produce EV components is one of the most important obstacles. Another hindrance stated by the respondents was the fact that production volumes are currently so small that there are no economies of scale. In general, Chinese manufacturers are notorious for their reluctance to produce “short series”, as one respondent put it. Furthermore, localization was complicated further due to an overall lack of quality thinking and lack of technological capabilities. One manager expressed the situation as follows:

> “The Chinese orients are directly going to the field of EVs and hybrid cars, so in this sense they lift the rock. I still have my doubts if they can lift the rock in terms of innovating technology. I think this will mostly come from a German origin and the Japanese because they have the biggest engineering competence and experience to do that.”
> (Source: anonymous interviewee, 01/09/2009

As a consequence, the lack of domestic technology is a big hurdle as the local OEMs thus have to pay expensive license fees to use such components. The general conclusion was that this issue is hard to circumvent, but it is obvious from the responses that most of the domestic OEMs will rely on technology obtained through their foreign JV partners. Furthermore, the respondents claimed that the lack of local producers resulted in a need to import key EV components, which in turn has an adverse effect on profit margins. Fortunately, as part of the WTO commitments, China lowered the tariffs on cars, SUVs, and mini-buses from 28 percent to 25 percent, while import taxes on auto parts were reduced to 10 percent (Ministry of Commerce 2006).

6.4 Battery Performance

Currently the very important factor that is affecting the electric car entry to the market is the performance of rechargeable batteries. According to automobile experts, the best battery can only last a few minutes at high-speed driving conditions, as the battery will be exhausted very fast. Therefore, EVs today do not have the capability to travel long distances and highway driving is not feasible. The weight of the lithium battery is about 10 kilograms per kilowatt-hour. So to drive the Chery QQ mini-car, it needs 16-20 kilowatts hours of electric power, which makes the corresponding size and weight become large and has to carry the additional weight of 160-200 kg of lithium batteries (Gu 2009). One interviewee stated it as follows:

> "If you really want to go like 500 kilometers you need much higher energy density, today's main technology simply cannot offer. Therefore it is definitely something which is from short to middle range distance for the next decades."
>
> (Source: anonymous interviewee, 03/09/2009)

Another constraint of electric vehicle development is the cost of the battery. The cost of the battery accounts for nearly 60 percent of the cost of the pure electric vehicle, including the battery control system (Xia 2010), so reducing the cost of the battery is critical to lower the cost.

> "If you look at the hybrid, as we walk up that curb, we are talking about hundreds of dollars for a battery of the micro type hybrid. The next step will be thousands of dollars for implementation of full hybrids for a battery. If you go to the bigger battery packer and pure EV, you will be talking about tens of thousands of dollars for a battery. Even that is beyond the price of most cars."
>
> (Source: anonymous interviewee, 03/09/2009)

As the criteria on environmental friendly performance are more and more strict, the Lead acid battery and Ni-Cd are becoming less viable. Ni-MH batteries have a much higher level of safety and lower cost. Compared to Ni-MH batteries, Lithium batteries only have half weight and size, while the energy density and power density per unit of weight are two times that of Ni-MH batteries. Lithium batteries are the main type of energy storage system for EV, HEV and Fuel Cell Hybrid Vehicle (FCHV) vehicles today. Lithium battery is the future technology in respect of commercialization as it has been widely accepted (Sun 2007).

6.5 Lack of Incentive Policies

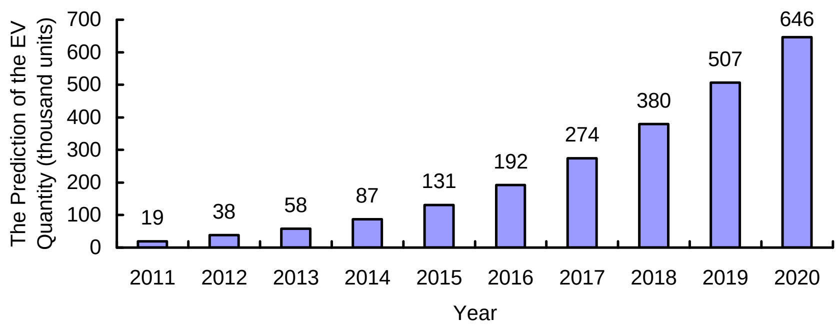
Despite the various government programs for new and alternative energy sources, the lack of more stringent fuel-efficiency and carbon standards explain the current absence of policy incentives for hybrids in China. In sum, this is an important bottleneck to commercial breakthrough of EV technologies. As one interviewee argued:

