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Understanding socio-technical barriers to sustainable mobility – insights from Demonstration Program of EVs in China

Społeczne i techniczne bariery dla zrównoważonego transport – wdrażanie programu promującego samochody elektryczne w Chinach

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Abstract

It is widely accepted that EV (electric vehicles) is one of the several green technologies to address environmental issues associated with the transport sector and promote the transition to sustainable mobility. In spite of this, a number of barriers still need to be overcome before EVs achieve widespread market penetration. This paper is a contribution to understanding the key tools and strategies that might support the take-up of EVs by adopting a social-technical approach to explore the main barriers encountered in the Chinese EV Demonstration Program. The key findings of the research are that interest conflict between different stakeholders and the inaction of related actors are the key barriers inhibiting the further development of EVs. So the policies that put much pressure on the current auto regime are necessary.

Key words: electric vehicles, social-technical approach, barriers

Streszczenie

Nie budzi wątpliwości, że samochody elektryczne należą do grupy zielonych technologii stanowiących alternatywę w kontekście kwestii środowiskowych związanych z sektorem transportowym, wspierając przejście do zrównoważonej mobilności. Istnieje jednak wiele barier na drodze do rzeczywistego upowszechnienia się takich samochodów. Niniejszy artykuł wskazuje na kluczowe narzędzia i strategie, zakładające przyjęcie podejścia społeczno-technicznego, które pozwalają na wskazanie głównych barier w rozwoju samochodów elektrycznych na przykładzie Chin. Okazuje się, konflikt interesów pomiędzy interesariuszami i bierność stanowią główne wyzwania. Wprowadzenie polityki, która zdecydowanie skuteczniej niż teraz wywierałaby presję na tradycyjny rynek samochodowy to konieczność.

Słowa kluczowe: samochody elektryczne, podejście społeczno-techniczne, bariery

1. Introduction

Today, we face fundamental wicked problems in several domains such as depletion of natural resources, air pollution and greenhouse gas (GHG) emissions, etc. (Shan at al., 2012). Most countries in the world have taken attempts to make development more sustainable in order to address these persistent problems. It seems that sustainability involve so many aspects of our civilization that sustainable development has become an inherent societal characteristic and nowadays period can be named as a sustainable development revolution (Pawłowski, 2003, 2009).

Actually, most of unsustainable problems are due to the extensive use of fossil energy (Pawłowski, 2011, 2010). Transport sector, heavily dependent on oil consumption and responsible for 22% of global CO_2 emissions (IEA, 2012), has been worldwide accepted as a priority area in sustainability discussion. Given that most of the problems are related to internal combustion engine vehicles (ICEVs), the question whether the existing transport system can be transformed into something more sustainable, therefore, has great relevance with vehicle use. However, lowering CO_2 emissions by controlling the volume of transport seems to be unlikely (International Transport Forum, 2010), so electric vehicles (EVs) as a promising green technology are increasingly favored by policy-makers (Yeh, 2007).

EV achieving widespread diffusion has never been an easy thing and they have failed to compete with ICEVs over the last century. Previous research mainly argues that battery technology limitations and high battery cost are the major obstacles to the development of EVs (Egbue at al., 2012). However, we find that this view does not reveal key areas of resistance to EVs. Actually, mobility is a complex and adaptive system. To achieve sustainability requires a more systemic thinking. More specific, influencing technological change toward a sustainable direction (EVs) not only involves technical change but also changes in for example fuel infrastructures and policies (Geels, 2002).

The socio-technical approach conceptualizes road transport systems as a socio-technical system, which is defined as a configuration of a set of elements including technology, policy, markets, consumer practices, infrastructure, etc. necessary to fulfill societal functions, and highlights co-evolution and interactions between these elements, as shown in Figure 1 (Geels, 2004). Once the socio-technical system consistent with ICEV technology is established, it is stable and hard to transform. This stability and lock-in is mainly due to the interrelation and complementarity between the elements. The elements depend on each other to fulfill their functions. In addition, some elements, such as plants and fuel infrastructure, have a certain *hardness*, making them difficult to change. Once made, they are not easily abandoned and changed. Moreover, vested interests of the current automobile regime are resistant to major change, which is another important source of inertia.

