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Promoting the deployment of electric vehicles: The role of policy in matching user expectations

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MASTER'S THESIS

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PREFACE

Twenty years from now you will be more disappointed by the things that you didn't do than by the ones you did do. So throw off the bowlines. Sail away from the safe harbour. Catch the trade winds in your sails. Explore. Dream. Discover. — Mark Twain

Thanks to European Commission offering me the chance to carry on my study in Europe. The two-year study has broadened my vision with all the amazing adventures. I would like to acknowledge all my family and friends in Taiwan, Austria, and Sweden who give me their ultimate supports and encourage me to fulfil this master thesis work. At this moment, my overwhelming two-year journey in Europe is sailing to a harbour. The sky is still bright and the sun is shinning. There are still a lot to be explored. Once more, load the courage and get ready to depart.

Acknowledgements

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ABSTRACT

This thesis utilises the qualitative case study (document analysis) to examine how policy could pave the way for electric vehicles while considering user needs. The EV deployment of San Diego (California, US), London (UK), Stockholm (Sweden), and Shanghai (China) were chosen as cases to analyse for their representative features and different policy strategies employed under specific socio-political environments. The four cases were analysed with the policy strategy promoting the deployment of electric vehicles and linked with the user perceptions.

The result shows that the policy supporting user adoption of electric vehicle is geographically specified. There exists no universal policy strategy for electric vehicle deployment because of the heterogeneity of political situations, social-economic status, and cultural backgrounds in different countries. However, financial supports and incentives for both vehicle and charging infrastructure, trialability and experience, and the new business models for removing social lock-ins are the three solid factors to be included in the policy for achieving electromobility in the cities. The content of policy should be specific, meanwhile flexible in order to be able to adjust under the highly dynamic socio-economic environment in the modern society. Furthermore, some parallel policies or supporting measures for sustainable electricity production could contribute to drawing more concrete interests for procuring a new electric vehicle.

Key words: Electromobility; Electric Vehicle (EV); Policy; User needs; Trialability

Glossary of Terms

BEV	Battery Electric Vehicle
CCSE	California Center for Sustainable Energy
CYN	Chinese Yuan
CVRP	Clean Vehicle Rebate Project
CO2	Carbon Dioxide
Deloitte	Deloitte Touche Tomatsu Limited Global Industry Group
EEA	Europe Environment Agency
EERP	European Economic Recovery Plan
EGCI	European Green Car Initiative
EST	Energy Saving Trust
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
EVUE	Electric Vehicle in Urban Europe
EU	European Union
GHG	Greenhouse Gases
GLA	Great London Authority
ICEV	Internal Combustion Engine Vehicle
ICT	Information and communication technology
KTH	KTH Royal Institute of Technology (Sweden)
kWh	Kilowatt hour

OECD	Organisation for Economic Co-operation and Development
PEV	Plug-in Electric Vehicle
PiFi	Plugged-in Fleet initiative
PAN	Play Association Network
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaic
R&D	Research and Design
RD&D	Research, Development and Design
SEK	Swedish Kronor
UK	United Kingdom
UN	United Nations
US	United States
ZEUS	Zero and Low Emission in Urban Society

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1 INTRODUCTION

Electromobility, or electric mobility, is the transport mode using powertrain. Electric vehicles (EVs), or plug-in hybrid vehicles (PHEVs), represent different options for electrification of private mobility. The European Commission (EC) has considered electromobility as the guidance for fossil-fuel-free transportation. With the robust growth of cars and commercial vehicles produced since the millennium, automotive industry has played an important role in the global economy. Struck by the economic recession in 2008, the automotive industry has experienced a low-sales period. Production fell in most of the traditional locations for vehicle manufacturing, including Canada, Belgium, France, Germany, Italy, the UK and the Netherlands (Wells, 2010). So as to respond to this economic crisis, the EC launched the European Economic Recovery Plan (EERP) in November 2008 to restore the confidence of consumers and businesses. Among the three public partnership plans of the EERP, the European Green Cars Initiative (EGCI) has brought Europe to the arena of developing fossil-fuel-free and low-emission vehicles by supporting R&D on technology breakthrough for renewable energy (EU, 2008).

Together with increasing urbanisation in most of the countries, dense and centralised cities has become dominate worldwide (Mori & Christodoulou, 2012). More and more people are moving from countryside to the cities and require short distance journey as daily mobility. According to the UN's forecast (UN, 2011), more than 70% of population (around five billion people) will live in the city by 2050. Cities now require new mobility solutions for congestion, GHG emissions, air pollution, and noise. Theoretically, EVs appear to be a genuine solution that can easily satisfy the mobility demand in the cities without harmful exhaustion, noise, and a significant change for adaptation. The change in lifestyle and travel pattern, urban design, renewable energy production and smart grid network make electrification in the future transport system more credential and promising.

With the long history of technology development of EVs and the continuous improvement in smart grid system, the adoption is theoretically feasible in this century. However, the promotion of EVs is not as smooth as expected. The reliability of EVs is somehow questioned by driving range pre charge, inadequate infrastructure and standardisation, lengthy recharging, and future technology uncertainty (Daziano & Chiew, 2012). A significant gap exists between what users expect towards the EV utility and current technology competency (Deloitte, 2010). Range anxiety, which refers to the anxiety towards the capability of the EV to reach the destination, and high cost for adoption are the two major obstacles for consumers to accept EVs (Deloitte, 2010; Franke et al., 2012; Marrow et al., 2008). The OECD countries are now considering EVs as one of solutions that can make the transport sector more sustainable. However, the lack of manufacturing standards for vehicles and also the charging infrastructure partly hinder the deployment of EVs at a larger scale (EC, 2012).

Besides the discussion of gap of expectations from users, some argue that electric vehicles are not necessarily better for the environment (Doyle & Adomaitis, 2013;Turton & Moura, 2008; Richardson, 2013). The benefit of significant reduction of CO_2 from EVs comes along with the sustainable electricity generation. The electric cars may reduce pollution locally through zero-exhaust but are charged from electricity generated by high-polluting coal-fired power plants elsewhere. A recent report from *Reuters* stated that the rapid deployment of electric cars in China would not lead to a good cause for its coal-based electricity production, which also caused a lot of health problems (Doyle & Adomaitis, 2013). The uncertainty of technology development and the problem of electricity generation for vehicle fuelling also hamper the development of EVs in the society (Deloitte, 2011; Huo et al., 2010). Nevertheless, one of the effective measures that could make EVs more competitive on the market is based on the authority.

The role of policy is perceived as the driver for fuel efficiency and lowering CO_2 emissions for the reason that public policy motivates car providers more explicitly than customer demand (Sprei & Wickelgren, 2011). Policy instruments as deployment strategy to raise market penetration for new eco-innovations go far beyond the traditional State regulations and financial incentives (Leurent & Windisch, 2011). For instance, subsidies, taxation, public procurement, deposit-refund scheme, etc. are the instruments making EVs more appealing and affordable to the consumers. Initiatives to promote EVs at different geographical and legislative levels have been booming since the Millennium. The European Strategy on Clean and Energy Efficient Vehicles purported to encourage the uptake of clean and energy efficient vehicles was released in 2010 (EC, 2010; Leurent & Windisch, 2011). The EGCI, which aims to revive the economy through greener industry followed up (*Green Car Initiative*, 2012). The US recently introduced a two billion US dollar trust from the royalties the government received from offshore drilling for the research in alternative energy replacing gasoline (Dizikes & Banerjee, 2013). Under the development scheme of alternative fuels and vehicle technology in the American Recovery and Reinvestment Act in 2009, the US government announced another $2.4 billion budget are specially dedicated to battery technology (ARRA, 2009; US Department of Energy, 2009a, 2009b). An international collaboration also took place between the US and China with the US-China Bilateral Electric Vehicle Initiative in 2009. Car manufacturers like Audi, BMW, Nissan, and Toyota also were motivated and started taking pro-active actions in EV deployment (Vasilash, 2011). BMW has committed in the development of electromobility and already identified their responsibility in designing more energy efficient and zero-emission vehicles and recharging measures (BMW Concord, 2010).

Based on practical cases, the study focuses on how eco-innovations could be commercialised considering the actual needs from users through the support of policy instruments. The purpose is to figure out how users react to certain type of eco-innovation and the role of policy in relation to its deployment. Considering EVs as the alternative for smaller-scale and flexible mobility, four cases in different countries and regions are compared with their policy strategies for EV deployment. Starting from understanding the real needs and expectations for EVs expressed by users, a theoretical framework for electromobility, user needs and the function of different types of policy could be found in *Theoretical Background*. *Methodology* follows up and explains the technique applied for this study; meanwhile, delimitate the criteria for case selection. *Case study* includes four different cities/countries: San Diego/the US, London/the UK, Stockholm/Sweden, and Shanghai/ China. Different initiatives promoting the EV adoption have been performing in these countries supported by various policy instruments. In the *Discussion* part, it lays the arguments about the effectiveness of policy instruments and the general policy. In *Conclusion*, the outcome of background study, document analysis and policy research would bring the possibility to explicitly identify the role of policy in different context; furthermore, enlighten the major actors for EV adoption breakthrough.

2 THEORETICAL BACKGROUND

Before proceeding data gathering and analysis, some literature review ought to be done for better understanding of the background. By downscaling the term 'electromobility', which is broadly defined as the electrification of transportation, it is agreed upon the interpretation as the individual daily mobility. In this section, the introduction of the origin and development of electromobility, the review of user needs and expectations towards electric cars, and the function of common adopted policy instruments are presented respectively.

2.1 The development of electromobility – Electric Vehicle

Acknowledging the resource scarcity and the foreseeable peak-oil era, it has been an extent development of technologies in the automotive industry in order to reduce GHG emissions and resource consumption such as efficiency improvements of conventional ICEVs, battery electric vehicles (BEVs), and ICE/electric hybrids, fuel-cell vehicles and biofuels in ICEVs (Aftabuzzaman & Mazloumi, 2011; Köhler et al., 2013). Electromobility refers to the use of electric powertrain and storage system as mobility solutions. Due to the negative environmental impacts and rising oil prices, the interest of electric cars re-emerged in the US during the 1960s to 1970s (Dijk et al., 2013). The automotive industry starts to create the market in this field and has been officially used as a guidance to lead the trend towards CO2-free transport. Many studies have identified the importance of electromobility for the future society, including the academia, the automakers, and also the policy makers (BMW-i, 2011; Dijk et al., 2013; GLA, 2009ab; Helmholtz Association of German Research Centers, 2012). The study of EVs could be dated back to 1981, Beggs et al. studied the potential demand for EVs through a ranked logit model with price, fuel cost, range, top speed, number of seats, warranty, acceleration, and air condition (Hidrue et al., 2011). Following up with the programme initiated by the EC, electromobility has been brought to a new phase of development for the full-scale deployment throughout Europe.

Confining to road transport, electromobility is tightly associated with the automobiles using electricity as the major power source. EVs have a history of development since the end of 19th century. Starting with the first electric locomotive in 1837, the earliest electric vehicle was built in the US and imported in the Germany in 1893 (Larminie & Lowry, 2012). Despite the long development path for EVs, there are still some technical barriers when it comes to adoption. The BEV requires a battery breakthrough with lower cost and better efficiency and capacity in order to resolve the concern of driving range from the drivers, thus make a progress on the market (Schlachter, 2012). Solutions to conquer this difficulty in regard to the battery appeared, such as shifting the battery ownership from recharging to swapping, or leasing the battery for using phase with insurance. Through shifting the cost from owing to using the battery, the cost premium brought by the battery could be removed (*Better place,* (n.d.)), making the EVs more economically competitive on the market.

2.2 User needs and expectations

There are several important factors potentially driving and impeding the consumer adoption to eco-innovations (Jansson, 2011).

"The current trend towards EVs is only recent, and only a small number of EVs is available on the market. Thus, user experience with EVs of the current generation is rare." (Peters et al., 2011)

Consumers still have limited knowledge about the new technology; however, those who are knowledgeable in technology feel that new vehicles were not responding to the needs (Deloitte, 2011; Franke et al., 2012). Since the market success of products is mostly dependent on the consumers' attitude, it is crucial to ensure the innovation being equipped with the functions meets their expectations.

The EV is still reserved in a niche market for its relatively much higher price and limited utility (considering status of charging infrastructure) currently comparing to the ICEV. Consumer acceptance of EVs is based on the history with the ownership of ICEVs, and some corresponding driving patterns (Peters et al., 2011). Technology adoption of individuals is crucial and to an extent determines the level of market success of the innovation. Some argue that it is difficult for users to derive a concrete attitude and convey the real needs towards the new and rather unfamiliar vehicles (Ehrler & Hebes, 2012), whilst some think the failure of promoting EVs originates from the incompatibility with personal mobility demands (Deloitte, 2011). According the study of consumer expectations by Deloitte (2011), there exists a substantial gap between what the consumers expect and what the market can offer today.

Mobility is the service offered by a vehicle, and driving is the way to claim this service. The driving pattern thus becomes one of the critical factors that need to be considered at the R&D stage for automotive manufacture. Ericsson (2000) identified the driving patterns in urban area through mapping all the relevant factors. These factors form the inter-related influence towards the driving pattern as individual behaviour. By centring the vehicle factor that mostly associated with the R&D of car industry, the impact factors will be the driver factors, driving patterns and its contributors, and the weather factors (Fig. 1). The individual driver factors related to traveling behaviour would be the travel distance and the driving hours. These are also considered as the major barriers for keeping EVs from being competitive on the vehicle market. The well-established and non-adaptable expectations not only are embedded in the mind of the deep-rooted customers but the new comers to the current market.

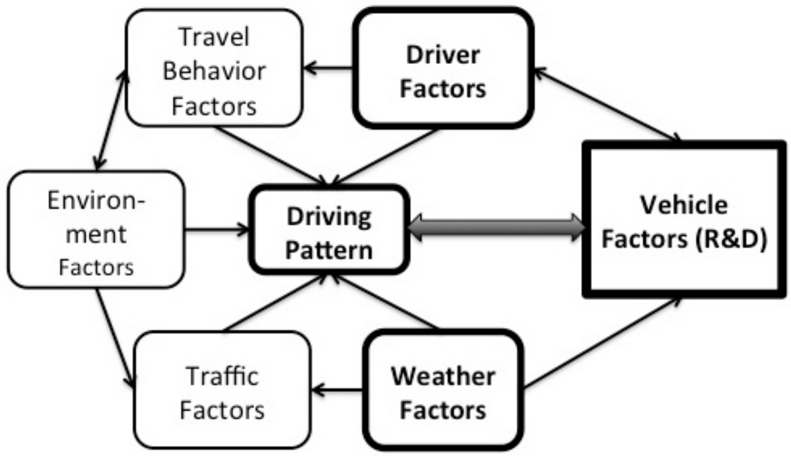


Figure 1 The simplified cause-effect map focus on vehicle design (Ericsson, 2000)

Aside from driving pattern, perceived compatibility with one's values is another important factor for the user intention to adopt new technology, like EVs (Peters et al., 2011). Comparing to other factors in the Rogers model (2003) adapted by Peters et al. (2011) (Fig. 2), compatibility is found as the main reason to inspire the intention of purchasing an EV.

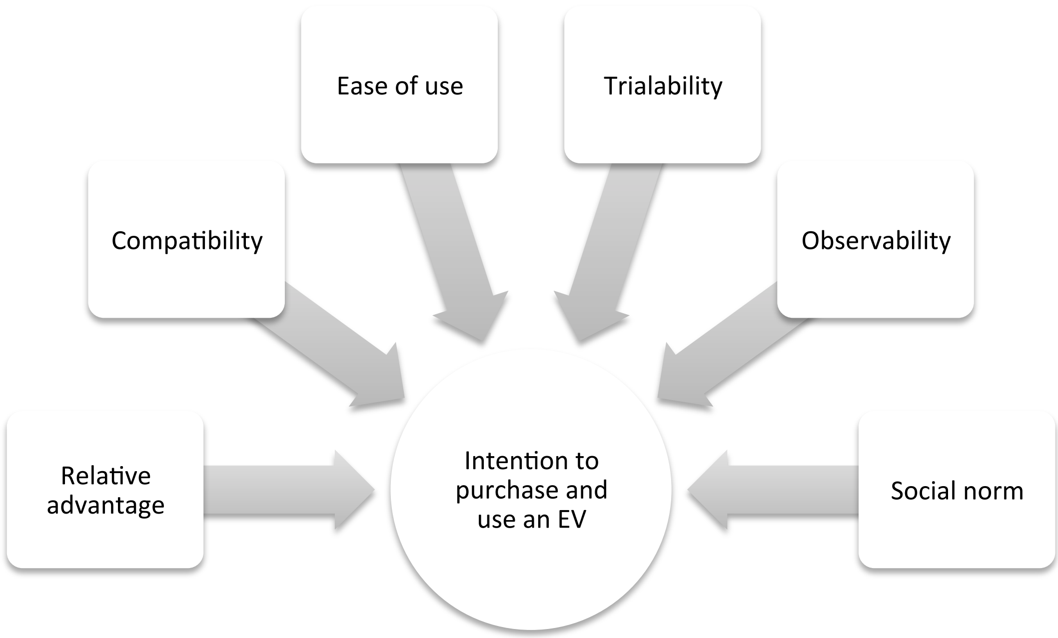


Figure 2 The theoretical model to explain the adoption of EVs (Rogers, 2003; Peters et al., 2011).