"I agree with you, I don't think that they [Chinese government] haven't thought about it. But the information coming out here is not very rich. You know, there are a lot of discussions about it, but nobody know the exactly situation." (Source: anonymous interviewee, 31/08/2009)

All the respondents representing the pre-study claimed that the timing of market launch is not so much about availability of technology, but a clear signal from the central government on producer and consumer subsidies. Before this happens, OEMs are very reluctant to launch their products in the market, as a definite price tag cannot be set.

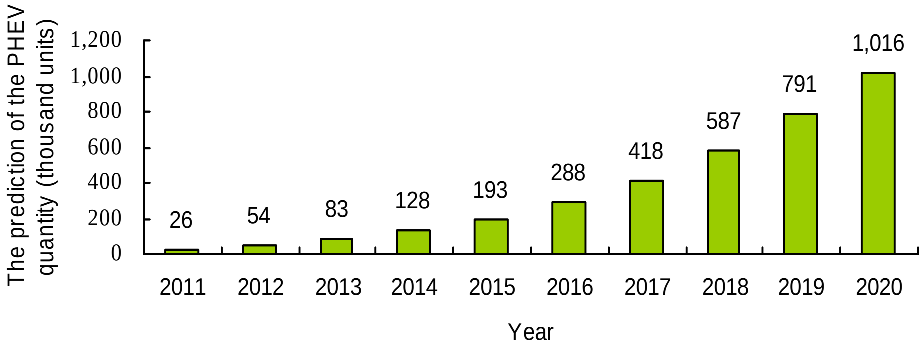
Despite the various roadblocks against commercialization of EV adoption in China, the proactive attitude from Chinese government and automotive producers leads to the consensus that the EV industry has a bright future in China. (See Figure and 6)

Figure 5: The future scenario of EV.



Source: Michael Valentine-Urbschat (2009)

Figure 6: The future scenario of Plug-in Hybrid Electric Vehicle (PHEV)



Source: Michael Valentine-Urbschat (2009)