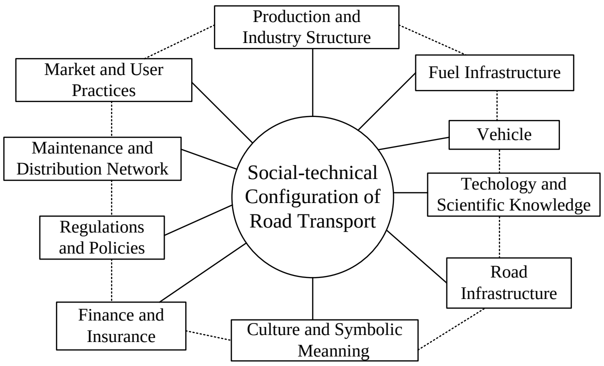

Figure 1. Socio-technical Configuration of Road Transport.

This system stability is a powerful obstacle for the widespread diffusion of EVs. However, technologists and policymakers usually separate technical concerns from social concerns while describing EV development. Indeed, the *social* barriers many pose as much of a problem as the *technical* (Egbue at al., 2012). So it is necessary to adopt the socio-technical approach to identify the barriers in the development of EVs. In this research, we take the Chinese EV demonstration program as a case to determine potential socio-technical obstacles to EV adoption. Insights gained from the results of this research will shed more light on policy-making.

2. Electric Vehicle Demonstration Program in China

2.1 Background of EV Development in China

China, one of the fastest growing economies, has witnessed an accelerating growth of the automobile industry in recent years. By 2012, the total vehicle population in China had reached 120 million (Xinhuanet, 2013), which in turn result in huge oil demand. The annul fuel consumption by road transport now accounts for approximately 60% of China's domestic oil consumption (Xue at al., 2013). On the contrary, China's domestic oil production capacity is limited. The amount and dependence of and on import oil has continued to increase in recent years, as shown in Figure 2 (NBSC, 2002-2012a, 2002-2012b).

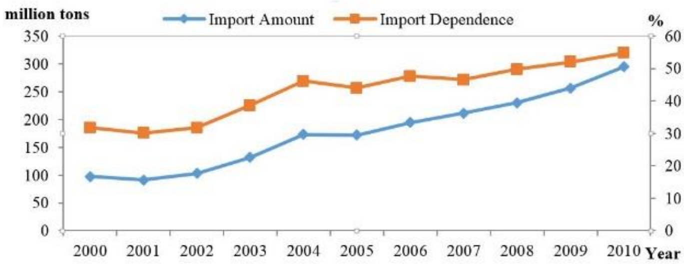

Figure 2. Import Amount and Dependenc of Oil in China from 2000 to 2010.

In the meantime, the air pollution and emission of CO_2 caused by oil consumption used in autos have become more serious problems in China. Chinese cities are suffering from poor air quality increasingly attributable to vehicle tailpipe emissions. The mean annual concentration of PM10 between 2003 and 2010 from the 32 Chinese cities is all far over the WHO basic guideline of 20 $\mu g/m^3$ (WHO, 2011). He (at al., 2005) even predicted that the vehicle-related CO_2 emissions will be 1146 million tons by 2030 under the current development pattern. In this context, the Chinese government recognizes NEVs as a key direction to decarbonize the transportation sector and to provide sustainable mobility. Of the various NEV technologies, EV has gained the most attention lately.

2.2 EV Demonstration Program in China

In China, the development of EV policies mainly involves four ministries under the State Council: National Development and Reform Commission (NDRC), Ministry of Industry and Information Technology (MIIT), Ministry of Science & Technology (MOST) and Ministry of Finance (MOF). In February 2006, the term *NEV* is first mentioned in the official policy issued by the State Council *The National Medium- and Long-Term Program for Science and Technology Development (2006-2020)* (State Council, 2006). From then on, much more polices about EVs are developed and EVs have been determined as the transformation direction for Chinese automobile industry.

In February 2009, MOF and MOST jointly issued the *Notice on the Demonstration Program of Promoting Energy-saving and New Energy Vehicles* (hereafter referred to as the *Notice*) and launched a four-year demonstration program (MOF, 2009). Of all polices about EVs, this demonstration program is the only practical demonstration project and has the most profound influence for EV diffusion. At first, 13 cities (Batch I) were approved to carry out the demonstration. Following that, MIIT and NDRC joined the program and approved 7 additional pilot cities (Batch II) in May 2010 and five more cities (Batch III) in August 2010.