As for user expectations, a consumer evaluation survey done by the automotive industry provides some valuable information. Some studies have characterised the challenges of promoting EVs: maximum driving range, refuelling time and infrastructure, price premium, high initial production and purchase price, fuel price, fuel/energy efficiency (Peters et al., 2011; Daziano & Chiew, 2012; Deloitte, 2011; Ehrler & Hebes, 2012; Franke et al., 2012), and low consumer risk tolerance (Jaff & Stavins, 1994). Mobility, human-machine interaction, traffic and safely implication, and acceptance are the four pillars identified by Cocron et al. (2011) in user psychology evaluation as decisive factors of EV adoption (Fig. 3). In order to understand the consumers' expectations towards EVs, Deloitte prepared a study based on a survey with 13,000 individuals in 17 countries (America, Europe, and Asia) inquiring into willingness to purchase and other data regarding to car selling points, including price, range and charge time (Deloitte, 2011). This reported has a special attention to geographical differences and similarities in consumers' responses about EVs. Deloitte (2011) stated that the user needs and expectations of driving range, charge time and purchase price are all consistent global wise; however, these expectations are significantly different from what the automotive manufactures can offer at present. Many drivers are still worried that the limited range offered by EVs would not be able to lead them to the destination (Daziano & Chiew, 2012).

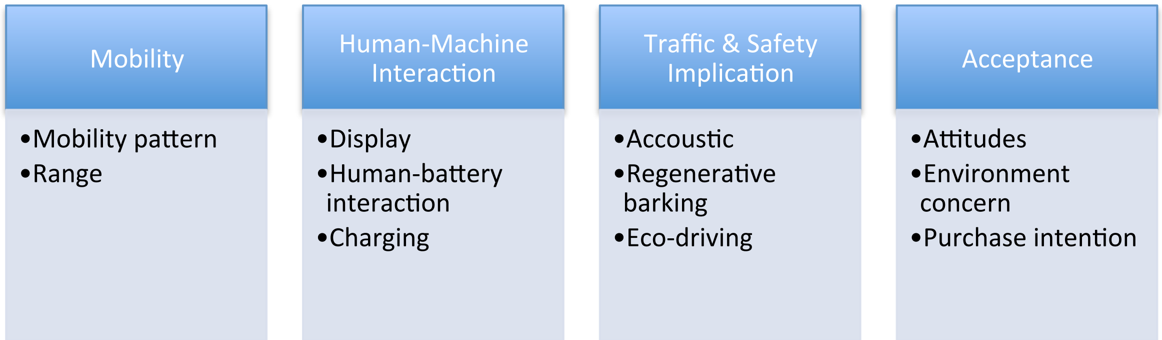
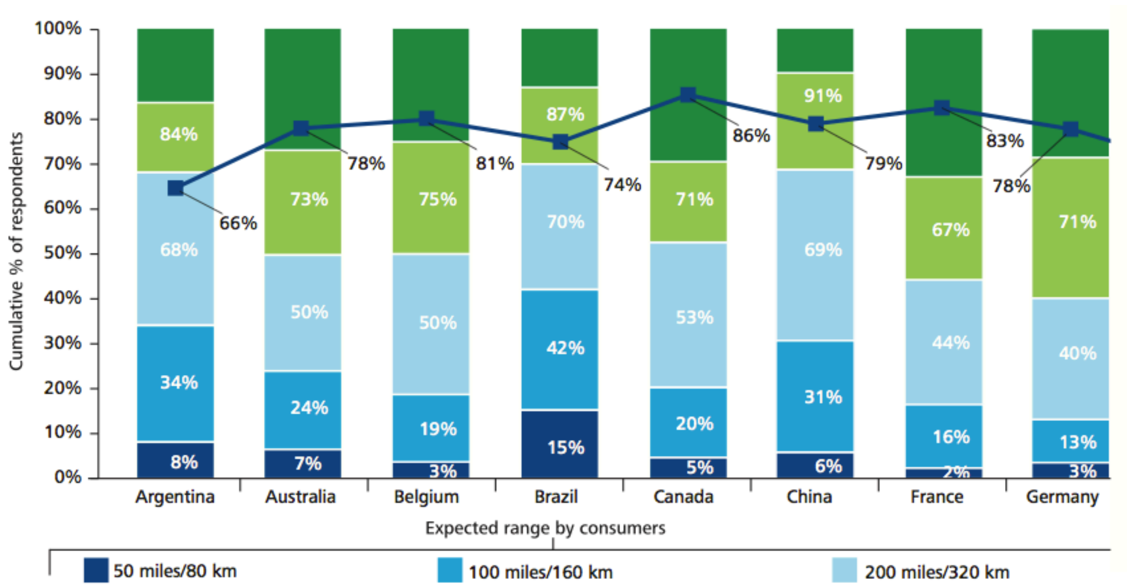


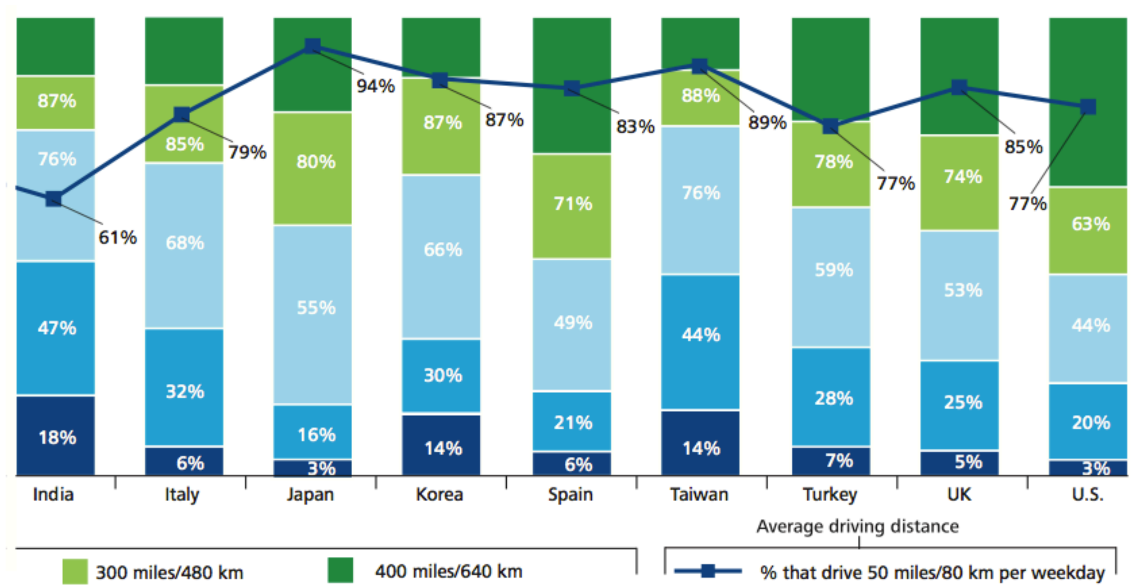
Figure 3 Four Pillars in psychological evaluation (Cocron et al., 2011)

2.2.1 Range Limit

For drivers, range is appreciated as the resource for their daily mobility needs. Understanding the range experience and range utilisation is important for resolving range anxiety (Franke et al., 2012). According to Deloitte's survey, drivers in the US and France have the highest sensitivity with an expectation for the range up to 480 km. Comparing to what is expected, current technology provides a driving range around 160 km, which can by far meet the consumer requirement. On the other hand, the result also suggests that most of the drivers expect EVs to allow more driving range than what is provided in the conventional ICE vehicles. A survey in German also suggested that range anxiety exists only before the driver tries the EV. After the three-month trial, a range of 140-160 km is considered sufficient for more than 94% of the users (Cocron et al., 2011). The driving range permitted in reality, c.a. 160 km between charging, could meet the expectation of nearly half of the drivers but the ones in France and the US (Fig. 4ab). From the study of Cocron et al. (2011), it drew an analogous conclusion that the limited range can already satisfy the basic mobility need. Judging from the disparity in range between the expectation and the reality, the experience in using EVs is crucial to demolish the barrier of range anxiety (Cocron et al. 2011), which is identified as the importance of trialability in Rogers model for EVs (Fig. 2). However, the general tendency showed that most of the users try to stay on the safe side not to plan trips possibly exceeding the range limit (Franke et al., 2012). The study of Franke et al. (2012) stated that most of the users are categorized as seeing range as a problem to be resolved rather than a "threating encounter" to be avoided. The range barrier, which is approved to be a psychological barrier, could be successfully overcome by practice in managing range such as trip planning (Franke et al., 2012).



(a)



(b)

Figure 4 Range expectations from drivers (a)(b) (Deloitte, 2011)

2.2.2 Charging Time and Charging Infrastructure

The lengthy recharging, insufficient charging infrastructure, and uncertainty provoked from lacking of standards for charging facilities are partly responsible for range anxiety (Daziano & Chiew, 2012). Unlike the conventional gas/petrol vehicles, EVs takes more time to charge. Deriving from the habit built with ICEV ownership, it is obvious that drivers prefer EVs to be fully charged in short.

The charging infrastructure primarily used in Europe has a different categorisation standard than that in the US. The International Electrotechnical Commission (2011) has set up an international standard that is applicable to plugs, socket-outlets, connectors, inlets and cable assemblies for EVs (IEC 62196). Table 1 lists a detail of the four modes of charging infrastructure. Mode 1 to Mode 3 chargers are estimated to allow an EV to be fully charged in three to ten hours through direct connection with a mains supply (IEC, 2011b). Mode 4 chargers offer the possibility of fully recharged an EV in ten minutes with off-grid batteries. However, the cost for applying Mode 4 charging system is still not realistic at present. Currently, the US has been limited to Mode 1 charging on safety grounds, whilst Europe has a lot of interest in developing Mode 3 for public charging. Yet, Mode 4 DC fast charging system is more favourable in Japan.

Table 1 Charging mode

Charging Mode	Power	Description
Mode 1, AC	16 amps 3.7 – 11.0 kW	Slow charging from a standard household-type socket-outlet.
Mode 2, AC	32 amps 7.4 – 22.0 kW	Slow charging from a standard household-type socket-outlet with an in-cable protection device.
Mode 3, AC	63 amps 14.5 – 23.5 kW	Slow or fast charging using a specific EV socket-outlet and plug with control and protection function permanently installed.
Mode 4, DC	95 kW	Fast charging using an external charger.

Source: International Electrotechnical Commission, 2011

Based on the categorising system in the US, there are three major types of EVSE at present. The Level 1 charger requires a relatively longer time to recharge the vehicles and is regarded as an entry for battery electric cars. The Level 2 charger is more preferred by users as the residential charging infrastructure. To increase the efficiency of charging, the Level 2 charger is designed with 240-VAC, single-phase, 40-Amp branch circuit that allows vehicles to be fully charged in a shorter time with higher safety level (Marrow et al., 2008). The Level 3 charger uses the DC fast charging system. The Deloitte consumer survey shows that most drivers expect their vehicles to be fully charged within two hours. However, the charge time ranges from 3 to 20 hours with Level 1 or Level 2 charger (Deloitte, 2011). A vast gap between technology and user expectation for charging still exists.

The request of shorter charging time and the anxiety towards range are also associated with the availability of infrastructure. The new fast charging station allows users to charge their vehicle up to more than 80% of battery capacity with less than 30 minutes, which could also largely reduce the concern towards range (Vattenfall AB, 2013). However, concerns over the safety of high voltage, shortening lifetime of batteries and the higher cost still exist (Deloitte, 2011). Battery swapping service is an alternative to increase the efficiency of refuelling for EVs. The Better Place project launched in Israel in 2007 has been developing and promoting the switchable battery mechanism that allows drivers to charge their vehicles in less than five minutes with another 80 to 200 meters range (*Better Place*, (n.d.)).

2.2.3 Price Premium

The price premium of EVs originates from the cost of the battery, which is extremely high and needs to be subsidised by the government (Franke et al., 2012). The price is regarded as a decisive factor that shatters the EV ownership. According to the Deloitte's survey (2011), consumers are not willing to pay a premium for EVs over ICEVs even with the incentive for saving fuel price in the future. Nevertheless, Hidrue et al. (2011) suggested that the battery would require a drastic decrease in cost before EVs will find a mass market without subsidy.

2.2.4 Production cost and Purchase Price

The high initial production cost (Argote & Epple, 1990) and purchase price has been regarded as one of the major reasons impeding the public acceptance of EVs. Many industrial reports stated that the EVs would remain in the niche market unless automakers can lower the prices and demonstrate the ecological benefits to consumers (Dagsvike et al., 2002; Hidrue et al., 2012; J.D.Power and Associates, 2012). Some come up with the idea that different strategies should be used for promoting EVs in developing countries and developed countries. The EVs in developing countries are expected to become the cheapest module to purchase for consumers on the market; on the other hand, in most of the OECD countries, the consumers are less price-sensitive with an average price as conventional ICEVs (stated as $20,000 or €15,550 by Deloitte). However, the price of the EV is hard to go down since the battery price is fixed and is even likely to rise in the future owing to the increase in storage capacity for higher range (Franke et al., 2012; Hidrue et al., 2012). Therefore, EVs still have low penetrating likelihood on the market owing to the high purchase price.

2.2.5 Fuel Price and Fuel Efficiency

Fuel Price is another cause for pushing mobility towards electrification generated in a sustainable mean. Fuel efficiency can be converted into actual operational costs since the cost for owning a vehicle will rise with the energy price. In general, the consumer's interest for EVs is largely stimulated by the rising gas/petrol price (Daziano & Chiew, 2012; Deloitte, 2011; Hidrue et al., 2011). Fuel price is an incentive for orienting automotive industry towards electromobility. Evaluating the situation in all the countries around the world, it appears that the US market is having the petrol price closest to the tipping point at which consumers are most convinced to adopt EVs (Deloitte, 2011).

2.2.6 Trialability

In conclusion, the gap between the available technology and the expectations from consumers appears in the range, charge time, and purchase price. Range anxiety could probably be resolved by trialability, which offers the experience and knowledge of mobility pattern of users, during test and demonstration, and also the inter-modality with other transportation means. According to the research of Ehrler and Hebes (2012), drivers usually became enthusiastic about the new technology at the beginning of the trial phase even though their knowledge about EVs is limited. Switchable batteries, different policies for managing battery and multiple standard charging stations would release the anxiety towards charge time and price. However, technology for battery and charging facilities is still advancing. Subsidies and alternative battery management would make EVs competitive with other ICEVs on the market in terms of purchase price. Policy stands a role in fostering the development and public acceptance of EVs. The intervention of policy would catalyse the diffusion of electromobility and make EVs more attractive to the consumers.

2.3 Policy instruments and their functions

Eco-innovations are the innovation that improves the environmental performance (Carillo-Hermosilla et al., 2009; Kemp & Foxon, 2007). Nevertheless, the existing potential eco-innovations are still weakly adopted although most of them are identified with high capability of bringing social and environment benefits. Barriers such as high external cost, environmental externalities and technological lock-in within the existing systems are factors that hinder the development of eco-innovations (Carillo-Hermosilla et al., 2009). Policy plays as the driver for eco-innovations, whilst also aims to demolish these barriers. The degree of maturity of specific eco-innovations should be taken into account for applying a policy approach to eco-innovations (Carillo-Hermosilla et al., 2009, pp.56). A combination of supply-push and demand-pull measures, which is interpreted as the way how government supports technology development as well as encouraging demand through the market creation, is usually applied for different stage of eco-innovations. Supply-push measurements are more effective to aid the development of technology for immature eco-innovations. In contrast, the mature eco-innovations are more suitable to be sustained with the demand-pull provided mainly by environmental policy instruments (Carillo-Hermosilla et al., 2009, pp.88-89). Judging from this criterion, demand-side policy theoretically more crucial for boosting user adoption of EVs in the modern society.

Table 2 Instruments to encourage eco-innovations (Carrillo-Hermosilla, 2009)

Environmental policy instruments	• CAC instruments (technology standards, performance standards) • Market instruments (taxes, ETS[a], subsidies, deposit-refund schemes) • Others (EMS[b], eco-labels, life-cycle analysis and produced product responsibility, voluntary agreements, information disclosure)
Technology policy instruments	• Government funding of RD&D • Technological assistance programmes • Training in new technologies • Strategic Niche Management • Technological foresight studies • Environmental technology awards • Innovation waivers • Creation of a network of actors involved in environmental technological change (networking)
Other instruments	• Public Procurement • Instruments targeted at SMEs • Establish long-term visions

[a] Environmental Technology System

[b] Environment Management System

2.3.1 Environmental policy instruments

Environmental policy instruments and innovation policy measures focusing on technology are the two typical categories of policy instruments for eco-innovations. Command-and-Control (CAC) instruments, Market-based instruments, and a miscellaneous category are considered as the environmental policy instruments.

2.3.1.1 Command-and-Control instruments

Command-and-Control instruments represent the core of a government's strategy and usually used by the public authorities at national level (Leurent & Windisch, 2011). In technical terms, the technology standards and the performance standards are the major elements for CAC instruments (Carillo-Hermosilla et al., 2009). Technology standards specify the technology that needs to be adopted by the firms, and thus creates incentives for developing this specific technology. Performance standards constrain the firms to meet the environment requirements in terms of pollutant discharges or GHG emissions. This measurement allows firms to develop the technology whichever they deem best, and thus provide a certain freedom to eco-innovation. CAC instruments are usually adapted to market and technological development throughout time (Leurent & Windisch, 2011).