7 Comparison with India

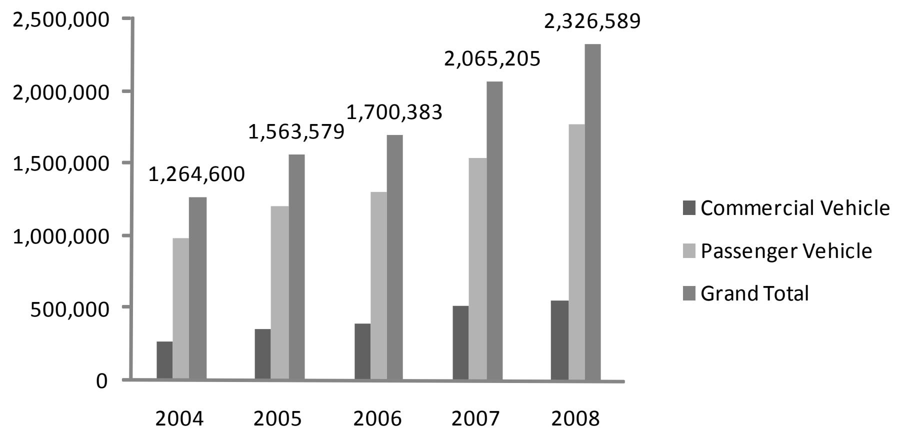
7.1 Industry Characteristics

The Indian automotive industry has experienced tremendous growth in recent years, largely due to the burgeoning middle class, and a significant increase in their disposable income. According to recent estimates, industry output is expected to reach four million units by 2013 (PriceWaterhouseCoopers 2009), to which the commercial vehicle segment will be a major contributor. Industry experts peg the Indian automobile sales growth at a compounded annual growth rate (CAGR) of 9.5 percent by 2010. The industry (OEMs and suppliers together) contributed nearly five percent to the country's GDP in 2006. In terms of the job market, the automotive sector employs nearly 13 million people directly and indirectly. The capabilities in design, engineering and manufacturing have been recognized the across the world and most automotive majors are looking to increasingly source auto components from India.

Cost and quality remain the underlying bottlenecks of India's auto industry expansion in the global marketplace. Especially labor costs are rising steadily due to a skill shortage, while logistics remain the main hurdle due to the poor infrastructure in comparison to China. By the end of 2009, the total road mileage of China had reached more than 3.87 million kilometers and total mileage of highway now up to 65,000 kilometers, which has already ranked second in the world (Lin 2010). India only has total road mileage 3.3 million kilometers (NHAI 2009) up to now. The quality imperative means that Indian makers have to seek new technological resources through alliances and acquisitions, challenging the capital and management resources of companies that are often small and family owned.

Infrastructure development projects which are underway in India combined with favorable government policies will also drive automotive growth over the next few years. Also easy access to credit and moderate cost of financing facilitated by dual income families will further nurture the sales growth. Moreover, thanks to its strength in IT, India is also emerging as an outsourcing hub for global majors. Global OEMs such as GM, Ford, Toyota and Hyundai have expanded their operations over the past years. While Ford and Toyota continue to leverage India as a source of components, Hyundai and Suzuki have acknowledged India as a key market for the compact-car segment. An overview of the outputs for Indian auto industry is shown in Figure .

Figure 7: India automobiles productive output from 2004-2008 (Units)



Source: Emerging Markets Information Service (2009)

Nevertheless, cars are still out of reach for most Indians, although they are becoming increasingly attractive for urban, middle class consumers. Production volumes of passenger and commercial vehicles reached 2.26 million units in 2008 (SIAM 2009). This made India the fifth largest commercial vehicle manufacturer in the world and the fourth largest passenger vehicle manufacturer in Asia (Surfindia 2009). Interestingly, India has one of the lowest car ownership ratios in the world with only about eleven car-owners per thousand inhabitants (Ramesh 2009),. Like in China, Indian car buyers primarily focus on purchase price. Fuel efficiency is secondary, but usually implied effect due to the inherent preference for small and cheap cars.

Although this chapter deals with conventional cars, the dominance of two- and three-wheelers in India makes the discussion worthwhile. Among the two-wheeler segment, motorcycles have major share in the market. Here, Hero–Honda holds a fifty-percent market share (Hero Honda 2009). Forty percent of the three-wheelers are used for goods transportation, with Piaggio as the key foreign market player at a forty-percent market share. Among the passenger transport, domestic Bajaj is the leader with a two-third market share. In the passenger vehicle segment, Maruti Suzuki holds more than a fifty-percent market share and almost complete monopoly (Surfindia 2009).

The key challenges for the auto industry in India are high fuel costs, congested city roads, low vehicular speeds and limited driving distances. On the other hand, this also makes India an attractive market for compact-sized EVs. Furthermore, the availability of skilled engineers, low manufacturing cost and access to both hardware and software uniquely positions India as a pioneer market for EVs. So far India has two companies involved in EV development as shown in Table 8.

Table 8: India OEMs involved in EV development

Company Name	Model Name	Type	Battery	Range	Max Speed
TATA	Tara Tiny	-	-	100 km	70 km/h
	Indica Vista EV	PEV	Super Polymer Lithium Ion battery	200 km	110 km/h
REVA The electriCity Car	Reva NXR	PEV	Lithium Ion battery	160 km	104 km/h
	REVA-NXG	PEV	Lithium Ion battery	200 km	130 km/h
HERO electric		-	-	-	-
Mahindra	-	-	-	-	-

Note: Hero and Mahindra have the plan for EV production but so far no motorcycle type on the market.