This demonstration program mainly focuses on financing EVs used in the public service sectors such as buses, taxis, governmental fleet. Since the widespread adoption of EVs ultimately depend on private purchase, the four ministries jointly issued the *Notice on the Pilot Project of Subsidies for Private Purchase of New Energy Vehicles* (hereafter referred to as *Pilot for Private Purchase*) in May 2010 and selected five cities (Shanghai, Changchun, Shenzhen, Hefei, Hangzhou) among the 25 pilot cities as *dual pilot cities* (MIIT, 2010). Private purchase in these five *dual pilot cities* can also get subsidy MOF.

One target of the demonstration program is that each pilot city deploys 1000 EVs by 2012. Nevertheless, the pilot cities are not satisfied with this low target and all make their own plan, about 10000 to 30000 EVs for each. Additionally, the four ministries think this demonstration program can act as a leading role and stimulate the development of EVs in other cities, so they set another ambitious target that the national scale of EVs could account for 10% of the automotive market by 2012. However, significant problems and barriers have been exposed in the demonstration, not only *technical* barriers but also the *socio*, which result in the failure. By 2012, only 27400 EVs are on the road in the 25 pilot cities (MOST, 2013), far below the overall targets set by them. In addition, 19 million vehicles were sold in China in 2012, among which the sale number of EVs is only 12800 (CAAM, 2013a), far below the target of 10% market share.

3. Social-technical Barriers in the Demonstration

Barriers exposed in the demonstration would hinder the further introduction and widespread adoption of EVs. So it is necessary to analyze them in depth in order to achieve the commercialization of EVs. Based on the socio-technical configuration of road transport (as shown in Figure 1) and the demonstration practice in China, this paper addresses the barriers from the following six elements: production and industry structure, policies and regulations, fuel infrastructure, technology, market and consumers, culture and symbolic meaning.

The survey supported by the *Shanghai Excellent Academic Leaders Plan* of Science and Technology Commission of Shanghai Municipality was conducted in the summer of 2012. Within the transport realm, qualitative methods are more commonly used for inductive purposes. So interviews with EV experts, related stakeholders and filed research in some pilot cities including Shenzhen, Shanghai, Jinan, Hangzhou, Hefei, Dalian are the main survey methods. In addition, we also collect second-hand information from the internet and official documents. The results of this study are representative for all the pilot cities in the demonstration and provide a good overview of the barriers faced in the introduction of this radical innovation, and how far the Chinese auto market still needs to go from ICEVs to EVs.

3.1 Barriers in auto production and industry structure

Auto manufacturers, who are responsible for R&D and production of EVs, hold an important position in the EV industry. However, major Chinese automobile manufacturers are extraordinarily cautious when introducing EVs. *Recommendation List of Vehicle Types for the Demonstration program of Promoting Energy Conservation and New Energy Vehicles* (hereafter referred to as *Recommendation List*) is one prerequisite that EVs must satisfy so as to enter the demonstration program and receive the financial subsidies (MIT, 2009a). From August 12, 2009 to March 21, 2013, the first forty-three parts of the list have been announced by MIIT and total 681 EV types produced by different car companies have been included (MIIT, 2009b, 2013). However, the biggest five automobile groups in China only account for 19.6% among the total types and the proportion of each group is no more than 6 percent as shown in Figure 4. In contrast, these five automobile groups produced and sold 13.83 million vehicles, which constitute 71.6% of total domestic auto sales in 2012 (CAAM, 2013b). Reasons for such a phenomenon are multiple. Here we mainly discuss two major reasons from the perspective of auto manufacturers themselves.