Although CAC instruments are implemented as legislation, it is generally believed that they are less effective at stimulating eco-innovation than the market-base ones (del Río, 2009; del Río et al, 2012). This argument stands on basis of the importance of economic incentive and involves users as part of the persona for the successful eco-innovation development.

2.3.1.2 Market-based instruments

Market-based instruments, also called "incentive based" mechanisms, encompass a wide variety of instruments. For instance, fiscal measures (taxes), tradable permit system, subsidies, deposit-refund scheme, and awards (Carillo-Hermosilla et al., 2009). Taxation is common fiscal measure easy to implement for regulating undesirable activities. It requires regulated entities a certain amount of expense for each unit of pollutant released to the environment. In the tradable permits scheme, the regulator sets the environmental target and issues some tradable permits that could be freely distributed by the firms. Firms have an incentive to eco-innovate to reduce their environmental impacts or reduce the amount of permits they need buy.

Subsidies as market-based instrument can effectively upsurge the interests in developing eco-innovations. It can work in both way as the investment subsidy or the production subsidy. An investment subsidy is the one-time payment to the firm for developing an eco-innovation. Given per unit of production achieved for the eco-innovation, the production subsidy help to reduce the cost in the manufacturing phase and ensure better competitiveness on of the eco-innovation (Carrillo-Hermosilla et al., 2009).

Deposit-refund scheme system focuses on the industry instead of private sectors. The system requires the industry or organisations to pay in advance for the potential pollution. However, the deposit will be returned if the pollution does not take place. Considering the reputation and social norm, the government awards can be considered as another economic instrument give credits to the firms.

By offering consistent fiscal incentives, market-based instruments are generally seen as a more powerful and effective measurement for promoting eco-innovations in the society. For eco-innovations like EVs, incentives that provide payments upfront appear to be the most effective among all (Gallagher & Muehlegger, 2008).

2.3.2 Technology policy instrument

The technology policy instruments are intended to support the early stage of innovation – RD&D. Technology policy is effective for mitigating the double externality problem of eco-innovations (Carillo-Hermosilla et al., 2009). To support the starting phase, this instrument is crucial for the development of immature eco-innovations. For EVs, the intervention of technology policy could help to generate the solution to improve the efficiency of the battery. The market is still expecting batteries with longer life span and larger capacity at lower cost, which is still under development.

The lack of individual technology proficiency results in the difficulty in embracing eco-innovations in organisations. Training is subject to the inflow of the knowledge of eco-innovations into the company and the ability of existing personnel in operating the new eco-innovations. The acceptance and appreciation of eco-innovations are likewise established during the education process (Carillo-Hermosilla et al., 2009).

2.3.3 Public Procurement instrument

Public procurement is an effective demand-side policy instrument that creates a demand for presently unattractive eco-innovations. Since EV deployment one of the cases in most countries, the procurement instrument aims to push the demand amount in order to enlarge the economic size for mass production (Leurent & Windisch, 2011). Considering the external factors for the environment performance, green procurement policy, which involves the concern of environmental performance (Mosgaard et al., 2013), for public or industrial vehicle fleets could also be adopted on a voluntary or mandatory basis (Leurent & Windisch, 2011).

2.4 Policy for innovation deployment

Policy is entitled to support the deployment and diffusion of innovations (Suwa & Jupesta, 2012). Government policy is subject to innovations; however, does not receive enough attention in terms of its innovation to support the diffusion rate. Several cases declaim the importance of policy for supporting the diffusion of the renewable energy technology. Dalton and Ó Gallachóir (2010) analysed the successful cases of policy stimulating innovation deployment and efficient policy for manufacturing for wave energy technology in Ireland. After 2002, science innovation for ICT and biotechnology has been viewed as a job creation strategy in Ireland; consequently, has drawn a lot of funding from the Irish government (Dalton & Ó Gallachóir, 2010). With a strong emphasis on fund development, the Irish policy for wind energy deployment has been regarded successful.

Some other market-based instruments are also deemed useful for promoting innovations. Taxes are another commonly adopted measure for innovation deployment. In Denmark, the energy taxes were imposed since 1974 and thus have driven the innovation for wind energy (Dalton & Ó Gallachóir, 2010). A renewable portfolio standards (RPS) and a feed-in tariff (FIT) policy are designed to promote the renewable sources adoption in Japan. With the goal to ensure the market efficiency, the RPS scheme requests the electricity retailer to supply a certain amount of renewable electricity to grid consumers. On the other hand, the FIT scheme allows electricity utilities to purchase electricity generated from renewable energy sources with regulated prices (Suwa & Jupesta, 2012).

Financial supports and economic incentives are the commonly used measures to motivate innovation diffusion. In most of the cases, market-based policies together with the support in RD&D play a crucial role for the successful innovation deployment. However, the effectiveness of different policies still largely depends on the local socio-political backgrounds and the government strategy. A combination of policy instruments could be useful in demolishing the barrier such as costs, regulatory, and market performance. Currently, not much literature is available when it comes to policies supporting the deployment of electromobility.

3 METHODOLOGY

This section describes the methodology applied in this research. The whole research process is based on reviewing various kinds of academic literature, initiatives, and assessment reports done by organisations, institutions, and governments.

This study comprises a qualitative method [document analysis] of a literature review of main concerns over using EV for daily mobility, and policy and user experience survey about electromobility from four different regions. The overall objective is to evaluate to what extent can policy support the deployment of EVs in the society with different political environment, legislation systems, and cultural backgrounds. Qualitative analysis offers the advantage of in-depth examination of the phenomenon with perspective of those involved; moreover, the possibility of managing the value-laden questions and investigating situations where little is known or hard to foresee the trajectory (Gillham, 2010, pp.11; Marvasti, 2004). Regarding to the nature of the research question, the qualitative analysis approach is preferred over the quantitative one. Among all the research methods, document analysis is particularly suitable for qualitative analysis for its capability of producing intensive studies producing rich description of single phenomenon (Bowen, 2009; Yin, 1994).

The research starts with studying the general needs and preferences expressed by the users according to documents and investigation reports in different regions, aiming to capture a comprehensive figure of how users feel about incorporating EVs in their life. The case study approach excels at simplifying the complex issues and delivering an informative outcome. Yin defines the case study as an empirical inquiry that investigates a contemporary phenomenon within its genuine context (Yin, 1994). Some argue that too small number of cases fails to offer the ground of reliability and generality of the findings; on the other hand, some claim that the intense exposure to cases would bias the outcomes (Easton, 2010; Einsenhardt, 1989; Gerring, 2004). Including a good number of cases in the study would influence its validity and reliability. Electromobility is a novel concept perceived as a strategy encompassing a great variety and possibility. The practice of electromobility differs under cultural backgrounds and the level of development in this area. Therefore, choosing cases with different contextual backgrounds is illustrative of regional characteristics (e.g. common problems with different responses) based on different socio-political climates, specifically the relationship between government and industry.

Exploratory case study approach based on literature is the methodology applied in this study. Exploratory case study is practiced on basis of the descriptive features and studying surround context (Ellet, 2007). The report is built upon an exhaustive literature review for user perspectives, data collection through different EV initiative reports and evaluation of the adoption and user acceptance, and a document analysis of how different national and municipal systems work for EV deployment. Within the goal to discover how assorted policy instruments could support the delivery of EVs, the research focus on working with the needs of end-users. By defining and categorising the user needs and expectations EVs, it is easier to identify the obstacles and potential of EVs on the market; furthermore, appraising the progress of EV adoption.

3.1 Case Selection

This study aims to figure out how policy should be designed and combined to introduce eco-innovations that fulfil the needs and preferences of the end-users in terms of electromobility. The scope of policy discussed in this project is addressed as the ones that are relevant to electromobility in general, especially the policies that address direct incentives for steering eco-innovation adoption. Since the focus is more on the user perspectives for individual daily mobility, it is appropriate to delimit the case study to road transportation. Only commercial cars for private or business use, including the relevant infrastructure and services, are considered in this study.

The cases selected here all have similar scale of implementation, geographical area and population, and at comparable authority level. For instance, cities with comparable political hierarchy, surface area, population density, role of regional development (i.e. leading the economic development, pilot of clean industry, etc.) are defined as the criteria for case selection. The widespread of EV is restrained and meanwhile, supported, by energy resources (electricity) allocation, infrastructure installation, and procurement incentives. Since the influential range for public policies, utilities and services is bounded within a nation or certain geographical or organisational boundaries (e.g. EU), it is appropriate to delimitate the case study on the national/municipal level. Four cities/countries were identified suitable as one of the cases: San Diego/(California) the US, London/the UK, Stockholm/Sweden, and Shanghai/China. The US is regarded as one of the leading actors in the automotive industry. San Diego is currently directing the policy to encourage residential charging infrastructure in California for its urban feature of separated residential and commercial areas. With the entirely different urban design, residential charging could be less important in Europe. UK aims to build a full-scale network for public charge points. Sweden is at the forefront of renewable energy production, and China is renowned for the ultimate growth in terms of population and pollution.

3.2 Data Collection and Sample

Electromobility is still on the developing stage that is dynamically implemented and interpreted in many ways in different parts of the world. To ensure the timeliness and validity of data, most of the information comes from credible sources online. For example, the government websites, the website of European union or other international organisation. The reports referenced in this study are all reviewed and approved by the sound institutions (e.g. EU, governments, municipalities, national institutes, associations). In order to warrant the robustness and reliability of data, the Internet sources are checked with the value of credibility, accuracy reasonableness and supports of the content (Harris, 2010). Most of the information and reports are available online and frequently updated and maintained by the responsible institutes; however, some data are not as favourable as expected. As the result, email and phone contact are also used to support data inquiry.

The information about San Diego was collected through the California Center of Sustainable Energy (CCSE). Through the CVRP, the California Plugged-In and Ready Plan was analysed with the San Diego Electric Vehicle Readiness Plan (2009). Together with the CVRP, the Plug-in Vehicle Owner Survey (2012) also provided valuable information about the early EV adopters and how they reacted with the support from subsidies and other incentives. Public policy and legislation were organised by the California Plug-in Electric Vehicle Collaborative and available in the market place evaluation report – *Taking Charge*.

Data for the case of London were mainly collected from the Greater London Authority Group (*Source London*) under the Plugged-in Places Programme (2013) administered by the Office of Low Emission Vehicles, and the integrated delivery plan and demonstrator programme for low-carbon cars under the Department for Transport, and the Technology Strategy Board. The Plugged-in Places Programme has been instrumentally supporting the uptake of the ultra-low emission vehicles in the UK by providing the possibility for work with the industry in order to provide greater interoperability by supporting eight EV deployment projects throughout the UK, including *Source London*. The national legislation and policy strategy for transportation are available on the official website of government of the UK. The Ultra Low Carbon Vehicle Demonstrator is launched with an objective to showcase new and emerging low-carbon technologies and to identify potential barriers to wider adoption.

For the case study of Stockholm, a large part of the information sources from the joint-procurement initiative – Elbilsupphandling. Based on the Swedish Mobilisation Initiative on Electric Vehicles and the Clean Vehicle in Stockholm Plan, a clear motivation and the overall action of clean car evolution in Stockholm could be illustrated. The policy instruments regarding to were collected through the Government Offices of Sweden. The evaluation result of user adoption was based on the test-drive report for a 12-month trial period executed under the procurement initiative. Only fleet drivers were able to participate in this test-drive scheme.

Shanghai has a history of being the base of automotive industry in China. Under the central authority political system, the availability and accessibility of credible data of EV deployment in China is relatively low comparing to that of other cases. Almost all the information sources to the People's Government of China. The policies were based on the national policy for the New Energy Vehicles (definition see 4.4.2) stated in the 12th Five-Year Plan and other local schemes set by the municipality or the key actors in industry. The concept of EV demonstration is distinctive in China. A fully equipped demonstration park was established for encouraging EV uptake among individuals and the *EVZONE* also provided limited data about the test-driving activities in Shanghai.

3.3 Data Analysis

The process of data extraction is based on the focus of the role of policy, the specific policy targeting on certain user needs, and the other factors influencing the EV deployment in a direct or indirect manner. A four-step procedure can roughly conclude the overall process in respect to data abstraction and compilation:

1. Filing out the information about the history and characteristics for EV adoption and its relevant activities.
2. Searching for the policy instruments regarding to EV technology development and uptake promotion utilised by the local authority.
3. Categorising the user expectations and needs for mobility in the demonstration reports.
4. Evaluating the design of policy instruments with the user appraisals in regard to the barriers for EV adoption under the current socio-technical and socio-political environment.

The choice of input for this research is the secondary data regarding to the deployment and adoption of alternative fuel vehicles. Initiatives and assessment reports already include a clear story about the EV deployment and a comprehensive investigation outcome for user adoption. However, this choice of data could risk to biasing the result through certain specific view angle addressed by the authors. Individual interview is usually seen as an authentic measure that offers more precise information regarding to individual opinion towards certain objects. Nevertheless, the surveys and reports done within the country or the city offer information that is more suitable considering the scope of this study – comparing the EV deployment strategy and user adaptation in different regions.

4 CASE STUDY

Several studies have already identified the importance of using policy instruments to boost the EV adoption. Within the European Union, most of successful innovation adoptions are policy driven. On the other hand, most of the successful innovations originate from the open market in the US. The difference in characteristics of the authority and the political systems brings the variety for promoting EVs in different regions. In order to see how policy could help integrating the user expectations into eco-innovations, four initiatives promoting EV adoption in different places were analysed. The selection of cases was based on the maturity level of EV technology and the scale of deployment. According to the political system, policy is usually set up and executed at the national or municipal level. As the result, the selected cases should also be narrowed down to the deployment in the city under the national criteria. San Diego, London, Stockholm, and Shanghai are the four examples for the case study (Fig. 5). The four countries involved are seen as the leading market for sustainable transportation solutions around the world, including the US, the UK, Sweden and China.

In this section, a brief description could be found in the beginning of each case, and then followed up by the policy instruments implemented for EV deployment. After learning the current progress for the electromobility, the evaluation of the current EV deployment and how users adapt to the EV lifestyle follow up. A short analysis for how different kinds of policy support EVs deployment considering user needs would be closing each case.

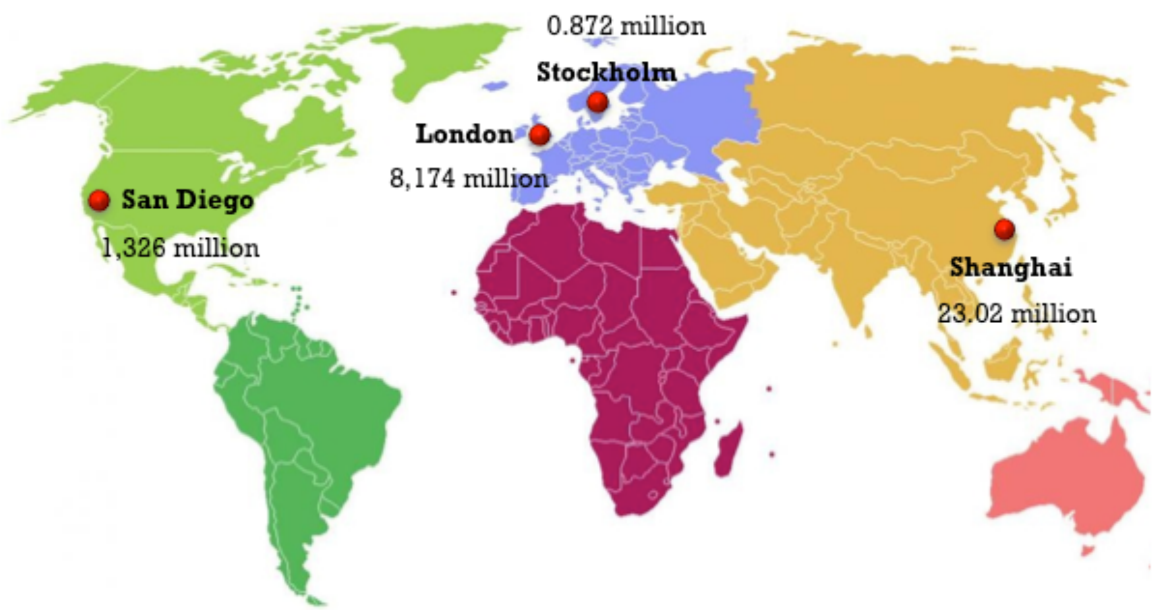


Figure 5 Profile of the cases chosen

4.1 San Diego/ California – Comprehensive policy for infrastructure and economic incentives

San Diego region is ranked as the eighth largest city in the US, and the second large city in the California (SANDAG, 2011). With 1.37 million inhabitants, San Diego region is purported to be forefront of the Plug-in Electric Vehicle (PEV)[1] deployment in the US. With the highest per capita amount of PEV purchase and infrastructure installation, San Diego region identified the barriers of widespread EV adoption and has set up some strategies as solutions (CCSE, 2012a). Together with the remarkable efforts in the largest national all-electric car-sharing programme, the San Diego PEV Readiness Assessment report shows that 20% of the California's PEV sales were contributed by San Diego region. Calling upon on million EVs on road, President Obama is dedicated in the development and the large-scale deployment of EVs in the US (CCSE, 2012; Dizikes & Banerjee, 2013).