Source: Autoblog (2008)

It is worth noting though, that the REVA is exempt from most European crash test rules, and due to its low weight and power it is classified as a “heavy quadracycle” (category L7e) rather than “car” in Europe. This fact is a double-edge sword, however. On the one hand, the exemptions of safety regulations make it much less costly to develop compared to a conventional car. On the other hand, it also positions it in a market segment which is completely new to Western consumers; in short, it does not, and will not compete with conventional cars. As the potential of the micro-car segment in Western countries is very uncertain, so is its own potential in such markets. The same applies to China, where consumers traditionally have a preference for comfortable, aesthetic mid-sized cars. In contrast, in China consumers actually seem to prefer being without car unless they can afford a conventional mid-sized sedan. Those who have visited China over the last years have noticed a glaring absence of ultra-compact cars in first- and second-tier cities.

7.2 Environmental Policy

The first Indian emission regulations were idle emission limits which came in effect in 1989. These idle emission regulations were soon replaced by mass emission limits for both petrol (1991) and diesel (1992) vehicles, which were gradually tightened during the 1990's. In the year 2000 passenger cars and commercial vehicles had to meet Euro I equivalent India 2000 norms, while two wheelers will be meeting one of the tightest emission norms in the world. Euro II equivalent Bharat Stage II norms are in force since 2001 in the four cities of Delhi, Mumbai, Chennai and Kolkata (DieselNet 2008).

On October 6th 2003, the National Auto Fuel Policy was announced, which envisaged a phased program for introducing Euro II-IV emission and fuel regulations by 2010 (DieselNet 2008). The implementation schedule of EU emission standards in India is summarized in Table 9.

Table 9: Indian Emission Standards

Standard	Reference	Date	Region
India 2000	Euro 1	2000	Nationwide
Baharat StageII	Euro 2	2001	NCR[1], Mumbai, Kolkata, Chennai
		04/2003	NCR[1], 10 Cities[2]
		04/2005	Nationwide
Baharat Stage III	Euro 3	04/2005	NCR[1], 10 Cities[2]
		04/2010	Nationwide

Notes: (1) National Capital Region (Delhi)

(2) Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur and Agra

Source: DieselNet (2008)

The above standards apply to all new four-wheel vehicles sold and registered in the respective regions. In addition, the National Auto Fuel Policy introduces certain emission requirements for interstate buses with routes originating or terminating in Delhi or the other ten cities. For 2-and 3-wheelers, Bharat Stage II (Euro 2) was applicable from April

1, 2005 and Stage III (Euro 3) standards came in effect during the period April 1, 2008, and April 1, 2010 (DieselNet 2008).

Since India started implementing a formal emission control regime as late as 1991, the country is still lagging behind more mature economies like the US and EU. Currently, they are behind Euro norms by a few years, however, as the country is gaining momentum, emission norms are step by step becoming aligned with Euro standards and vehicular technology is upgraded accordingly. Vehicle manufacturers are also working towards bridging the gap between Euro standards and Indian emission norms.

7.3 Government Support

In 2008, the central government waived the excise duty on EVs in, and state governments have also announced tax cuts to reduce pollution levels in cities. Also in 2008, the Delhi government announced a 29.5 percent discount for the small electric car Reva. Chandigarh offered a subsidy of 15 percent on battery-operated vehicles, whereas Bangalore has taken the lead to give 4 percent VAT waiver for the initial five years after the launch of the car and on registration costs (Chowdhury 2009).

The combination of high fuel prices and government support is steadily increasing the demand for EVs. Recent policy developments have attracted several other known and unknown market players to the market segment. For example, Tata Motors has also built a prototype EV model called Indica, whereas several foreign OEMs, such as Mitsubishi plan to launch EV models in the Indian market. Other new comers, such as the clock-maker Ajanta Group has begun producing electric bikes in Gujarat and has plans to make a electric car priced at Rs 85,000 (US$1,853) with 70 percent indigenous components (India Times 2008). Industry experts see this as a challenge to Tata’s low cost car Nano reported to be priced at Rs 100 thousand (US$2,180). Among the global OEMs, companies such as GM, Volkswagen, Mitsubishi Motors Corp, Chrysler have also shown interest in making electric cars.