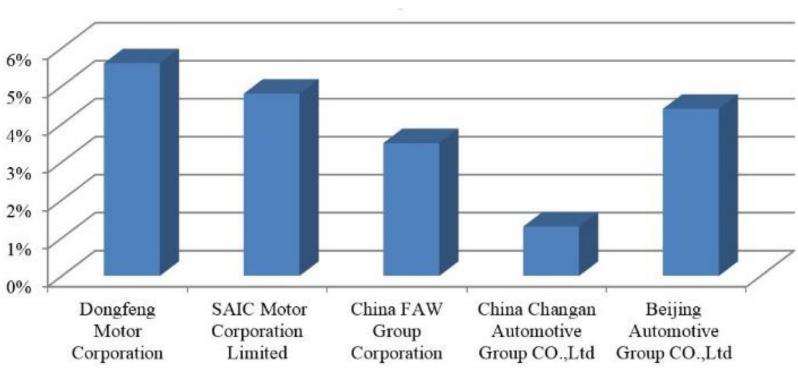

Figure 4. Proportion of EV Types of the Biggest Five Automotive Groups in the Recommend List.

3.1.1 Inherent inertia of production systems

To the Chines automobile manufacturers, their organizations are aligned with ICEVs. Sunk investments in plants, machinery and skills create vested interests for industry stakeholders. So they are reluctant to introduce EVs without external pressure and big consumption market. Additionally, Chinese auto industry now is under consolidation stage. Major car manufacturers prioritize R&D and production of ICEVs rather than EVs in order to maintain their dominant market positions. Many auto manufacturers even express in our interview that they are reluctant to sell EVs because poor performance of EVs may destroy their brand and reputation, which in turn affect the sales of ICEVs. For them, EV is more like a political task.

3.1.2 Auto industry structure

The Chinese auto industry contains about 200 car enterprises, most of which are stated-owned, especially the top-tier car companies. So the performance of these state enterprises is subject to the assessment from government. MIIT is responsible for assessment and one key assessment indicator is annual sales. In this case, most general managers pay more attention on how to achieve sales targets by selling more ICEVs during their short tenure so as to get promotion, rather than promoting EVs.

3.2 Barriers in government policy and regulatory framework

Socio-technical approach highlights the role of government in promoting the development of EVs, especially in the initial phase. Chinese governments are committed to environmental protection and sustainable development. However, some policy barriers still exist, which hamper the industrialization of EVs.

3.2.1 Competition between local governments

One of the important reasons for the limited EV diffusion scale is the competition between local governments. In the process of deepening economic decentralization, local protectionism is prevalent in China. Many local governments tend to protect local companies so that the local government performance appraisal indicators, such as local GDP, investment scale local and industrialization degree can have good results. In this demonstration program, almost all pilot cities have their own EV manufacturers and most local governments tend to give priority to support local EV industry. They only subsidize and purchase EVs produced by local manufactures, which leads to regional segmentation and the failure to achieve optimal allocation of resources, preventing the widespread adoption of EVs.

3.2.2 Unclear policy messages

NEVs include many different green technologies, such as EVs, fuel cell vehicles (FCVs), and other non-traditional fuels (ethanol, biogas, and biodiesel). Even EVs also contain different types, PEVs, HEVs, and PHVs. Among these green technologies, which one will dominate the future auto market is uncertain. Volatility and ambiguity of the policy focus further deepen the uncertainty. Initially, there was no clear policy preference in China. Then HEV technology became a high interest during the *10th Five-Year Plan* period (2001-2005). Following that, FCVs became more promising. Recently, PEV has become the focus and its top priority is determined by the *Development Plan*. Despite of this, many manufacturers still worry about the uncertain future market and are cautious in investment.

3.2.3 Lack of visions

Socio-technical approach advocates that sustainability visions help to influence or shape expectations about what might happen (Rotmans at al., 2001). Only by shaping and articulating expectations, can attention and resources be attracted as well as new actors, and which is essential for EV diffusion. However, this EV demonstrations program is carried out more or less ad hoc, without a coherent future vision. The Chinese government has not set and effectively communicated inspiring and future-oriented visions about sustainable mobility to the public. During our survey we find that many consumers actually have no idea about EV or just hear of it. All the target set by the governments are short-term and quantitative. Unfortunately, even the quantitative target has not been achieved. This failure further influences the public confidence about EVs.

3.2.4 Invalid incentives

High purchasing price of EVs is often considered to be an important barrier to large-scale diffusion. It is quite a disadvantage in Chinese automobile market, where the majority of consumers regard the price as one key decision indicator.