As an organisation for sustainability, CCSE has been working on accelerating the distribution of zero emission cars throughout California, especially in the San Diego region and the San Joaquin Valley. The Plug-In & Ready programme administered by CCSE is determined to this mission by collaborating with business and regional stakeholders including house owners, businesses, installers, municipalities and the government. Based on the PEV leadership initiatives carried out by the government of California, the regional governments play a role to work on a smaller scale to establish PEV marketplace. The California Plug-In Electric Vehicle Collaborative has also devoted in replacing ICEVs with EVs at the state level with the help from California Energy Commission. With up to $2,500 (€1,925) of rebate for purchases and lessees of eligible vehicles (*see 4.1.2*), CVRP provides a decent economic incentive to boost the development of technology (CCSE, 2012).

4.1.1 Policy for Electromobility

The policy of San Diego is nested within the state and national legislation. The city of San Diego has also developed a technical policy in order to ensure the accessibility of EV charging infrastructure (Technical Policy 11B-1, 2012). Policies regarding to PEVs are mostly authorised at state level in accordance with federal policies. California government has launched a series of policies, including fuel and electricity policies and vehicle related policies, to support the PEV technological development and the market for PEVs (Plug-in Electric Vehicle Collaborative, 2012). These

[1] PEV includes the battery electric vehicles, the plug-in hybrid electric vehicles and electric vehicle conversions of hybrid electric vehicles and ICE vehicles.

policies aim to promote the use of alternative fuel, decrease harmful emissions, and reduce environmental impacts from transportation while increase mobility. In spite of the PEV market policy, the technical policy could support the development and accessibility of the charging infrastructure. With the goal to make PEVs as competitive as ICEVs, the supporting policies for private purchase and charging infrastructure are critical. Table 3 lists all the policy at the California state level aiming to make EVs more attractive to the general public.

Based on the wide range of policy set by the California government from 2006 to 2010, there are in total 17 items as policies for clean vehicle deployment: ten items related to fuels and energy, five to vehicles, and two items relevant to EV deployment. Most of the items related to fuels and energy are set as the senate bill representing the core value of the government (Table 3). From the energy perspective, the major interest for EV adoption is the benefit of zero-emission during operation. As the result, the instruments regulating the CO2 emission based on the federal laws may push the California State to increase the share of PEV. By setting up a performance standard based on certain emission limit, the R&D and manufacturing process will fall in the sustainable criteria (*Low Emission Vehicle Program*, 1990). With an attempt to build up joint forces among different sectors for sustainable energy, the collaborative instruments such as realisation of smart grid network, energy storage solutions for PEVs, and regulations are also found in the policy set. The policy set in 2009 requires California Public Utilities Commission to develop rules to overcome barriers of PEV adoption by shaping the marketplace in California (SB 626, 2009). Collaborating stakeholders in energy and environment institute, organisations has been preparing for the transition of EVs. Loan or rebate on purchase (AB 118, 2007), and tax exemptions (SB 71, 2009) are the policy as economic instruments in order to demolish the wall created by the price premium for owning an EV. To assure the technology diffusion and social acceptance, California Sate adopted the communication and diffusion policy instruments to strategically increase residential charging stations (SB1340, 2010) and to open more benefits for PEVs in terms of use, such as accessing in the carpool lanes (SB 545, 2010).

The CCSE manages the CVRP with the funds from the California Environment Protection Agency's Air Resource Board. A total of $45.2 million has been distributed for the period of 2009-2013 to promote the production and the use of zero-emission vehicles (ZEV) (CCSE, 2012). According to the San Diego Readiness Plan (2011), the core of the policy in this area is on the residential recharging infrastructure. With the inclination to adopt technology policy instruments, the strategy of San Diego is about increasing the availability for charging infrastructure and other benefits for using PEVs. Other incentives are also assigned to make the driving experience more favourable for EVs, including the zoning and parking policy, which guarantees parking space and the possibility of recharging.

In summary, the policy instruments adopted in California are quite comprehensive. Despite the physical charging station, the building codes for charging equipment installation are also included. The technical policy 11b-1 published in 2012 by the city of San Diego includes guidance for building codes for charging infrastructure to ensure accessibility. The communication and diffusion policy instruments in terms of educations and information dissemination of EVs to the local residential and business are also part of the core strategy for EV adoption in San Diego region.

Table 3 Current California PEV policy

Level	Policy	Objectives
		Fuels and Energy
Federal	SB 1368 (2006)	Limits long-term investments in base load generation by the state's publicly owned utilities to power plants that meet an emissions performance standard that is equivalent to the emissions rate from a natural gas-fired combined-cycle plant.
	SB 1078 (2006)	Known as the Renewables Portfolio Standard, requires 20% of electricity generation to come from renewable resources by 2010. The California Air Resources Board has adopted a standard to require 33% renewable electricity by 2020.
	Low Carbon Fuel Standard (2009)	Sets performance standards for reducing transportation fuel carbon intensity by 10% in 2020 and recognize electricity as a low-carbon fuel.
	SB 17 (2009)	Requires the California Public Utilities Commission, in consultation with other state agencies, to develop a smart grid deployment plan that integrates the storage technologies of PEVs.
	SB 626 (2009)	Requires the California Public Utilities Commission to develop rules to overcome barriers to widespread use of PEVs in California. The Commission is currently developing those rules under OIR 09-08-009. The Commissions' rulemaking will provide much of the regulatory framework that will shape the EV marketplace in California, including metering, rate structure, charging protocol, and other issues.
State	AB 2076 (2000)	Requires state agencies to set goals for reducing petroleum consumption in California.

	AB 1007 (2005)	Establishes a state wide alternative fuels plan and a goal to reduce petroleum consumption in California by 15% by 2020.
	Executive Order S-03-05 (2005)	Sets an economy-wide target to reduce greenhouse gas emissions 80% below 1990 levels by 2050.
	AB 32 (2006)	Sets an economy-wide limit on greenhouse gas emissions to 1990 levels by 2020 and directs the California Air Resources Board to adopt regulations and implement market mechanisms to achieve the target.
	Vehicle policies	
Federal	SB 71 (2009)	Authorizes the California Alternative Energy and Advanced Transportation Financing Authority to approve sales and use tax exemptions through 2020 on manufacturing equipment for PEVs and other advanced or alternative transportation or energy technologies.
	SB 375 (2008)	Requires the California Air Resources Board to adopt regional greenhouse gas emissions target that will influence urban growth and planning.
State	Low Emission Vehicle Program (1990)	Sets performance standards for emissions of criteria pollutants and greenhouse gases in new light-duty vehicles
	Zero Emission Vehicle Program (1990)	Requires a percentage of new vehicles sold in the sate to have zero tailpipe emissions.
	AB 118 (2007)	Provide $1.4 billion in incentives through 2015 for loan or rebates on purchase.
	Related Policies	
Federal	SB 545 (2010)	Allows certain PEVs access to carpool lanes regardless of the number of passengers, until 2015.
	SB 1455 (2010)	Requires the California public Utilities Commission and the California Energy Commission to maintain to a public website with links and information specific to PEVs.

Source: http://www.evcollaborative.org/current-california-pev-policy

4.1.2 Current situation and user appraisals

With 35% of nation's total and a constant increase of 1,000 more PEVs per month, California takes the lead of PEV deployment (CCSE, 2012a, 2012b). Two thousand PEVs are now driving in San Diego region, supported by approximately 300 public and 700 residential charging stations. According to the statistics of 2012, one-quarter of the PEVs sold in the US were purchased in California. The data of user adaptation were extracted from the CVRP (2012). Drivers participating in the CVRP were also investigated about their experience in using the PEV. The California Plug-in Electric Vehicle Owner Survey (2012) shows that more than 20% of the PEVs in California are driven in San Diego. This fact makes San Diego become one of the strongest markets for PEV at regional level in the US (96% of EV drivers own the Nissan Leaf).

The cost for vehicle purchase, the cost of fuel, and the installation and purchase cost of charging equipment are the three decisive factors for user adoption of EVs. Seventy per cent of respondents reported that they have access to free-of-charge charging infrastructure at workplace or in public. However, 83% of PEV users still express dissatisfaction over the charging infrastructure in public. This could be associated with the time required to recharge the vehicle. The public charging equipment available now is the Level 1 or Level 2 chargers (Table 4), which require a rather long charging time. Owing to the long charging time and inadequate public charge points, most of the charging events happen at residence. Till 2012, 91% of California PEV owners have already installed a residential charger and 56% of them reported receiving a subsidised Level 2 charger for their residence. The survey showed that around 70% of respondents appear to be influenced by the introduction of the subsidy in terms of the willingness to purchase a Level 2 charger. For instant, some federal subsidies are determined to support the need for charging infrastructure. The Federal Alternative Infrastructure Tax Credit is available for the projects associated with EVSE. Commercial applicants are eligible for tax credits of 50% of incurred installation costs and with the refund capped at $50,000 (€38,580). Residential applicants are eligible for tax credits of 50% of the installation costs with a cap at $2,000 (€1,540). Since the cost for installing a Level 2 charger ranges from $1,500 (€1,155) to $5,000 (€3,845) (Bostford, 2012), the subsidies could almost cover up the expense. More than 10,950 Level 2 and 260 Level 3 chargers will be installed in California, especially in San Diego (Brown et al., 2010). From the statistics of the willingness to pay for PEV charging, it shows that most of the PEV owners in California are wiling to pay a considerable price premium for rapid charging, especially for critical need of unexpected low-battery occasions. Drivers are willing to pay $0.8/hour for Level 2 charging for daily use. However, the average willingness-to-pay price rises to $1.85/hour for fast charging, and even to $4.64 per hour for critical need. This could be the call for the subsidy for DC fast charging infrastructure, which is able to provide 4 to 15 times more power than a Level 2 charger (Table 4).

Table 4 Types of electric vehicle charging infrastructure

PEV charging station	Power	Required hours to recharge	Price
Level 1, AC	1.4 kW (12 amps)	8 – 14 hours	$878 (€680)
Level 2, AC	6.6 kW (30 amps)	4 – 6 hours	$2,146 (€1,655)
Level 3, DC fast charging	25-50 kW (100 amps)	10 – 15 minutes for over 50% of battery capacity	$30,000 to $160,000 (€23,105 to €123,215)

Source: Brown et al., 2010; CCSE 2012

Aside from the subsidies for infrastructure, economic instruments are also expected to encourage EV ownership because of the high initial purchase price. In California, consumers with more than $100,000 (€77,155) household income have better opportunity to buy an EV over a conventional car. The CVRP received a $4.1 million fiscal support from 2009 to 2010 to make EVs more affordable to the general consumers. Light-duty zero-emission cars are eligible to request a rebate up to $5,000 (€3,845), whereas PHEVs are only eligible for $3,000 (€2,315). Public agencies or heavy-duty vehicles are eligible for a rebate up to $20,000 (€15,425) (Table 5). For year 2012-2013, CVRP has already issued $22.6 million (€17.5 million) for electric car rebate (CCSE, 2013). All in all, subsidy as policy instrument could be crucial in response to the user need of real-time recharge. Enhancement of charging infrastructure, both in quantity and quality, might effectively reduce the anxiety for charging and make EVs more attractive to the public.

Table 5 Subsidies for EV deployment in the US

Authority level	Programme	Sub-project	Amount of subsidy
Federal	American Recovery and Reinvestment Act		$2.4 billion

	Federal Taxes Credits		$2,500 – $7,500 per vehicle 50% up or to $2,000 for residential charger
State	Alternative Vehicle Fuel Act	Alternative fuel and Renewable Fuel and Vehicle Technology Programme	$10 billion
		Enhanced Fleet Modernization Programme	$30 billion
		Air Quality Improvement Programme*	$3,000 - $5,000 per vehicle

Source: Brown et al., 2010

There are two other factors that also are associated with the user adoption of EVs in California. One is the ownership of solar photovoltaic (PV), and the other is the Time-of-Use electricity supply mechanism offered by the utility. By dividing 24 hours in a day to the on-peak hours and the off-peak hours with different electricity rate, the TOU supply mechanism aims to distribute the peak electricity demand. The on-peak period is between 10:00 to 18:00 and the off-peak period includes the rest of the time during weekdays (Southern California Edison, 2010). The rate for EV charging offered by San Diego electricity supplier (SDG&E) offers an economic incentive with around 50% of discount for off-peak period recharge. The electric rate at on-peak hours is $0.27/kWh and that at the off-peak hours is $0.16/kWh.

A strong relationship between PEV and PV ownership could be seen in California PEV Owner Survey (2012). Among the total population of ownership of the PV system and PEV, about 20% of people own both items. The installation of solar PV system might be able to reduce the cost and demand of electricity from centralised generation. The California State announced the solar rebate to promote electricity generation through renewable sources. This policy indirectly creates the incentive for PV owners to purchase a PEV for the privilege of fuel cost. Sixty per cent of respondents have been considering expanding their PV system in order to meet the fuel demand of PEVs. The TOU electricity supply mechanism plays as a supportive incentive that benefits the consumers with low-cost fueling at off-peak hours. However, only about half of the PEV owners are on TOU rate, although most of them acknowledge this economic benefit. Two reasons could explain this phenomenon. Firstly, the ones who are more likely to purchase a PEV are with higher education degree (52% of the respondents have a post graduate degree) or with an annual income more than $100,000. Approximately 50% of PEV owners that are not on TOU rate own the PV system, which could exempt them from the high-tier electric pricing. The grant on relevant facilities could have an effect on the boosting user acceptance on electromobility.

In conclusion, the decisive factors to improve the user acceptance over EVs are the efficiency (charging time and fuel consumption), and accessibility of physical charging infrastructure (quantity and cost of using) in San Diego. Subsidies are adopted as economic instrument in reducing the purchase cost of both the physical vehicle and the charging station. In order to ease the anxiety towards range and possibility of charging, subsidy plays the role to establish the network for infrastructure, both at public places and private residence. The installation of the fast charger is also expected since the consumers expressed high willingness to pay a price premium for fast charging. Subsidies as policy instrument are suitable to make EVs become more competitive on the vehicle market and fit in the user expectations in California. Last but not least, education and knowledge dissemination are crucial to motivate the adaptation towards EVs and bring in new users to the EV system.

4.2 London, United Kingdom – The charge point network

London, a city with about 8.2 million constant residents (Office of National Statistics 2011), has the greatest potential market in the UK for EV adoption. According to the National Statistics of England (2011), London is the only region in England with less than one car use per household. The Electric Vehicle Delivery Plan of London published in 2009 aims to promote the use of EVs with a series of strategies on three different aspects: infrastructure installation, vehicle purchase, and marketing and communication. The EV Delivery Plan was introduced as one strand of the Mayor's strategy to decarbonize transportation sector and improve air quality in London (GLA, 2009a). Motivated by the ambition of being the head of EV deployment in Europe, the mayor of London – Boris Johnson has started establishing a network for charging infrastructure and increasing the uptake of EVs in London since 2011 (*Source London*, 2013) through the national Plug-in Places programme. This network aims to create a single visual identity for electric driving and offer the refuelling service at public charge points for a membership fee no more than £100 per year. A goal of 1,300 public charge points throughout London was to be achieved by 2013 (*Source London*, 2013).

Apart from the privately owned vehicles, the fleets belonging to organisations are also included in the overall EV adoption plan. The Plugged-in Fleet initiative (PiFi) in London 2012–2013, administered by Energy Saving Trust (EST) and funded by Transport for London (TfL) and Department of Transport (DfT), has discovered a great opportunity for organisations to shift from traditional ICEV fleet to EV fleet. This initiative presented the fact of choosing EVs as a possible cost-efficient option. Companies could save up to 75% of fuel cost with the EV fleet without compromising the traveling mileage (128 km per day). By providing the market with multiple EV modules, lowering running cost, and addressing economic incentives, many organisations start to consider EVs as a beneficial long-term investment. At the next stage of the PiFi, EST Foundation plans to help 100 organisations to assess the possibility to adapt their businesses with the EV fleet.

4.2.1 Policy for electromobility

At national level, the policy for EV deployment is built upon the public policy for greenhouse gases and pollutions from transport (2012, October 3). With the aim to reduce GHG from transport by at least 80% compared to the levels of 1990 by 2050 (Climate Change Act 2008), the government provides several supportive policies in order to reach the ambitious target of having only zero-emission vehicles in the UK. The government's action includes:

- Contributing to the funding of a range of innovative research and development activities through the Office for Low Emission Vehicles (OLEV);
- Setting up a framework for the development of a recharging network for EVs and PHEVs;
- Continuing to financially support the Plug-in Places programme;
- Continuing to set ambitious, but realistic performance standards to deliver emissions reductions from new vehicles – a new car sold today is on average 18% more fuel efficient than the car it replaces.

Grants for encouraging EV purchase also have been placed in the policy system to move UK towards the low carbon future in order to meet the Climate Change Act (2008) targets. Stated in The Carbon Plan (2011), the government provides over £400 million funds for the development, supply and use of ultra-low emission vehicles, support for charging infrastructure establishment and RD&D.

The Plug-in Car Grant has been designed as an economic instrument to help the qualifying ultra-low carbon vehicle become more comparable with petrol or diesel equivalents. The overall goal is to trigger the manufacturers to produce the EVs at a large scale and thus leading to lower prices. The grant would make an EV a more realistic option for new buyers. Twenty-five per cent towards the cost of the qualifying ultra-low emission vehicle (up to £5,000) would be covered up by the grant. A similar grant has been addressed to plug-in vans as well. Motorists received 20% cost reduction (up to £8,000) for qualifying vans. Till the 31th March 2013, there have been 3,633 claims made through the Plug-in Car Grant scheme (UK Government, 2010b), whilst 264 claims have been made through the Plug-in Van scheme (UK Government, 2012).