The cost of the subsidy for EVs will be covered from the Air Ambience Fund created from an environment taxes of Rs 0.25 (US$0.005) per liter on diesel fuel sold in Delhi. Delhi government has already collected Rs 100 million (US$2.18 million) from these taxes (Mangaonkar 2009). Buyers of EVs are eligible for a 15 percent subsidy on the base price of the vehicle, a value added tax (VAT) refund of 12.5 percent and a two percent exemption on road tax and registration fees. In total these incentives has cut the price of Reva by more than Rs 100 thousand (US$2,180) (Lalchandani 2008).

7.4 Comparison of India and China

Forecasting the adoption of EVs is not an easy task. Doing so for China and India specifically is even more challenging. However, by considering price trends and existing price levels, a rough estimate of the time of a commercial breakthrough for EVs can be predicted. Firstly, it is fair to state that consumer preference for cars is very different between China and India. Whereas the Chinese mainstream consumer prefers a mid-sized sedan, the Indian counterpart would more likely opt for a compact-sized hatch-back. The reason to this is very obvious, as India is lacking the essential infrastructure in terms of proper roads that can accommodate larger passenger vehicles. In the absence of systemic shocks such as a spike in fuel prices, it is assumed that consumer preferences will not dramatically change over the next decade or two.

To further simplify the discussions, we select the two most popular multi-passenger vehicles and the two most promising EVs for the two countries, respectively. For China, the best-selling car of all times is Volkswagen Santana, which has been around in the streets since the mid 1980s, and has sold in more than three million units. Currently, the most recent model, VW Santana retails at about RMB 80,000 (US$11,000). In India, the best-seller is currently Maruti-Suzuki 800, with a total production volume of 2.5 million units since its introduction in 1985. It retails at about Rs 224,000 (US$5,000). Among Chinese EVs, the most prominent manufacturer is BYD, with its most promising model F3DM, which is not an FEV, but a PHEV. The company has an FEV called e6, but it is mainly targeting the US market and hence won't likely penetrate the Chinese market on a large scale. The F3DM currently retails at RMB 150,000 (US$22,000) (Green Car Congress 2008). The attractive price and the classic design makes it a strong contender for the mainstream segment. In India, the strongest EV candidate is REVAi, which comes in two editions; one with lead-acid batteries and one with Li-ion batteries. The former retails at about Rs 350,000 (US$7,700) whereas the latter retails at about twice that price.

Although it's interesting from an academic point of view to find the breakeven point in terms of total cost of ownership (purchase price of car plus fuel costs) vis-à-vis milage, we omit this discussion as earlier studies have shown that the majority of consumers are more concerned about the price tag (Horizon Research 2010). Having said that, we instead turn our attention to the price trends of existing ICE and EV models to identify a time frame during which commercial a breakthrough can occur for the two countries. The first step in doing so is assigning estimates for discount rates of the product parts. Currently, the single most expensive component of an EV is the battery. As a relatively immature technology, the lithium-ion battery today costs about US$1,000 per kWh, with a price reduction of about 8 percent per year. The remainder of the car uses relatively mature technology, and hence subject to a discount rate of 2 percent. Furthermore, by considering the performance of existing models (Table 10), it is possible to forecast price trends over the next two decades.