In order to overcome this barrier, the four ministries jointly issued the *Pilot for Private Purchase* and chose five cities to implement this policy. According to this subsidy policy, once private consumers in the five pilot cities purchase or lease PEVs and PHVs, or just lease batteries, central government will provide subsidies to the EV manufacturers or battery leasing companies. The subsidy standards are made according to the power energy of the battery pack, 3000 yuan / kWh. The maximum subsidy for a PHV is 50,000 yuan and 60,000 yuan for a PEV (MIIT, 2010). Influenced by this subsidy policy, many local governments also began to subsidize individual EV purchasing. For example, Shenzhen announced to subsidize auto manufacturers with maximum 30,000 yuan for a PHV and 60,000 yuan for a PEV.

However, it seems that subsidies fail to stimulate private purchase. By 2012, only 4400 private EVs are on the road in the 25 pilot cities (MOST, 2013). One of the main reasons for this failure perhaps is that this financial policy does not directly go to consumers. Although many companies lower the sale prices in order to attract consumers and get the subsidies, the results appear to be unsatisfactory. Additionally, this failure shows that only low purchasing price is not enough to persuade consumers into buying EVs. Many other factors such as the EV performance, convenience of refueling also need to be improved. Incentives that ignore these factors would have limited stimulation.

3.3 Refuelling infrastructure

In the mobility system, the risk of lock-in is particularly high because the vehicle technologies are infrastructure-dependent. High infrastructure investment costs and the presence of network externalities make it difficult to escape the lock-in of ICEVs. Over the demonstration period, only 174 charging (and swapping) stations and 8107 charging piles was established in the 25 pilot cities, which is far enough (CAAM, 2013c). Several barriers and problems result in this insufficiency.

3.3.1 'Chicken and egg' conundrum

This conundrum refers to an intractable situation where infrastructure providers are reluctant to invest too much money in refuelling infrastructure for EVs when there is no critical level of demand, and customers are reluctant to purchase EVs for which refueling infrastructure is not enough.

Although the construction of charging infrastructure has achieved great progress, this is not enough, especially when compared to the gas stations. So it is very difficult to persuade consumers into buying EVs. Yet at the same time, many Chinese enterprises think it is too risky and a financial burden to further conduct large-scale construction when the number of EVs in the nation's vehicle fleet is insufficient and the diffusion rate is very slow. So it seems that to get further progress is very hard.

3.3.2 Entry barrier

In China, major operators of existing charging infrastructure are oligopolistic energy suppliers, including the power suppliers China Southern Power Grid (CSPG) and State Grid (SG), the oil/gas suppliers CNOOC, Sinopec and Petro China, and information technology companies China Potevio. All of these operators are state-owned companies. Private enterprises are not admitted to enter the charging infrastructure domain. Although there is heated debate about who has the eligibility for the infrastructure construction, all discussions are just centered about which one of the oligopolistic companies mentioned above should be granted the monopoly right and private capital is barred altogether.

This entry barrier results in the lack of competition and the inaction of these oligopolistic enterprises. For these enterprises, it is actually a motion that encircles the ground in the market of charging infrastructure so as to get the first-mover advantage. What they only care about is reaching agreements with the governments and get the construction permit. Once they the permits, they are less concerned about the construction rate. This leads to a strange phenomenon that on one hand many companies announced their ambitious planning about infrastructure construction, on the other hand only a few charging facilities were built. For example, CSPG aims to deploy as many as 89 charging stations in Shenzhen by the year 2012. Unfortunately, only 4 charging stations had been built in Shenzhen by CSPG. Although multiple reasons contribute to such a huge gap between planning and reality, the inaction and inefficiency of the companies should not be ignored.