One of the key barriers to EVs uptake is the lack of well-planned charging infrastructure. The government grants for domestic charge stations, public charging infrastructure (at train station, on public sector estate), and residential on-street and rapid charge points have been placed to encourage the deployment of ultra-low carbon vehicles in the UK. These grants have been implemented to support the technology demonstration and realisation of EVs. Seventy-five per cent of the capital cost for procuring and installing the charging infrastructure are funded by the grant given through the local authorities.

Besides the common economic instruments as grants, the UK government has also worked on demonstrating eco-innovations to the public. The demonstration of ultra low-carbon vehicles (Ultra Low Carbon Vehicle demonstrator Programme, 2010) is one of the policies for promoting EV deployment. During the test-driving period, private and fleet drivers had the chance to learn about the EVs. Comparing the expectations expressed by the test-drivers before and after the trial, drivers expressed the needs more explicitly after the trial. This demonstration not only helps the general drivers to adapt to EVs, but also deliver the drivers' expectations to the automotive industry.

Table 6 Policies related to ultra-low carbon vehicles in UK and EU (2010)

Policy Level	Policy: Reducing greenhouse gases and other emissions from transport	Objectives
EU legislation	The Renewable Energy Directive	- Establishing a common framework for the production and promotion of energy from renewable sources.
	The Fuel Quality Directive	- Amending a number of elements of the petrol and diesel specifications and introducing a requirement on fuel suppliers to reduce the greenhouse gas intensity of energy supplied for road transport. - Establishing sustainability criteria that

		must be met by biofuels if they are to count towards the greenhouse gas intensity reduction obligation.
	Regulation 443/2009 of the European Parliament and the Council of the 23 April 2009	Setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles
	Regulation 510/2011 of the European Parliament and of the Council of 11 May 2011	Setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emission from light-duty vehicles
National Legislation	The Renewable Transport Fuel Obligation 2007 (RTFO)	A requirement on transport fuel suppliers to ensure that five per cent of all road vehicle fuel is supplied is from sustainable renewable sources by 2010.
	The Renewable Transport Fuel Obligation (Amendment) 2009, 2011	To ensure that the Fuel Quality Directive requirement for fuel suppliers to reduce the aggregate GHG intensity of the fuels/energy they supply is delivered through an expanded RTFO to supply renewable fuel that delivers certain minimum GHG savings.
	The Energy Act 2004 (Part 2. Chapter 5)	An Act to make provision - For the decommissioning and cleaning up of installations and sites used for, or contaminated by, nuclear activities; - Relating to the civil nuclear industry; - For the development, regulation and encouragement of the use of renewable energy sources; - In connection with the regulation of the gas and electricity industries; - For the imposition of charges in connection with the carrying out of the Secretary of State's functions relating to energy matters; - For giving effect to international agreements relating to pipelines and offshore installations
	The Climate Change Act 2008	An act to - set a target for the year 2050 for the reduction of targeted GHG emissions;

		- provide for a system of carbon budgeting; to establish a Committee on Climate Change; - confer powers to establish trading schemes for the purpose of limiting greenhouse gas emissions or encouraging activities that reduce such emissions or remove GHG from the atmosphere; - make provision about adaptation to climate change; - confer powers to make schemes for providing financial incentives to produce less domestic waste and to recycle more of what is produced; - make provision about the collection of household waste; to confer powers to make provision about charging for single use carrier bags; - amend the provisions of the Energy Act 2004 about renewable transport fuel obligations; - make provision about carbon emissions reduction targets; - make other provision about climate change
National Grants	Plug-in Car Grant 2010	A grant of 25% towards the cost of the vehicle, up to a maximum of £5,000 (€5,925) (starting from January 2011)
	Plug-in Van Grant 2012	A grant of 20% towards the cost of the vehicle, up to a maximum of £8,000 (€9,500) (starting from February 2012).
	Domestic charge points grant guidance	A grant up to 75% off the total capital costs of the charge point plus associated installation costs, capped at £1,000 (€1,185) (including VAT).
	Grants to provide residential on-street and rapid charge points 2013 February	The local authorities are able to sign up to grant schemes, administered by the Office for Low Emission Vehicles, aimed at increasing the availability of plug-in vehicle charging infrastructure.
	Grant fund for the installation of plug-in vehicle charging	A government fund of 75% of procuring and installing cost, capped with £7,500

	infrastructure at train station 2013	(€8,885) per installation. In total, £9 million is available to the train operating firms.
	Grant scheme for the installation of plug-in vehicle charge points on the UK Government and wider public sector estate 2013	A government fund of 75% of procuring and installing cost, capped with £7,500 per installation.
National Demonstration	Ultra Low Carbon Vehicle Demonstrator Programme 2011	Involving £25 million public sector funding, 8 consortia running projects, 19 vehicle manufacturers and 340 vehicles (electric, pure hybrid, and fuel cell).

Source: www.legislation.gov.uk

The policy for EV deployment in London can be roughly categorised according to two targets groups: the private user and the organisation. For private users, the Transport and Environment Committee of London Council has agreed upon a series of policy supporting the Electric Vehicle Delivery Plan published in 2009. The policy has inclusively considered the vehicle, the charging infrastructure and the market incentives for EV adoption. London Council is ready to support a Play Association Network (PAN) membership scheme for EV user adoption, which is based on voluntary efforts of a steering committee (London Council, 2009). The PAN is a network of associations and support agencies across London. The PAN-membership could bring the borough concerns and help the transmission period for EVs as smooth as possible. As for the financial support, London Council ensures the funding from the government for infrastructure development and installation. A comprehensive charge point network of 25,000 charging stations across London is expected by 2015. In addition to the promotion for using EVs for individual daily mobility, it is also important to avoid the conflict between EVs and the other sustainable modes of transport such as walking and biking (London Council, 2009).

A procurement plan is set up for EV fleet adoption for organisations in 2009. The goal is to have 1,000 EVs in the Great London Authority (GLA) fleet with 8,525 charge points in place by 2015. To be the leading role for EV deployment, the Mayoral team has been dedicated to making the entire fleet more sustainable by looking for chances to increase the share of EVs. Besides, some other public sectors also show the market potential with larger amount of EV fleet purchase. Aiming to a large-scale deployment, GLA also works with the boroughs and the other public to address needs and concerns from different perspectives. The supportive incentives such as free parking at public car parks in Westminster, free on-street parking permits, and off-street parking discount are also making EVs more favourable to the consumers. EV drivers in London now have the benefit of avoiding the congestion charge worth up to £1,700 per year (£8 per day) and also the privilege for parking (GLA, 2009a). To a greater extent, helping the organizations and fleet users to evaluate benefits and identify the opportunities and weakness for changing their fleet to EVs is another mission of the Mayoral team.

The strategies to boost EV deployment by London Council have been closely associated with economic incentives of owning an EV and the enhancement in charge point availability. The grant offered by the government plays as the main policy to lower the entrance barrier for EVs regarding the price on the vehicle market. Source London is now working on establishing a large-scale charge point network across London, and also expanding the charging infrastructure in the UK. DfT is working with the industry and all other cities in the UK to ensure the accessibility of charge points for members belonging to different local schemes (*Source London*, 2013).

4.2.2 Current situation and user appraisals

From January 1st 1994 to September 30th 2012, 3,624 BEVs and 120,378 PHEVs have been licensed in the UK with the largest EV fleet found in London (Fig. 5). According to the registration number of congestion charge discount, over 1,700 EVs are driven in London by 2009 (GLA, 2009b). In order to understand how users appraise EVs, several demonstrator programmes took place both at regional and at national level. The Low Carbon London trial for EVs supported by Transport of London (TfL) is focused on the need for charging. By monitoring the charging behaviour, the electricity network can be improved to support the increasing numbers of EVs on roads. Up to 50 new Nissan leaf are available for private users or companies to lease for at most two years until the end of the trial period, 2014. Participants of the Low Carbon London trial have a chance to have better understanding of the utilisation and receive a subsidised charge point at their place (*Low Carbon London*, 2011).

The Technology Strategy Board in the UK has evaluated how users adapt to EVs under the Ultra Low Carbon Car Demonstrator programme (Everett et al., 2011) through the experience of the test drivers. The Ultra Low Carbon Vehicle Demonstrator was initiated based on the recognition of the power of demonstration for new innovation. Initiated by the Integrated Delivery Programme, which aims to accelerate the introduction of new low carbon vehicles in the UK, the demonstrator programme's objective is to establish a positive image through the real experience with low-carbon vehicles. In order to promote the new technology of low-carbon vehicle in the reality, the programme made available of the funding around £25 million in order to support the demonstration projects for vehicles with less than 50g CO2 emission per kilometre. The major and also niche vehicle manufacturers, local authorities, power companies, research organisations and universities were involved in administering the projects. The demonstration trial involved 340 vehicles with private and fleet drivers (Table 7). The private users were typical early adopters who had chosen to pay for their participation by leasing the vehicles from different organisations, whilst the fleet drivers were a mix of early adopters and non-typical early adopters who did not pay for the participation. Through these demonstration projects and several public test-drive events, a large number of population and organisations had chance to experience EVs in practice. In order to provide credible insights for low carbon car deployment, the outcome of the EV user adaptation report was built upon 110,389 individual journeys with the total travel length of 1,089,862 km from December 2009 to June 2011. Some key findings regarding to user adoption were concluded as the following:

1. More than 95% of users found the EVs are compatible with their lifestyles and easy to drive in the technical aspect.
2. The fluctuation of daily mileage per vehicle over the three months was small. Users made only slight change or no change at all in their daily driving pattern after switching to EVs.
3. Private drivers and also fleet drivers became more positive and confident with the performance of the EVs after the trial.
4. The trial allows the drivers to learn about the vehicle capability and their driving pattern, which help to decrease the range anxiety by 35% among them. Journey planning and the spread of recharging points also reinforce the user's confidence for adopting EVs.
5. Despite the confidence in the capability of vehicles, longer range is still desired.

Table 7 Information of organisations and vehicles used for the demonstrator programme in the UK

Organisations	Area	Number and type of low-carbon vehicle
Toyota	London	20 plug-in hybrid (10 with the GLA, 10 for Government Car Dispatch and private businesses)
BMW	London, Oxford	40 MINI-E (20 for fleet users, 20 for private users)
smart	London and south east, West midland	60 smart ED in London and south east trial 40 smart ED in the West midland trial

		(with a variety of businesses and public bodies)
Allied ZEV	Glasgow	40 Peugeot eExperts and ePartner
Ford	London Borough of Hillingdon	Ford Focus passenger car
CABLED	West Midlands	25 Mitsubishi i-MiEVs, 25 Tata Indica Vista EVs, 40 smart fortwo electric drives, 5 Land Rover Range-e vehicle, and 5 LTI TX4 electric cabs
EEMS Accelerate	UK	16 high-performance sports electric cars from Delta Motorsport, Lightning, Electricity and Westfield
Switch EV	North East	35 electric vehicles (15 Nissan Leaf, and 20 others including the Avid CUE-V, Liberty Electric Range Rover, Smith electric LTI Taxis, and the Smith Edison Minibus)

Source: *Source London*, 2013

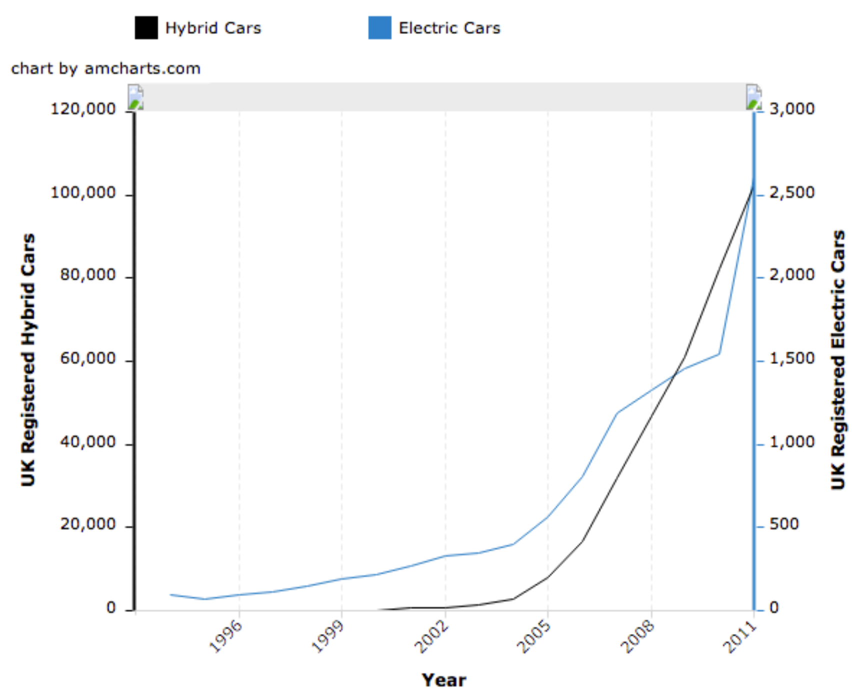


Figure 6 The growth of electric cars and hybrid cars in UK

Source: DfT vehicle licensing statistics

The information of user expectations is extracted from the preliminary usage and perception data from the first three-month trial. According to the data, the majority starts to charge their vehicles between 23:00 and 24:00 in a day. Most of the private drivers tend to start charging their EV between 21:00 and midnight, and from 6:00 to 9:00 in the morning. In contrary, the fleet drivers usually plug in their EVs during daytime, between 7:00 and 19:00 (Fig. 7). This shows the smart metering technology, which helps users to charge their car with the off-peak tariffs, can have a strong influence on the charge start time. Through the Source London network, the utility sector has also been involved in terms of the charge point and electricity tariffs. Drivers with off-street parking can demand dedicated charging packages from some energy suppliers (*Source London*, 2013a). A dedicate home charge point allows users to schedule the charge time to benefit from the off-peak tariffs, which could be less than one-third of the normal electricity tariffs (£5.61 versus £18.54 per kWh, including VAT)(EDF Energy, 2013). Coinciding with hours of the off-peak tariffs, around 35% of private drivers charge their EVs during this period. Over the three-month trial period, more and more drivers, both private and fleet drivers had reduced their daytime charging as they had become more familiar with the EVs and their driving patterns. This fact reflects the importance of trialability for users to learn and adjust their lifestyle for the new technology (Ehrler & Hebes, 2012).

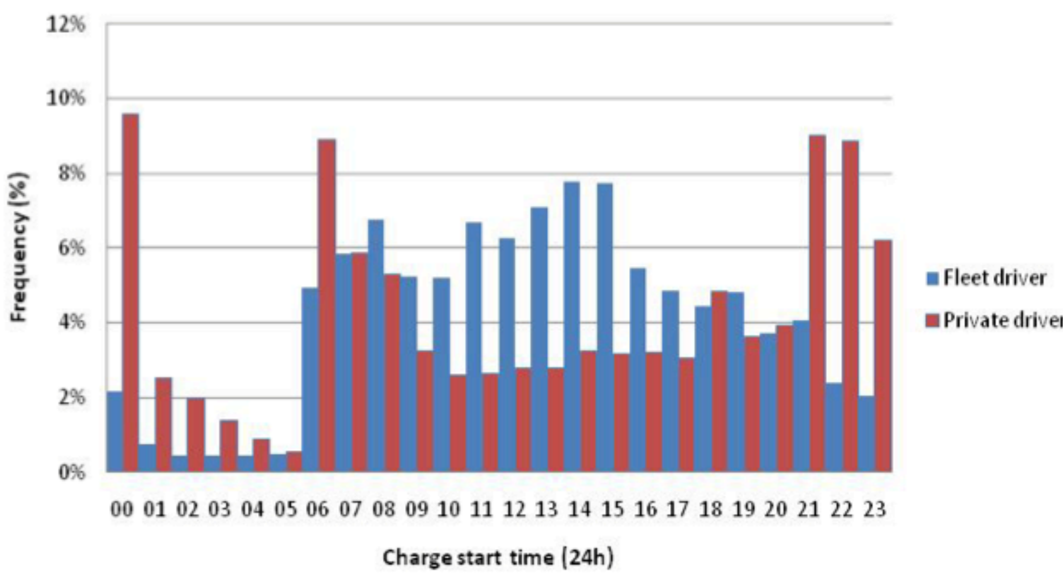


Figure 7 Frequency of commencement of charging event (Everett et al., 2011)

Through monitoring the driving mileage, the result shows that fleet drivers travel slightly more than the private drivers, with the daily average mileage 8.7 km (5.4

miles) to 10.1 km (6.3 miles). Fleet drivers dominate the low mileage journeys, whereas private drivers tend to have longer but less frequent journeys (Fig. 8). Regarding to the fact that the overall average of journey is 9.6 km (6 mile) and 63.2% of daily journeys go below 8.1 km (5 mile), an increase of 35% of users gain more confidence for the range after the trial period. However, the maximum journey length occurred is 161.1 km (100.1 mile). In general, longer range is still desirable for most of the users.