Table 10: Performance and pricing of key ICE and electric vehicles of China and India

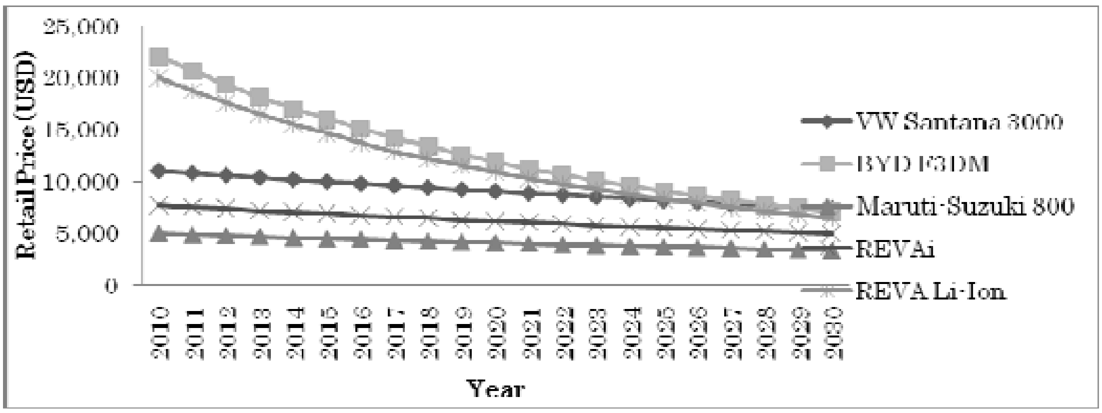
Dimension	BYD F3DM	REVAi	REVA Li-Ion	VW Santana 3000	Maruti Suzuki 800
Driving range (km)	100	80	120	N/A	N/A
Battery cost (USD)	16,000	1,400	14,000	N/A	N/A
Current price (USD)*	22,000	7,700	20,000	11,000	5,000

Note: Incl. battery.

Source: Prepared by the authors based on various information.

As can be seen in Figure 8, the scenarios for China and India are quite interesting. First, it is worth noting that the BYD F3DM (or a future equivalent model) will reach the same pricing as the VW Santana 3000 by year 2028. As a result, even without government subsidies, it would become equally competitive from a pricing point of view at this point of time. For India, the currently already inexpensive REVAi will not drop as sharply in price over time due to its reliance on mature lead-acid battery technology. REVA Li-Ion on the other hand, in line with BYD F3DM, will drop more rapidly in price over time. However, by year 2030, it will still be twice as expensive as the Maruti Suzuki 800 (or equivalent).

Figure 8: Forecasted price trend for key ICE and electric vehicles of China and India during the period 2010-2030.



Source: Own analysis.

Three key factors can change the timing of commercial break-through, namely potential fuel prices, the size of government subsidies and charging stations. As the oil price in China is capped, and will likely remain so in the foreseeable future, this is less of an important factor in China. Interestingly, the municipal government of Chongqing in China is already subsidizing purchases of the Changan Jiexun hybrid with RMB 36,000 (US$5,276), plus an exemption of road and bridge tolls amounting to RMB 7,000 (US$1,026) – a total of RMB 43,000 (US$6,302) (Gao 2009). If such subsidies would be implemented nationwide, the breakeven point (i.e. where purchase price of the typical ICE vehicle equates that of the typical EV) would be achieved by the year 2015, considering the estimates in Figure 8.

Meantime, state-owned utility company State Grid Corporation of China (SGCC) plans to construct 75 electric vehicle charging stations with a total of 6,209 charging points across 27 cities in 2010 (SGCC 2010). With the support from SGCC, The city of Xian in Central China plans to build four charging stations with 200 charging points and five charging stations with one hundred charging points will be on trial in the city of Tianjin in East China. China Southern Power Grid (CSG) closely followed, with the first batch of charging stations for electric vehicles, including two charging stations and 134 charging points was earlier completed and put into operation in late 2008 (CSG 2009). With the increased pace of charging station constructions in China, the promotion of EVs will be accelerated. This will potentially break the existing catch-22 in which EVs cannot succeed in the market unless there is proper charging infrastructure, and vice versa. In India, where the Delhi government currently subsidizes one-third of the purchase price of the REVA car, the lead-acid battery model is virtually competitive today. For the lithium-ion model, however, a subsidized version would still be almost US$1,000 more expensive (almost 29 percent in relative terms) than the Maruti Suzuki 800 model in year 2030. To make the REVA Li-Ion model competitive with the Maruti Suzuki 800 already in year 2015, a subsidy equivalent to two-thirds of the purchase price would be necessary, which is not realistic to expect. Regarding charging stations, we only learn that Reva is able to provide charging station by reservation from Reva distributors overseas like Norway, France, UK, Greece, Cyprus, Spain, Belgium and Ireland from February 2009 (Newspress 2009) and so far we cannot find any information from Reva and Indian government for the schedule of domestic charging station constructions. At this point, India is lag far behind China.