3.3.3. Lack of cooperation

The development of charging infrastructure need close cooperation among related stakeholders. However, during the demonstration each company only focuses on maximizing its own profit, which leads to the disorderly development of charging market and the lack of related standards. Firstly, there is intensive competition between SG and CSPG. The two companies build charging facilities with different standards and both try to lobby the government to set their own standards as national and industry standards so that they can monopolize the charging market. Secondly, the competition between auto manufactures leads to the different standards relating to battery size and charging interface. Each manufacturer wants to make its own production parameters prevalent so at to get more profit. The incompatibility of batteries and charging interfaces in turn makes the incompatibility of charging facilities. Thirdly, there still exist interest conflict between the power suppliers and the oil/gas enterprises. In China, CNOOC, Sinopec and Petro China occupy the dominant positions of gas station market and they want to sustain this dominance in the charging market by utilizing its advantage in the fueling network. On the other hand, power companies believe that this is an important opportunity for them to occupy the dominant position in the charging market by utilizing its advantage in the electricity domain. Although cooperation between them can integrate the advantages of both sides and accelerate the development of charging infrastructure, the interest conflict makes it unlike to happen. Fourthly, the SG wants to utilize its advantage on power supply not only to gain the dominant position in the charging market, but also in the whole industry chain. So it advocates the battery-swapping business model, by which it can control the key part of EVs-battery. However, the major auto manufacturers, however, wish to keep their current dominant positions in the auto industry chain and advocate the batter-charging business model. This imposes a great barrier for the further development and standardization of charging facilities.

3.3.4. Land use and urban planning

According to the socio-technical approach, the development of EVs involves not only the auto industry, but also need cooperation from other domains such as urban land planning. One major issue emerging in the demonstration is that the land-intensive feature of charging stations creates new challenges for urban planners. How to acquire enough land to house EV facilities, especially in the high density cities, is considered as a major challenge. In our survey, we find that many cities like Shanghai and Beijing construct charging stations in remote outskirts of the city, which is obvious a temporal solution and not suitable for further development of EVs.

3.4 Barriers in technology

The Chinese government regards the development of EV technology as an opportunity to leapfrog the auto industry to become globally competitive. During the 2001 to 2010, MOST invested 2 billion yuan in the R&D of EVs (MOST, 2013). However, many experts in our interview argue that Chinese auto manufacturers have already been left behind by foreign EV manufacturers. The core technology including battery and electronic control has not been mastered by the majority of Chinese auto manufacturer. EV technology has not been developed from an academic or industrial prototype to full mass-scale production. In addition, the technology level of domestic parts production equipment manufacturers is low. Some key EV parts are heavily dependent on imports, for example 80% of the key parts of batteries rely on import (Xinhuanet, 2010).

3.5 Barriers in consumers

Consumer acceptance is important as it is essential to the commercial success (or failure) of EVs, even if the other criteria that we have previously mentioned are met. Unfortunately, this demonstration indicates that the majority of consumers are resistant to EVs. Many reasons can explain this resistance.

3.5.1 Perceived risks

Consumers often resist new technology that is considered unproven and risky. This perception of risks is an important barrier to consumer acceptance of EVs. The perceived risks in the demonstration mainly involve three aspects: insecurity, inconvenience to charging and lack of after-sale service.

The most important concern that consumers show is the vehicle safety. This is mainly rooted in the media reports and spread of the unsafety of EVs, especially of the two EV battery accidents during the demonstration. In April 2011, an EV taxi in Hangzhou was on fire because of the wrong installation of battery and in March 2012, another EV taxi in Shenzhen had an accident and the battery exploded. Such accidents greatly influence consumers' perception about EVs and cause many consumers to lose confidence. Since the EV market is very sensitive, it is extremely difficult to remove consumers' suspicion, once it is formed.

As to the refuelling availability, current fuelling and charging infrastructure is generally inadequate in Chinese urban locations and not available along major urban arterial routes, which lead to a perception that EVs are not suitable for long journeys, particularly where vehicles have limited driving range before charging is required. Consumers, therefore, are reluctant to take the risk of being faced with inconvenient local refuelling and limited driving ranges for long distance trips.

After-sale service is playing an increasingly role in determining consumer's purchase behavior. In terms of vehicles, it means that the convenience and quality of repair and maintenance (R&M) is critical. In the demonstration project, however, no pilot city pays attention to building the R&M network for EVs. Professional R&M service and 4S shops for EVs are lack, which greatly influence consumers' perceived value of purchasing EVs. Additionally, the cost of R&M is also an important concern for consumers. In China, the average cost of ICEV use is becoming increasingly higher and a major reason is the high cost of R&M. Guided by this cognitive rule, most consumers hold the view that R&M cost of EVs would be higher, because of frequent battery repair and replacement.