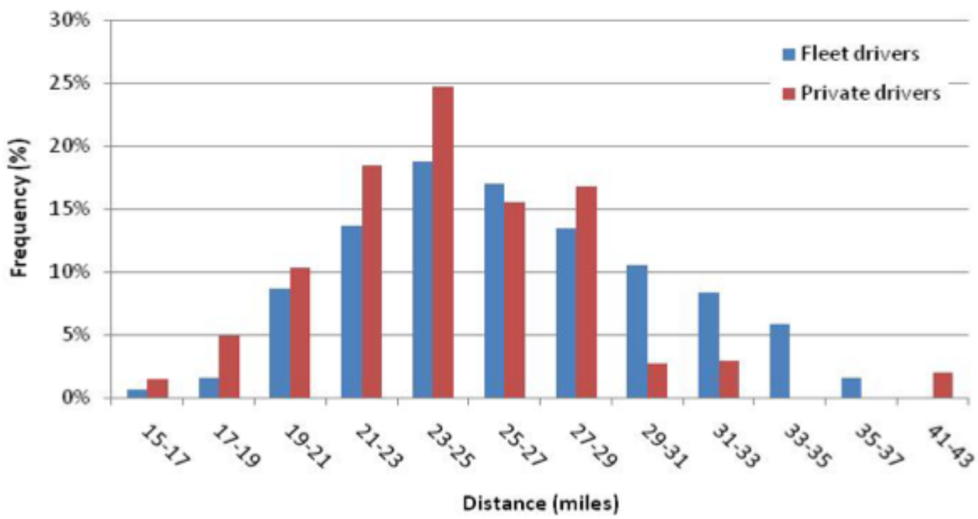


Figure 8 Frequency of daily travel mileage (Everett et al., 2011)

Grants are the major policy instrument applied to overcome the high up-front cost of EVs and allow more new comers to the market. Source London identified the economic benefits to users from shifting to the EVs. An annual saving over £3,500 could happen from this transfer with lower fuel cost and exemption from congestion fee and road tax. On basis of the 16,093 km (10,000 mile) annual mileage, the petrol/diesel vehicle requires £1,600 as fuel cost and the EV only requires £300 for this travel mileage. For the drivers joining the Source London network, the fuel cost is considerably low because members receive free electricity for recharging within their monthly payment (£10) (*Source London*, 2013b). The incentives regarding to fuel efficiency and purchase price could help open up the market after the large-scale testing and demonstration.

The user's perceptions towards EVs are one of the outcomes of the user adaptation preliminary survey. Some 95% of users denoted that there existed no difficulty to adapt EV in their daily mobility. Around 24% of users felt more confident for EVs in terms of vehicle performance. Although fewer fleet and private drivers think that

EVs are suitable as a viable option for daily mobility after the trial period, more than 60% of drivers in total still found EVs able to satisfy their daily mobility needs. As for range anxiety, although the data shows adequate range for daily mobility, private drivers require a longer range to cover all kinds of journey and fleet drivers feel they need longer range to cater the use as well. Some technical problems such as the fluctuated "remaining fuel" during a drive are also reported. No difficulty was shown in adapting to new driving style, charging behaviour, and low-noise operation for both groups of drivers. Drivers reported that they are more vigilant at low speed and more cautious with other road users.

Both private and fleet drivers have parallel perceptions towards the EVs. However, the vehicle usage behaviour in terms of charge time and frequent daily travel mileage was slightly different between them. Since the use of fleet EVs is mission-oriented based on different business utilities, it appears to be easier for private drivers to adapt EVs in their daily mobility than for fleet drivers (Everett et al., 2011). The demonstrator programme help users to gain more confidence in adopting EVs. On the other hand, the programme also benefits the automotive industry with the knowledge of the expectations and prerequisites of consumers for buying a new EV. The ideal range expressed by drivers after the trial could hint at the interval between charge points for network planning.

4.3 Stockholm, Sweden – The procurement strategy

As part of the International Energy Agency (IEA) network and a partner of Electric Vehicle in Urban Europe (EVUE), Sweden is one of the countries with high potential for non-fossil fuel vehicle deployment with high political commitment. As the capital of Sweden, the city of Stockholm has a population around 800,000. The national target of Sweden is to make the entire fleet fossil-fuel-free by 2050, and Stockholm is aimed to be an "EV city" by 2030. However, challenges like low availability of charging opportunity and high cost still obstruct the possibility of changing to EVs.

The action of 'cleaning up' the fleet in Sweden started around the 90s with the acknowledgement of climate change. Starting with the Clean Vehicle in Stockholm since 1994, the city of Stockholm has been working on removing obstacles and creating demands for clean vehicles[2] with less environmental impacts. Through the collaboration with Fortum (energy supplier and grid manager), Busslink (public transport sector), KTH (academia), etc., Stockholm started to participate in the

[2] General term for vehicles fuelling with renewable energy sources (e.g. biogas, ethanol, electricity)

projects promoting clean vehicles since 1996. Through the Zero and Low Emission in Urban Society (ZEUS) project, Stockholm had been working on the procurement framework for all the ZEUS cities to accelerate the market introduction of clean vehicles. Two main strategies were developed specifically for EVs in ZEUS: the development of fast charging stations and the introduction of economic incentives. The ZEUS created a positive profile for the city of Stockholm in EU and demonstrated EVs as a viable solution for clean transportation (Birath et al., 2010).

To speed up the market introduction for EVs, Sweden strategically applies the joint procurement decision, which makes it easier for companies or organisations to purchase EVs in Sweden at the best possible commercial terms. The national EV procurement initiative – the Swedish Mobilisation Initiative on Electric Vehicles (2010), is born under the collaboration between Vattenfall AB and city of Stockholm together with SKL Kommentus Inköpscental AB. The city of Stockholm functions as the coordinator to explore the interest of the municipalities, whilst Vattenfall has the overall responsibility to communicate with the other companies. This national joint-procurement initiative aims to gather and reduce the bureaucratic burdens for the companies, organisations, and whoever interested in procuring EVs to the existing fleet (Stockholms stad &Vattenfall AB, 2010). Many actors such as utilities, energy suppliers, car manufacturers, telecommunication companies, vehicle operators, and municipalities are all active in the joint-procurement initiative and the follow-up test drive scheme. The core strategy is to expand the niche market for EVs by increasing the volume of consumption through the joint forces. The report of Mobilisation Initiative on Electric Vehicles (2010) identified the threats and opportunities for EV deployment in Sweden. In summary, Sweden has great potential to be the forefront of EVs for its clean and low-cost electricity [45% of Sweden's energy supply comes from the renewable sources (Swedish Institute, 2011)]. Contributing by the high interests and demands from the municipalities and companies, suppliers have become more active in providing various modules of EVs for the market. To be at helm of the clean energy adoption in Europe, incentives are also decisive for the successful deployment of electromobility (Stockholms stad & Vattenfall AB, 2010).

4.3.1 Policy for electromobility

The principle policies applied for the EV deployment in Sweden are procurement policy and taxation. As mentioned in the previous section, a joint-procurement framework for EV has been formulated under the collaboration of Stockholm and a state-owned energy supplier – Vattenfall AB. Exemption of vehicle tax and some local economic incentives have been addressed by EV taxation policy. The Swedish vehicle industry has been working on the technology of fuel efficiency in order to oblige to the EU Directive Regulation CE/443 of 2009, which defines the emission standard for new passenger cars. For energy supply, Sweden has a national target for the share of 50% renewable energy in 2020. The same as all other member states in EU, Sweden also has the target for at least 10% of renewable energy share in transport (Government Offices of Sweden, 2012). With the well-established electricity supply system, approximately 65% of Swedish population has easy success to electrical outlets at home or at work for charging. The city of Stockholm has formulated a strategy and policy concerning charging opportunity, procurement, regulation and standards, and purchase incentives to boost the deployment of EVs.

The Green Car Rebate Programme for environment-friendly vehicles was first introduced to Sweden in 2007. The Swedish government distributed up to 10,000 SEK (€1,158) to subsidize individuals for private purchase of the green vehicles. The rebate scheme was in effect from April 2007 to December 2009. The Government allocated 50 million SEK in 2007, 100 million SEK (~€12 million) in both 2008 and 2009 for the rebate, presented in the Spring Fiscal Policy Bill. The "Green Car" is defined by the Swedish Road Administrative (Vägverket) as the following (Swedish Government – Ministry of Environment, 2007):

- Conventional cars: Petrol and diesel cars with carbon dioxide emissions that do not exceed 120 grams/km.
- Alternative fuel cars: Cars that can run on fuels other than petrol or diesel and with fuel consumption that does not exceed 0.92 litre petrol/10 km, 0.84 litre diesel/10 km or 0.97 m^3 compressed natural gas/10 km.
- Electric cars: A passenger car meeting environmental class Mk EL standards and with electric energy consumption that does not exceed 3.7 kWh/10 km.

Starting from 2011, at least 85% of the total number of cars purchased or leased by a public authority during the calendar year should be the eco-vehicle, defined as the alternative fuel vehicle (see definition of "Green Car") (IEA, *(*n.d.*)*). The main objective of the procurement initiative is to build a national procurement framework agreement for BEVs and PHEVs among different suppliers. At the pre-study stage for the mobilisation initiative, the capacity of demand for EVs for joint-procurement was evaluated in order to obtain a holistic view of the current EV industry and market. The purpose was to estimate if there would be enough EVs on the European market that could be attractive to the Swedish market in the early phase of development. Two major tasks were planned to be achieved in the pre-study report: the buyers dialogue, which narrows down the vehicles types and assures the acceptance of customised procurement process, and the joint-supply process (Stockholms stad & Vatenfall AB, 2010). The initiative has been officially put into action in October 2011 with a target of the contract of at least 5,000 EVs, with a commercially available test fleet and under the signatures of the six suppliers. Based on the report from public procurement sector in Sweden, 296 partners/buyers have already joined the EV procurement initiative which results in an estimated volume of 1,250 vehicles trade per year. This procurement framework supports the organisations to procure the vehicle but the charging infrastructure. Organisations are responsible for resolving the fuelling issue for the EV fleet.

EVs are exempt from the vehicle tax for the first five years of operation. The vehicle tax is the charged according to the CO2 emission of conventional car. In practice, this incentive is worth between 1,000 to 3,000 SEK per year, which sums up to a maximum of 15,000 SEK (€1,760) over the five-year period. Another incentive is for individual EV used for business purpose (owned by a commercial organisation): 40% 'fringe benefits' tax of the car compared to petrol equivalent. This incentive gives the car operator a reduction of 16,000 SEK (€1,875) of vehicle tax per year. The benefit goes up to 8,000 SEK (€ 940) per year with a 50% tax, a tax level which is most likely applicable to employees that drive a 'fringe benefits' car, addressed to individuals (Vattenfall AB & Stockholms stad, 2010) (Table 8).

For batch procurement, the Swedish Energy Agency (Energimyndigheten) offers financial support by compensating additional cost[3] of the first 500 vehicles bought through the procurement framework contracts. Up to 50% of funding for additional cost (max. 100,000 SEK or €12,000) will be allocated to the organisations. Currently, the available fleet for passenger car includes Chevrolet Volt (PHEV), Citroën C Zero, Mitsubish iMiEV, Renault Fluence; and two other types for transport vehicle (Stockholms stad & Vattenfall AB, 2013) (Table 8). With a large amount of economic incentives such as the rebate and free parking policy in almost half the amount of the cities in Sweden, EVs are more accepted by the consumers.

Table 8 Policy related to environment, energy and climate in EU and Sweden

Policy Level	Policy type	Policy Content
National	CAC	An emission-neutral country by 2050: • Reduce GHG by 40 per cent by 2020 • Fleet free of fossil fuel by 2030

[3] The cost difference between an EV and the closest counterpart among an ICEV

	Economic instrument	Energy taxes levied on their energy content.
		Special Carbon dioxide tax was introduced in the 1990s (Now, more than €100/tonne)
		Green electricity certification system for promoting electricity from renewable sources.
		Financial support for the physical planning of wind power wind power projects and PV installation.
		Taxation of car based on their CO2 emission instead of weight.
		Congestion tax was introduced in Stockholm in 2006
		Compensating additional cost for batch procurement up to 50% (max. 100,000 SEK or €11,713)
		Super Car Rebate (Supermiljöbilspremien) supports individuals with 40,000 SEK and 35% of the additional costs (Förordning (2011:1590) om supermiljöbilspremie, 2011).
	Procurement instrument	Joint-procurement framework for municipalities and organisations

Source: Government Offices of Sweden http://www.regeringen.se

4.3.2 Current situation and user appraisals

The early adopters for electromobility in Sweden, who aim to gather joint-forces for expanding the market for non-fossil fuel vehicles, are identified in the Swedish Mobilisation Initiative on Electric Vehicles (Stockholms stad & Vattenfall AB, 2010). In order to understand the interest and attitude of sustainable transport, a survey through online questionnaire was distributed to different actors. The questionnaire collected in 2010 showed that the municipalities and authorities were less interested in adopting EVs or PHEVs than the private companies in Sweden. Among all the organisations, only about one-third of the purchase interest came from the municipalities (27%). This could be interpreted by the influence of the social awareness for sustainability motivating the companies to reduce their CO2 emissions in order to maintain their reputation. The EV light van appears to be the most attractive choice to the buyers for its compatible capacity, and then the PHEV medium-size passenger car (Fig. 9). The Swedish society has a high interest and competency in incorporating EVs in the daily mobility. Sufficient economic incentives, lower electricity price and stable production and transmission system with high capacity upkeep possibility of the rapid EV introduction in Sweden. The operating cost for using EVs appears to be only one-third of the conventional petrol vehicles. Based on the result of the EV test by Vattenfall and Volvo, the fuel cost for EVs ranges from 1.5 to 2.0 SEK (€0.18-0.23) per 10 km. For PHEV, the fuel cost is around 3 SEK per 10 km, and 9.3 SEK (~€1) per 10 km for vehicle run on diesel (*Elbilsupphandling.se*, 2013a). Less change in behaviour is required from the Swedish drivers to shift from conventional ICE cars to EVs due to the existing plug-in engine heaters. Most of the Swedish drivers are used to plug in their vehicles to the main power supply for heating (Stockholms stad & Vattenfall AB, 2010, 2013).

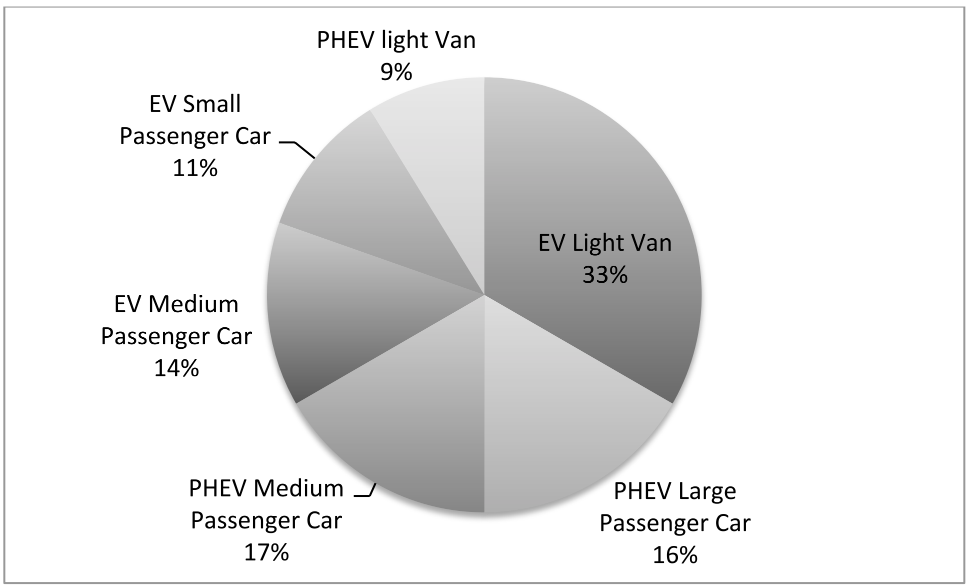


Figure 9 Vehicle volume requested in percentage (Stockholms stadts & Vattenfall AB, 2010)

From 2010 to 2011, a fleet of 50 new model vehicles, including pure EVs and PHEVs, were engaged in the test-drive scheme under the procurement initiative in order to understand the driving behaviour and user expectations. Financial support was attributed to the fleet managers to encourage the increase of EV in their existing fleet. A portion of 25% of the purchase cost with a cap of 100,000 SEK (€11,735) per vehicle was reimbursed to the fleet manager (*Elbilsupphandling.se*, 2013a). The test-drive survey from the procurement initiative involved the collaboration among 30 different organisations, including municipalities, energy suppliers, car manufacturers, and telecommunication companies (Appendix I). Since private organisations and the municipalities are the main participants in the procurement initiative, the driving patterns and the experiences of utilisation gathered from the trial were based on the fleet drivers. Private drivers are excluded from this test-drive scheme. Fleet drivers use electric cars for business utility, e.g., service vehicles, trucks, delivery vehicles, taxis, and pool cars. The preferable areas for this test drive scheme are Stockholm, Gothenburg, Malmö, and Uppsala. The fleet vehicles include passenger cars, vans and light trucks produced by different suppliers. From the trial period from 2011 to 2012, in total 174 EVs were involved in this test drive scheme with an accumulated mileage over 300,000 km which had already successfully avoiding 34 tonnes of CO2.

Based on the survey of the two six-month EV trial interim reports, two major obstacles were identified according to the driving behaviour and using pattern of the fleet drivers: the limited range and long charge time (Wikström, 2012, 2013). Although 88.2% of drivers were satisfied with the charging experience during the trial, drivers still reported that the EV required more than eight hour to be fully charged. However, according to the second report for the latter six-month trial, drivers appeared to become more confident with the range and eventually stopped charging their vehicles within a mileage of 40 km. An increase of about 15% of drivers obtained a more positive opinion towards EVs after the test-drive period. Overall, a portion of 63.5% test drivers thought that the EVs were equally competent as ICE vehicles. The test and demonstration scheme of electric vehicle effectively help this innovation to penetrate through the society.