8 Conclusions

Global warming and climate change has over the years become one of the most pressing issues for policy makers. Increasingly, the issues have also become acknowledged as global concerns that call for multi-lateral solutions and agreements. Often being pinpointed as non-cooperative and not doing enough to reduce greenhouse gas emissions, it is clear that China is one of the most advanced and progressive countries in the world when it comes to establishment of regulatory frameworks related to alternative fuels, new energy sources and corresponding technologies.

As of today, China is one of the leading countries in the world in terms of encouraging and incentivizing the development and adoption of new-energy vehicles. By virtue of being the largest automotive market in the world, combined with effective policy implementation, the country has the scale and determination to make a commercial breakthrough come true. Despite the heterogeneity of the country, the geographic reach of pilot projects is impressive, where most of the Eastern and Central parts of the country are engaged. The already existing, excellent physical infrastructure can relatively easily be augmented with charging infrastructure once the political decision has been made. Another factor contributing to the Chinese perseverance regarding new energy technologies are that the country simply does not accept finger-pointing from foreign country governments or NGOs – in contrast to the US, which often has responded with a great deal of ignorance to outside forces in the past, the Chinese government often responds in fury followed by an astonishing determination to take leadership.

When discussing China, it is often hard to leave out India from the discussion, as it is currently the second most populous country in the world, and likely destined to overtake China in terms of population in a matter of decades. Interestingly, the question on which country will be the first to commercialize EVs on a large scale has different answers, which are not mutually exclusive. First, the perception of a “typical car” is very different in China and India. The fact that India has a higher consumer acceptance for ultra-compact, low-tech, inexpensive cars also lowers the barriers for inexpensive EVs. This is a double-edged sword however, as shown in the previous section, where the baseline as defined by the most common ICE vehicle model also sets the threshold for commercial break-through. In other words, simply being inexpensive does not automatically imply commercially viable, as the two concepts are relative, not absolute. Secondly, paradoxically as it may seem, the higher average “mainstream” car prices in China also leads to a proportionally lower “premium price” for EV technologies. This is the very reason why companies like Volkswagen have chosen to develop hybrid powertrains for its large-sized VW Touareg model and not for the small-sized models like

VW Polo. This is also the reason why it is believed that a commercial EV breakthrough will happen earlier in China than India, also supported by the higher decision-making speed commonly seen in China.

The characteristics of the “common car” in China and India, respectively, will also have implications for the overseas expansion for EV technologies. As the typical Chinese car has higher resemblance with the mainstream Western car, it is reasonable to believe that also the Chinese manufacturers will have higher success rate in the global marketplace than their Indian counterparts. On the contrary, it is also believed that the Indian manufacturers (and/or in combination with foreign JV partners) will dominate the Indian market, with the Chinese as laggards or completely absent. Hence, from this research the conclusion is that the Chinese and Indian automotive markets are idiosyncratically different, and will remain so in the foreseeable future in absence of major externalities.

Despite these differences, it is certain that both countries will have very rapid developments in terms of new products and technologies, as well as a high rate of consumer adoption of such. Needless to say, emerging markets like China and India will play an increasing role in the future, not only for low-cost production, but increasingly for new product development, and even more so for consumption. Regardless of which country will reach large-scale break-through earliest, one thing is for sure: the quest for technological leadership will permanently redraw the global automotive landscape. And governments will play a key role to provide the carrots and sticks to make it all happen.

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