3.5.2 Lack of interpersonal communication channels
Other's influence is an important determinant of an individual's purchase intention and behavior. Susceptibility to influence by others is manifest in Chinese auto market. Many consumers' perception of vehicles is influenced by their surrounding persons such as friends and families and most consumers get information about vehicles either through the social network of friends or make inferences based on the observation of the behavior of others. However, the diffusion scope of EVs is rather narrow now and very few persons buy or even know EVs, which means that little information flow happen among individuals and there are no observation objects for consumers. All of these lead to the diffusion barrier for EVs.

3.6 Culture and symbolic meanings
In China, it is only after 2000 year that cars really began to enter domestic families. This is a very short period compared to the developed countries. So cars are still symbols of status and wealth in Chinese contemporary culture. However, EVs are often considered inferior products by the public because of the poor performance/price ratio. So buying EVs seems to be conflict with cars' symbolic meanings in China. Additionally, the automobile has become an icon of the modern life-style due to its high speed and convenience for travelling at any given time. According to the study by Climate Policy Research Center of Tsinghua University, convenience, freedom and comfort are the three most important purchase drivers for Chinese consumers and environmental-pursuing is the least important driver. Unfortunately, EVs are more environmentally friendly and less convenient for daily use. This has greatly affected consumers' purchase behavior.

4. Conclusions and implications for policymakers

The introduction of EVs is confronted by several barriers that inhibit a larger market penetration under current conditions. Evidence provided in our study emphasizes the need to address socio-technical barriers facing EVs. Consistent with many other studies, we find that some reasons such as inherent technical limitations of EVs, high initial cost and insufficient charging facilities in this study exemplify the immature status of EV commercialization.
However, our study finds some social barriers that are not mentioned in other studies or not consistent with other study results. Interest conflict among auto manufacturers, infrastructure operators seems to pose a large barrier and leads to many problems such as lack of standards and the delayed charging infrastructure construction. Major automobile manufacturers have poor sense of social responsibility and the inaction phenomenon is prevalent among them. Private enterprises are often been ignored and many benefits are obtained by state-owned enterprises, which result in a possibility of monopoly. Local governments only care for their own local interest and set local market entry barriers, which result in inefficient allocation of resources. Therefore, the central government should pay more attention to top-level design and overall plan of EV industry. The central government should take a more comprehensive strategic perspective, coordinate the interest from various aspects, and fully recognize the systematic and holistic characteristic among these social-technical barriers. Governments should not only develop policies focusing on the EV niche, but also need to make much more policies that can put pressure on the current ICEV regime.
Our study also finds that current incentives to subsidize the cost of EVs have little effect. Consumers have low confidence in EV technology. Therefore, certain measures need to be taken including education, infrastructure, and strong warranties on the EV batteries. Since public opinion can be influenced through media and social networks, policy makers can use this medium to influence the public appreciation for non-financial benefits of adopting EVs.

References

1. CAAM (China Assoc. of Automobile Manufacturers), 2013a, http://www.caam.org.cn/xxdt/20130606/1405092807.html (26.06.2013).
2. CAAM, 2013b, http://www.caam.org.cn/zhengche/20130125/1005086137.html (26.06.2013).
3. CAAM, 2013c, http://www.caam.irg.cn/jfdh/20130621/0905093691.html (26.06.2013).
4. Climate Policy Research Center of Tsinghua University, *Report on Chinese Low Carbon Development*, Social Sciences Academic Press, China 2011.
5. IEA, http://www.worldenergyoutlook.org (26.06.2013).
6. EGBUE O., LONG S., 2012, Barriers to Widespread Adoption of Electric Vehicles: An Analysis of Consumer Attitudes and Perceptions, in: *Energy Policy*, vol. 48, p. 717-729.
7. GEELS F. W., 2002, Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-level Perspective and a Case-study, in: *Research Policy*, vol. 31, no 8-9, p. 1257-1274.
8. GEELS F. W., 2004, From Sectoral Systems of Innovation to Socio-technical Systems: Insights about Dynamics and Change from Sociology and Institutional Theory, in: *Research Policy*, vol. 33, no 6-7, p. 897-920.
9. HE K., HUO H., ZHANG Q., HE D. Q., AN F., WANG M.,WALSH M. P, 2005, Oil Consumption and CO_2 Emissions in China's Road Transport Current Status, Future Trends, and Policy Implications, in: *Energy Policy*, vol. 33, no 12, p. 1499-1507.