The EV deployment strategy in Sweden depends primarily on the organisations. The national procurement framework helps the private organisations and municipalities to adopt EVs for business use. However, the private drivers are excluded from the EV initiative and also the test-drive scheme. Starting from May 2013, a bottom-up demonstration scheme has been promoted to motivate employees to propose the use of EV to the organisations (*Elbilsupphandling.se*, 2013b). Private users could participate in the local test-drive scheme operated by car manufactures or research institutes under different EV networks. For example, the ELVIRE project with Lindholmen Science Park, which aims to resolve the range anxiety problem of EVs. Instead of promoting EV for private mobility use, the procurement policy in Sweden has effectively stimulated the EV demonstration through the commercial organisations and municipality fleets. Supports from the electric grid system for charge stations are also found in the plan of urban smart grids of Stockholm Royal Seaport as a joint-initiative from Fortum, ABB, and KTH. Based on the functional requirements and specifications for charging infrastructure, the EV charging unit is designed to place with buildings instead of the private household (Swedish Energy Agency, 2013). This also implies that the target group for EV is the fleet driver inside the organisations. Since the procurement initiative does not provide support for the charging infrastructure, the organisations have to collaborate with the utility to resolve the fuelling problem.

There was also some policy suggestions delivered from the energy sector – Fortum. The incentives for purchasing EVs are to be reinforced at state level, and the development of charging infrastructure should be supported and widespread at the municipality level (Fortum, 2011). The test and demonstration scheme for the general public could be addressed as one of the policies to smoothen the transition process of EV deployment.

4.4 Shanghai, China – the full-scale EV deployment policy

Emerging with a profound concern of energy security and the environmental impacts source from the reckless growth, the Chinese government has been aware of the importance of clean energy development and energy technology (Fig. 10). In the 863 programme[4] – energy efficient and alternative fuel vehicles (under the 11th Five-year Plan), all cities were evaluated with their potential of implementing EVs according the activity level of the automotive industry. Starting from the official launch of "Ten Cities, Thousand Vehicles" programme in 2009 (Fig. 10), the Chinese government has oriented the policy on accelerating the development of electromobility. This programme aims to upraise the portion of EVs within the vehicle fleet in China by 50% before 2050 through technology research, development, and demonstration. In accordance with the title, thirteen cities have initiated to procure EVs and charging infrastructure. The engagement of public policy strongly influences the development of EVs in China (Cheng, 2013). China has a great potential in developing innovations based on its massive market and prodigious industry capacity. With the support of well-structured policy strategy and international technology exchange and communication, the EV adoption in China seems promising. However, further assessment of sustainable energy production and grid system improvement are still required.

[4] The 863 programme is the abbreviation of National High-Tech Development Program. This programme was launched in respond to the challenge of climate change in terms of technology revolution and competition.

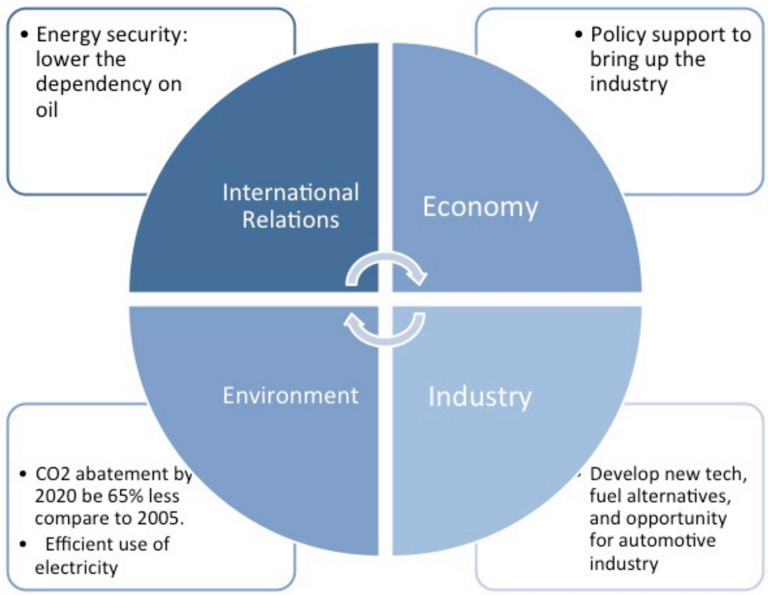


Figure 10 Driving force for EV development in China

Source: ARTC, 2011

With the supreme potential for EV adoption in terms of visibility and globalisation among all the cities, the city of Shanghai is assigned as the city of demonstration for EVs in China. The first charge point was officially put into use in 2009 within a plan to create a network with 13,000 charge stations (*EVZONE*, 2011). Around 1000 electric buses, EVs, and biofuel vehicles were at service for transportation during the 2010 Shanghai World Expo, including 120 battery-switchable electric busses developed by the Beijing Institute of Technical University (Duan, 2010, April 30) (Fig. 11). By setting up a demonstration in Jiading, it allows users to experience test-driving EVs and thus reduces the anxiety towards new technologies (*EVZONE*, 2011). Experts also identified that the success of EV promotion and adoption in China depends largely on the business model (Chen, 2011). New business models for the EVs have been introduced under the cooperation with other experienced international organisations. The municipality is now working on developing a flexible EV-sharing rental system that gives the general public a wider access to EVs at a reasonable price (less than €25 per day for renting) (Chang, 2013, March 07). This new EV-sharing system allows users to rent an EV at multiple sites in the city and return it at any one of them. This could successfully help avoiding the high capital fee of EV. Inspired by the current city bike rental system, users can spontaneously hop on the available pool EV and park it at the site close to the their destination. A comprehensive network of EV stops equipped with charging infrastructure would be required under this system. In summary, low fueling cost is a significant driving force for using EVs; however, lacking of charging infrastructure and service stations would be the biggest challenge.

Figure 11 Battery swapping stations for electric busses

Source: http://www.bit.edu.cn/xww/xwtt/54942.htm

4.4.1 Policy for electromobility

Five years after the first action of EV promotion in China – "Ten Cities, Thousand Vehicles" in 2009, the Chinese government has decided the commencement of EV adoption targeting to private users starting from 2013. According to the national target within the 12th Five-year Plan in 2013, the Chinese government has set up the guidance and national strategy to encourage the development of energy efficient innovations and environment-friendly firms, including automotive manufacturers. The objectives assigned a 15% of annual growth in output value for energy-efficient industrial sectors and defined a goal for the market share of high-performance products (Table 9). With the premier authority power, this policy orientated the technology development for electromobility and local execution of EV deployment. The Energy Efficient and New Energy Vehicle Industry Development Regulation authorised by the Central People's Government drew up the strategy and goals for the development of energy-efficient vehicles in period 2012-2020. An achievement of 500,000 New Energy Vehicles[5] was announced as a guideline with support of technology development and management scheme. In addition to the general principles for EV development, a significant amount of grant has also been assigned through the Automotive Industry Revitalisation Plan (2009). Fifty thousand million CNY (€6,220 million) had been invested to replace the polluting vehicles, and double the amount of the investment was put to the technology improving energy efficiency and EVs. The policy set shows the adoption of EVs has become a national guidance in China.

Most of the grants for boosting the EV deployment in China source from the Central People's Government in accordance with the implementation of policies. Several policy schemes were fostered with a focus on economic instruments under the "Ten Cities, Thousand Vehicles". Thirteen billion CNY was assigned as the budget for supporting technology development and networking within different actors for EVs by the State Council of People's Republic of China. Drawing incentives are the major measure employed by the government. In the "Ten Cities, Thousand Vehicles" plan, the government aims to financially support more than 60,000 vehicles using alternative fuels and launches the open market of private EVs in six cities by 2013. The rebate ranges up to 60,000 CNY for each EV purchase (Table 10). Nevertheless, the financial barrier for private users still exists as the subsidy only covers the public service. The ignorance of private users could impede EV deployment in the cities or leave the financial burden to the municipalities or individuals, which would lead to the failure of the national ambition of EV adoption (Zheng et al., 2012).

In the 10th Five-year Plan, the construction of Shanghai International Automobile City was planned with a purpose to motivate the automobile development in the east cost. With a history of automotive industry, Shanghai has been declared as the first EV International pilot city and Jiading district as the demonstration zone by the central government in 2011 (*EVZONE*, 2011). The municipality of Shanghai has formulated a measurement for encouraging the uptake of EV of the general public in accordance with the national policy (Table 9). The focus of this policy lies on the spread of solid infrastructure for charging. Incentives such as off-peak electricity rate for private household charge point and free access to charge points are designed to make EV a more viable option for people's daily mobility. The municipality has also approved extra subsidies for new energy vehicle purchase: a maximum of 20,000 CNY (€2,480) for a PHEV and 40,000 CNY (€4,960) for a pure EV (*EVZONE*, 2011). The municipality has been working on small-scale

[5]New energy vehicles refer to the vehicles using renewable energy with low carbon emission

demonstration programme in Jiading district in Shanghai. A target of 10,000 EVs and 13,000 charge points, 15 charging/battery-swapping stations, and more two hydrogen fuelling stations were set under the demonstration scheme. Three types of demonstration were provided in the EV test drive park in Jiading district, Shanghai: the professional driving experience, fixed-route operation, and test drive/ride experience.

The lack of competency in technology development, the inconsistency of product quality, and higher production cost due to smaller economic scale were identified as three major obstacles for full-scale EV deployment at current stage in China, by the association of automotive industry (Chen, 2009 Oct 14). With a vision to overcome these problems, the automotive industry has set up a common action to support the technology development of battery EV and PHEV, and the coalition for communication and technical exchanges among the cities.

Table 9 Policy instruments for EV deployment in China

Policy level	Year	Policy	Content/Objectives
National Policy	2013	The 12th Five-year Plan: energy efficient and environment-friendly industry development planning	• An average of 15% annual growth in output value for environment-friendly industry • Technology improvement in terms of energy efficiency and product quality • The market share of high-performance products should be raised from 10% to 30%; • Rapid development of service related to energy efficiency (e.g. waste management)
	2012	Energy Efficient and New Energy Vehicles Industry Development Regulation 2012 – 2020	• 500,000 new energy vehicle, including EVs and PHEVs; • Improving fuel efficiency by the average fuel efficiency of 5.0L petrol/100km for passenger vehicles; • Increasing competence in technology; • Increasing the overall planning and service around the development of EVs; • Establishing an effective

			management scheme for the new energy vehicles.
	2009	Automotive Industry Revitalisation Plan (Plan on Shaping and Revitalizing the Auto Industry[6])	• A grant of 50,000 million CNY for direct replace of old vehicles • A grant of 100,000 million CNY for technology development in the following three years
	2009	"Ten Cities, Thousand Vehicles" programme	• 13 cities joined this initiative for EV deployment • Grants for EVs, PHEVs, fuel cell vehicles and electric or hybrid buses (see Table 10).
Municipal Policy	2013	Measurement for promoting the development of charging infrastructure for EVs in Shanghai city	• Household charge point is eligible for off-peak electricity rate. • Private-owned charge point goes with the private residential electricity rate; the public and special one is charged with commercial unit electricity rate. • During the demonstration period (2012-2014), no fee required for charge point installation.
	2011	China (Shanghai) EV International Pilot City Partnership (demonstration)	• "Collaboration, application, sharing and exploration" as the core value; • Three modes of demonstration • A goal to deliver 10,000 EVs and 13,000 charge points, 15 battery-swapping stations, and 2 hydrogen fuelling stations.
Industrial Act	2009	Outline of Common Action for Electric Vehicle Development	More than ten actors have joined the coalition for EV deployment in terms of technical exchanges and business collaboration.

Source: The People's Government of the People's Republic of China www.gov.cn

[6] Translated by Zheng et al., 2012

Table 10 Financial Incentives for EV purchase in China

Vehicle type	Power type	Funding (CNY)	Funding (c.a. EUR)*
Passenger car	Hybrid vehicle	50,000	6,210
	Electric Vehicle	60,000	7,444
	Fuel cell vehicle	250,000	31,035
Bus	Hybrid vehicles	420,000	52,140
	Electric vehicle	500,000	62,110
	Fuel cell vehicle	600,000	74,440

* Rate on date May 7, 2013

Source: Ministry of Finance of the People's Republic of China (2009)

The policy strategy of China has largely dependent on national guidance for energy efficiency and renewable energy. Currently, electricity generation in China is still heavily dependent on coal (Fig. 12). Special strategies for emission control of coal-fire power plants and low-carbon electricity generation will be crucial as the development of EVs progresses (Huo et al., 2010). Increasing the technology competency of new energy vehicles and the refuelling system through collaboration would be mandatory for successful EV deployment in China. A vast amount of subsidy has been put into the R&D cluster for new energy vehicles, especially in the EV demonstration pilot city – Shanghai. However, the target for the development of fuelling infrastructure shows the uncertainty for future technology. Instead of being confident of the future of EVs, fuel cell vehicles and biodiesel vehicles are still considered as the viable options for mobility in China. This unveiled China's concern about the uncertainty of the mainstream technology for the future. Besides the subsidies provided by the government for new energy vehicles purchase, the city of Shanghai created a demonstration scheme in Jiading district under collaboration with various organisations. The demonstration scheme commenced with the goal to reach public opinions for EVs, including the fleet and private drivers.

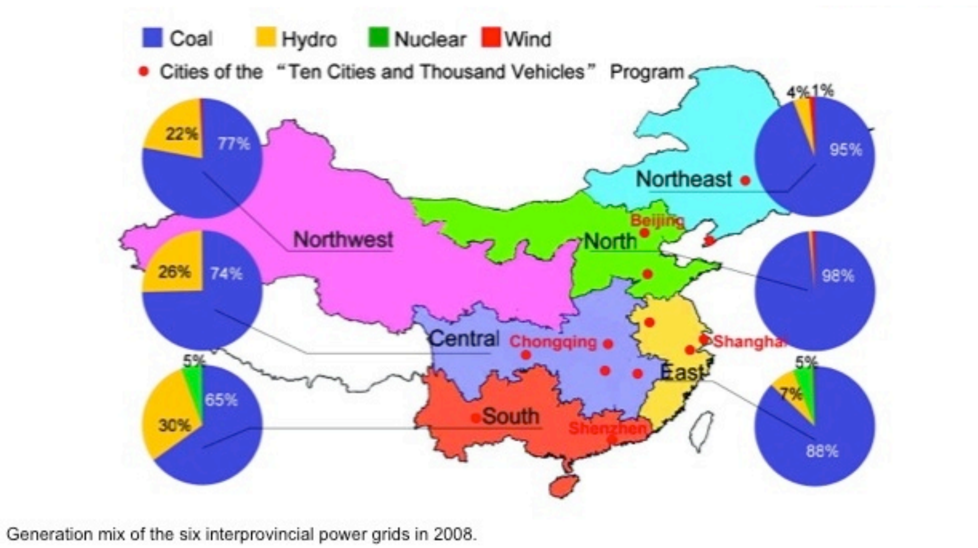


Figure 12 Electricity generation mix of the six interprovincial electric power grids (Huo et al., 2010)

4.4.2 Current situation and user appraisals

Confirmed by the CEO of the Shanghai international Vehicle City – Wen-Wei Rong, demonstration programme and new business model are the key elements for successful large-scale EV deployment (Wang, 2012). The Shanghai international EV demonstration zone was established in 2011 for technology demonstration and collaboration. The available vehicles for test drive are the Toyota Prius, Coda Sedan, Volvo C30, Chevrolet Volt, and other domestically produced EVs and PHEVs. Three types of demonstration are available at the EV drive scheme. The fixed route operation allows drivers to test the EV with certain routes. This type of test drive is targeted to public transport actors with electric buses or vans. The second test drive scheme is professional driving. The test drivers are allowed to drive in the demonstration park, which provides a comprehensive set of road conditions. The third test drive scheme focuses on the on-road experience. The test drivers can gain the on-road experience with EV on the prescribed routes. However, these test drive schemes can only offer the one-time on-site experience. No personal experience for daily mobility was available with this scheme. The statistics reported by the demonstration centre shows that 77.2% of test drivers think the overall experience offered by an EV is better than that by an ICEV. Without experiencing the driving range in reality, most of the test drivers expressed a range expectation about 161-200 km (Fig. 13). The survey shows that the availability of charging infrastructure at work place or public areas could significantly increase the interest of drivers towards EVs. A share of 72.06% of the test drivers are willing to purchase an EV if charging infrastructure is accessible in public areas. And almost 65% of test drivers think that EVs would be more applicable if they had sufficient charge points in the residential areas for overnight charging. This report identified two crucial problems for current EV deployment strategy: the lack of charging infrastructure and real-world test and demonstration.

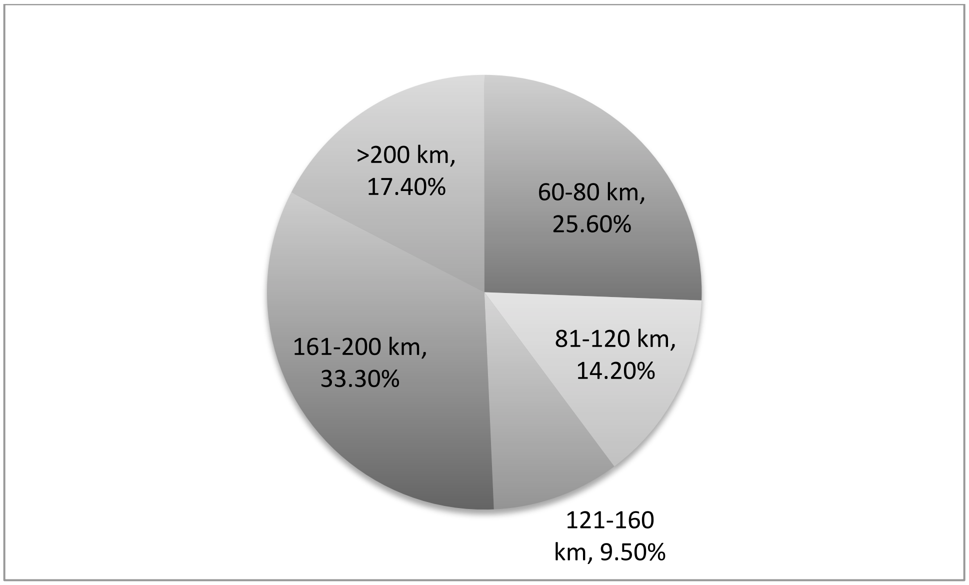


Figure 13 User expectation towards driving range

Source: *EVZONE*, 2012

By the end of 2012, Shanghai city has already installed 1,710 charging points (Shanghai Municipality Electricity Power Company, 2013). However, most of them are still idle since the slow charger takes more than 8 hours to recharge the vehicle and the EV test drivers consider the fast charger could be harmful to the battery (State Power Information Network, 2013). The test drive is currently limited in the experience in the demonstration park. The first long-term demonstration scheme – "Electric Vehicle 100" in Shanghai started in January 2013. Eight volunteers with different education backgrounds, occupations, and commuting distance were selected as test drivers with Volvo C30 for 100 days. The longest commuting distance for the test drivers appeared to be 30 km each way. Since no charging infrastructure was available at work place, the charging activity could only happen at home with normal plug. Test drivers expressed satisfaction with the driving range and the experience on road. Comparing to the expectation for driving range expressed before long-term test-drive, the driving range of 60-80 km become realistic to the users.

A competent EV system with sufficient charging infrastructure and service stations is expected after the demonstration programme in Jiading district. However, incentives for the adoption of EVs seem to be low profile and lack of attraction to the majority of drivers in Shanghai. High purchase cost, inadequate physical charging infrastructure, and deficient knowledge about EV among the population significantly deter the public acceptance of EV in China (Cheng, 2011). According to the 2011 statistics report of the "Ten Cities, Thousand Vehicles", most of the cities were still far from the target set in 2009 (Table 11). Policy supports as subsidies for private user purchase, grants for public charge point installation and long-term demonstration schemes are decisive for the future of electromobility in China.

Table 11 Progress of EV promotion of the "Ten Cities, Thousand Vehicles" project

City	Expected number of EVs	Real adoption (end of 2010)	City	Expected number of EVs	Real adoption (end of 2010)
Beijing	5000	2050	**Tianjin**	1500	160
Shenzhen	9000	1639	**Haikou**	1050	7
Shanghai	4157	1300	**Xiamen**	1010	4
Changsha-Zhuzhou-Xiangtan	4000	752	**Zhengzhou**	1500	346
Hanzhou	3000	800	**Tangshan**	1600	10
Wuhan	2500	500	**Guangzhou**	2600	200
Dalian	2400	300	**Suzhou**	1000	10
Jinan	1610	100	**Chengdu**	1900	6
Hefei	1400	700	**Shenyang**	1100	3
Kunming	1000	135	**Nantung**	1100	100
Nanchang	1000	300	**Xiangfan**	1070	12
Changchun	1000	220	**Hohhot**	1050	0
Chongqing	1150	152	**Summation**	**53697**	**9806**

Source: ARTC, 2011 http://www.artc.org.tw/

5 DISCUSSION

Policy plays an important role in supporting the deployment of electromobility in the society. The four cases show different strategies for increasing the adoption rate of EV. California has been leading the trend of integrating EVs in the cities for daily mobility. The case of California shows a solid policy emphasis on the installation of residential charging infrastructure. Subsidies are employed as the policy instrument to reduce the high capital cost for vehicle and charge point purchase. The development and financial support for fast charging equipment is also expected for the improvement of EV system in San Diego.

In London, the main strategy for fostering EV adoption is based on the implementation of charge point network. A full-scale charge point network is expected to increase the number of EV ownership. Several grants from the UK government have been allocated to support EV deployment. Test and demonstration has been regarded as an effective strategy for successful incorporation of EVs in the society. The Ultra Low Carbon Car Demonstrator was carried out with 340 EVs under collaboration within many organisations and administered by the Technology Strategy Board in UK. More than 60% of the test drivers expressed positive feedback of the experience with EV and regarded EV as a viable option for their mobility with sufficient range. This implies that the demonstration programme has helped the users to appreciate the EV and also learn about their own mobility patterns through personal experience.

Rather than motivating the EV adoption with private users, organisations and municipalities are the target group for promoting electric car use in Sweden. A Joint-procurement initiative has been generated and signed by 296 organisations for reducing the bureaucratic work for batch purchase. Since this procurement policy aims to create influence through the municipality or companies, it could be interpreted as a top-down strategy. Although no large-scale demonstration programme has happened in Sweden, regional test drive schemes have been operating within the organisation or municipality since 2010. This top-down EV deployment strategy has included the bottom-up impact from the fleet drivers in May 2013 by encouraging the employees to test-drive EVs.

China has been one of the most influential actors in global economy and the automotive industry (Forbes, 2013). With its development capacity in automotive industry, Shanghai has been selected as the major city for EV demonstration since 2011. Test and demonstration is considered as the main strategy for EV deployment in Shanghai. Besides, a new business model for car leasing and rental service is on the way to support the widespread of EVs inside the city. In summary, although the policies implemented are different among the countries, the goals and strategies are all identical: to make EVs more attractive and affordable via personal experience, reduction of purchase cost, and the possibility of refuelling.

As for the user expectations, test drivers are satisfied with the performance of EVs after the trial. Not much change is required in terms of driving technics and habits. However, range limit, high purchase cost and long charge time still remain the main concerns in all three test-drive schemes in the UK, Sweden, and Shanghai. Although most of the users find EVs compatible with their lifestyles, longer driving range is still expected. Concluding from the analysis result, this feature could be supported by the improvement of battery technology, possibility of faster charging, sufficient and easy-to-use charging infrastructure, and new business models. At current stage, the technology for battery regarding to capacity and life span is still in development. Drivers also feel more confortable to drive EVs when the charging infrastructure is anticipated. This implies the importance of establishing a comprehensive refuelling service network, which matches the major policy strategy employed in the UK. The Source London project now has already made 1,145 charge points[7] available and aimed to source more than 13,000 charge points throughout London before the end of 2013 (*Source London*, 2013). In order to make EV as easy to adapt as possible, the IT industry has also developed several mobile applications to help EV drivers plan the route and search for the closet charge points within the major networks (e.g. ChargePoint, CarStations, PlugShare).

Utility incentives could also have strong influence on convincing users to drive an EV. Low cost fuel in use phase is the major economic incentive (Daziano & Chiew, 2012; Deloitte, 2011). Comparing to conventional ICEVs, the EVs have lower operational cost even with regular electricity tariff (*Source London*, 2013). The off-peak electricity rates offered by the utility addressed extra economic incentive to EV users with almost half of the electricity rate for fuelling. Nevertheless, since the electricity price has already been cheap enough for most of the EV adopters comparing to the petrol price, TOU seems an added value but not a vital factor for the successful EV deployment in most of the cases. The residential solar panel system adoption in California State has been co-evolving with the promotion of EV adoption. With the advantage of fuelling cost, EV owners are inclined to install the household solar panel system, which is also subsidized by the government. There exists a possibility for co-developments in EVs and micro-scale electricity generation through renewable sources given user preference in residential solar panels. Even though the price for fuelling is competitive, the price premium for purchasing the vehicle is still a significant barrier for EV adoption. Subsidies or

[7] Data on May 27, 2013

vehicle rebate programme were found in four cases to make EV affordable to the general public. The authorities still try to increase the competitiveness of EVs on the vehicle market through the subsidies on vehicle itself and the charging infrastructure as public policy. For long-term development, an EV market stimulated by the demand is expected to expand the economies of scale.

Demonstration is an effective measure to promote eco-innovations by exhibiting the viability of new technology in real application through personal experience, especially for car consumers, the group which is considered as the slow adopter (Sprei & Wickelgren, 2011). Trialability is always crucial for making a innovation to win acceptance by the society (Rogers, 2003), especially for a change requiring a vast investment as EVs. The vice president of the China Association of Automotive Industry has also come to the same conclusion emphasising the importance of the possibility to test drive and the development of new business models (CAA, 2013). Among the four cases, the government of the UK and China have involved demonstration as one of their major policies for EV deployment. Multiple small-scale demonstration projects were found done by the car manufacturers or research institutes in the US. For instance, Deloitte group has studied the expectation and the adaptation ability of its customers. The Electric Power Research Institute also collaborated with the utility companies in California to characterise the consumer's interest in and infrastructure expectations for EVs (EPRI, 2010). Although subsidies are still the most realistic and effective policy instrument for EV deployment highlighted in all the cases, test and demonstration could help the users to learn and trigger the intuition of individuals to accept the new technology. The case for London shows an integration of both policies. The national institutes have been working on the demonstrator programme for low-carbon vehicles on a national scale, seeking for acknowledgement from users through the test-driving experience. The demonstrator programme in the UK could be seen as a way of communication between the consumers and the car manufacturers. After test-driving the vehicles, consumers can explicitly express their needs and expectations towards the EVs. The acknowledgement of user needs and expectations could also be seen as a hint for policy makers.

The test and demonstration scheme in Shanghai has been designed in a very different way. Instead of recruiting a limited number of volunteers to practice living with EV, the scheme tends to allow more people to have the one-time experience of driving or riding on an EV in the park. This could be due to the dense population in Shanghai and insufficient public charging infrastructure. However, the designed scenarios in the EV demonstration park could create biased outcomes of testing experience. The effect of range anxiety, which has been the major user concern expressed in several studies, would be neglected without test drive under real-world situation with long-enough mileage. The development of the new EV rental business model could overcome this deficiency of demonstration. To cope with the price issue, some car rental companies have already decided to initiate a new EV rental scheme that could help the users to avoid the high entrance cost but still are able to use the EV. In order to compete with the firm technology as ICEV with energy-dense fuel as oil, a change from the root should happen in order to create more opportunity for EVs. Policies may not be designed to match user expectations on basis of the history of ICEV ownership; vice versa, to change user acceptance, encouraging new driving patterns and modes via new business models, such as vehicle leasing or rental schemes.

In Sweden, EV demonstration is administered as part of the EV joint-procurement initiative, which assists the EV adoption of companies or municipalities. As the incentives and the chance for test drive exclude the individual buyers, this organisation-based EV initiative could be seen as an act of demonstration to show the applicability of EVs. Instead of having a strong focus on encouraging EV and supporting the development of charge point network as the UK, the municipalities in Sweden accentuate the suitable sustainable solution for the entire transport system. The County Council has stronger power and is able to decide the most appropriate local transport solution within this region depending on the industry, population, and the development. For instance, EV deployment appears to be less prioritised in Gothenburg since the municipality regards a comprehensive public transportation as the solution for sustainable transportation in the city. Reducing vehicles from the centre of the city, which is contradictory to encouraging EVs, and improving the public transport have been the main policy. Respecting the regional development, there exists no harmonised policy strategy for EV deployment in Sweden.

Considering the analysis of the four cases, policy does play a large part to increase the EV ownership by creating interests and acceptance in the society. Leaving alone the technical problem, demonstration and subsidies seem to be the most commonly applied policy in all the cases (Table 12). Trialability could successfully resolve the anxiety towards the adaptation and the sense of incapability of new technology. Demonstrations as policy for eco-innovation deployment could make drivers become more familiar and confident with EV. By wining the trust from the users, EVs could have better competitiveness on the market together with the aid from the government subsidy. Nevertheless, the choice of policy instruments also should be adjusted in accordance with the regional political, economic and cultural backgrounds. For example, Sweden has a different way of demonstration through procurement policy. This is also the reason why evaluation of the EV deployment measurement would be appropriate to be managed with qualitative analysis with descriptive interpretations.

Table 12 Policy comparison among the four cases

Case	Main focus	Common policy	Target group	Unique policy	Contextual factors
San Diego	Residential charging infrastructure	Subsidies for residential charge point and rebate programme for EV purchase	Private users	• Support from parallel policy encouraging renewable sources for energy production	• Off-peak electricity tariffs [TOU mechanism]
London	Charge point network	Grants for cars and charging infrastructure	Private users and organisations	• A special focus in CP network in London	• Off-peak electricity tariffs
Stockholm	Joint-procurement framework	Rebate programme for EV purchase	Organisations and municipalities	• No support in charging infrastructure • No large-scale demonstration • Region-specific strategy	• Low electricity tariffs • Clean electricity production
Shanghai	Demonstration and new business models	Subsidies for charging infrastructure and EV purchase	Private users and organisations	• Designed and controlled demonstration	• EV rental service and utility

6 CONCLUSION

Electromobility has been perceived as a promising path towards the decarbonised industrialized society. Several actions have been taken to resolve the strong dependency of fossil fuel in the transport sector. Although the overall goal for sustainability in transportation is identical, multiple means have been adopted according to the regional heterogeneity.

With the top-down influence, public policy is capable of motivating and supporting the development of EV in many ways. Policy for raising the penetration rate of EV in the society seems to be geographically limited. The effectiveness of policy instruments for electromobility could be largely associated with the local development of the society. For example, political circumstance, hierarchy of authority, legislation and policy systems, economic development status, cultural backgrounds, urban design and public transportation system. Among all the policies, subsidies and the demonstration scheme appear to be the most effective and genuine instruments with the greatest potential to strengthen the market competitiveness of EV. In almost all the cases, subsidies could help to lower the barriers of high entrance fee for the EV arena and make the transition to EV feasible to the general users. Higher adoption cost is generally the problem for eco-innovations. In order to reach for wider acceptance and recognition, test and demonstration is a commonly applied measurement for accelerating the adoption of them. In the case of EVs, demonstration as policy has some positive utility via personal experience and the appreciation of this technology. Through the demonstration programme, drivers have a chance to experience operating an EV for business or private use, including learning the driving technics and environment, fuelling routines, the travel mileage; moreover, his/her daily management habits with the vehicle. With the development of other supporting gadgets (e.g. smartphones), possibilities would be offered to the market to make EVs easier to operate. This implies the new eco-innovation could go inline with or being supported by the some parallel innovations. Beside the demand-side needs, policy supports are important to the research and design process in the technical development phase, especially for developing countries. At present, most of the sources are devoted to the perfection of battery technology and fuel efficiency in China.

The expectation for a new eco-innovation is usually derived based on the experience with existing identical product. The case of electromobility delivers a similar result. The new business model shifting the ownership of vehicles could make the transportation system more sustainable with larger-scale EV adoption compensating by the reduction of private passenger vehicles, which also relieves the congestion and air pollution. The EV rental business is designed to overcome high upfront cost and also to function as a demonstration tool for reaching more users. Through generating and enforcing new business models, policy could help users reforming another set of needs for EVs. Owing to the deficiency of technology and sources, developing countries are usually seen as the slow adaptor for new eco-innovations. However, since technological lock-in in the society typically hinders the introduction of eco-innovations, an opportunity could be created for the developing world, which is somehow detached with any lock-ins. Nevertheless, the supporting measures for the entire electromobility system (e.g. smart grid system, low-carbon electricity generation) are essential for the successful EV deployment.

In conclusion, policy plays an important role both in supporting the technology development, the adoption of new vehicles, the acceptance of users and the full-scale implementation of electromobility; moreover, triggering different perceptions and needs towards EVs. A dynamic and flexible policy strategy should be in place for different regions with a core of reassuring public acceptance and drawing interests from the users considering the social-economic development. Economic supports as subsidy, personal experience as demonstration, and new business models for a large-scale behaviour change could be the three crucial factors for realising electromobility in the near future.

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Appendix I – Organisations involved in the procurement initiative

Type	Organisation
Municipality	Karlstads kommun Gnosjö kommun Hammarö Kommun Lidingö stad Stockholm stad Värnamo Kommun Örebro kommun
Energy Supplier	Eskilstuna Energi & Miljö AB Falu Energi & Vatten AB H-O Enterprise AB (wind power) Jönköping Energi Nät AB Kalmar Energi Elnät AB Kalmar Energi Värme AB Mälarenergi AB Vattenfall AB Växjö Energi AB Öresundskraft AB Öresundskraft Kraft Värme
Grid Operator	Utsikt Nät AB
Bank and Insurance	Humlegården Fastigheter AB Länsförsäkringar Kronoberg
Investment	Linoinvest AB Walleniusrederierna AB
Vehicle Retailor	Bilhallen E14 AB Härene Bil AB Eije Petterssons Bil AB Företagsföreningen, Hälla Fackhandel Härene Bil AB MMC Malmö AB

Car Rental	Perpetum Biluthyrning AB
Telecommunication	Affinity Telecom AB/Club Telespararna

Source: *Elbilsupphandling.se*, 2013