10. INTERNATIONAL TRANSPORT FORUM, *Transport Outlook 2010: The Potential for Innovation*. OECD, Paris 2012.
11. MIIT, 2010, http://www.miit.gov.cn/n11293472/n11293832/n11293907/n11368223/13247375.html (26.06.2013).
12. MIIT, 2009a, http://www.miit.gov.cn/n11293472/n11293832/n11294057/n11302390/12427300.html (26.06.2013).
13. MIIT, 2009b, http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916898/14051087.html (26.06.2013).
14. MIIT, 2013, http://www.miit.gov.cn/n11293472/n11293832/n12845605/n13916898/15311617.html (26.06.2013).
15. MOF, http://jjs.mof.gov.cn/zhengwuxinxi/zhengcefagui/200902/t200902 05_111617.html (26.06.2013).
16. MOST, http://www.most.gov.cn/ztzl/kjzjbxsh/kjzjbxmt/201302/t20130204_99603.htm (26.06.2013).
17. NATIONAL BUREAU OF STATISTICS OF CHINA (NBSC), *China Statistical Yearbook 2001-2011*, *Bejing* 2002-2012a.
18. NATIONAL BUREAU OF STATISTICS OF CHINA (NBSC), *China Energy Statistical Yearbook 2001-2011*, *Bejing* 2002-2012b.
19. PAWŁOWSKI A., Introducing Sustainable Development-a Polish Perspective, in: *Environmental Engineering Studies, Polish Research on the Way to the EU*, *eds*. Pawłowski L., Dudzińska M.R., Pawłowski A., Kluwer Academic/Plenum Press, New York, Boston, Dordrecht, London, Moscow 2003.
20. PAWŁOWSKI A., *Sustainable Development as a Civilizational Revolution. A Multidisciplinary Approach to the Challenges of the 21st Century*, CRC Press/Balkema Book, Boca Raton, London, New York, Leiden 2011.
21. PAWŁOWSKI A., Sustainable Development vs Environmental Engineering: Energy Issues, in: *Paths to Sustainable Energy, eds*. Nathwani J., Ng A., Tech, Rijeka 2010.
22. PAWŁOWSKA M., LEBIOCKA M., MONTUSIEWICZ A., Removal of Methane and Selected NMOCs From Landfill Gas-Field Studies, in: *Proceedings of EURASIA Waste Symposium*, 14-17 November, Istanbul 2011.
23. ROTMANS J., KEMP R., ASSELT M. V., 2001, More Evolution than Revolution: Transition Management in Public Policy, in: *Foresight*, vol. 3, no 1, p. 15-31.
24. SHAN S. D, BI X. H., 2012, Low Carbon Development of China's Yangtze River Delta Region, in: *Problemy Ekorozwoju/Problems of Sustainable Development*, vol. 7, no 2, p. 33-41.
25. STATE COUNCIL, http://www.gov.cn/gongbao/content/2006/ content_240244.htm (26.06.2013).
26. WORLD HEALTH ORGANIZATION (WHO), http://www.who.int/phe/health_topics/outdoorair/databases/en/index.html (26.06.2013).
27. XINHUANET, http://news.xinhuanet.com/yzyd/ auto/20130131/c_114561927.htm (26.06.2013).
28. XINHUANET, http://news.xinhuanet.com/fortune/2010-09/16/c_12577505.htm (26.06.2013).
29. XUE Y. X., SHAO L. N., YOU J. X., BI X. H., 2013, Research on Transition to Alternative Fuel Vehicles: Social-Technical Regime Analysis in China, in: *China Soft Science*, vol. 3, p. 78-88.
30. YEH S., 2007, An Empirical Analysis on the Adoption of Alternative Fuelled Vehicles: The Case of Natural Gas Vehicles, in: *Energy Policy*, vol. 35, no 11, p. 5865-5875.