CEGS

DISCUSSION　PAPER　SERIES

No.2018-CEGS-01

Barriers affecting the growth strategy for electric vehicles

ミハイル　マリノフ

横浜国立大学　成長戦略研究センター　リサーチャー

2019 年 3 月

横浜国立大学　成長戦略研究センター

Center for Economic Growth Strategy（ＣＥＧＳ）

Yokohama National University

79-4 Tokiwadai hodogaya-ku
Yokohama 240-8501 JAPAN

CEGS

Barriers affecting the growth strategy for electric vehicles

Discussion paper

Mihail Marinov

1. Overview of alternative fuel vehicles

Electric motors have been traditionally considered best fit for light duty vehicles (i.e. cars, vans, and possibly light trucks), because the electricity demand of heavy duty vehicles (HDVs) is generally thought to be too great to be met without a significant number of batteries which adds considerable weight to the vehicle. However, pure electric buses and diesel electric hybrid are beginning to operate in a number of cities, and with gradual improvement in battery performance, heavy duty battery electric vehicles (BEVs) may potentially be feasible within a decade (Boer et al., 2013).

Trials have been made with wireless recharging technology for buses in order to investigate whether battery electric buses can match the performance of diesel buses. For example, in 2014 electric buses already began to operate in Milton Keynes, England. The batteries of the buses are charged with the help of an induction coil that is buried in the road. There is also a second coil on the bus. Two thirds of the energy consumed by the electric bus can be replenished in approximately ten minutes when the bus is parked over a coil. The induction coils in the road are set up at three locations and the buses can also be charged during the layover time at the ends of the route. In addition, in the UK the feasibility of induction charging for EVs on the move is being investigated, and in Korea a similar project involving a 12km highway section has been demonstrated.

Regarding heavy duty vehicles (HDVs), it is considered that gas is the best alternative fuel, particularly for long-distance delivery vehicles in the short to medium term, but it is also used in light duty vehicles in a number of European countries, particularly in Italy.

Electric vehicles (EVs) have a surprisingly long history, beginning in the last years of the 19th century when the first EV appeared. However, by the 1930s the internal combustion engine (ICE) had replaced EVs, and BEVs reappeared on the market only in the 1990s. However, a renewed interest in the technology has emerged in the last decade, facilitated significantly by the need to reduce carbon dioxide (CO2) emissions. Vehicles with that technology have virtually zero exhaust emissions, however, their life-cycle emissions (i.e. CO2 released in various activities related to the generation of electric power) also depend on the fuel used at the power station, therefore, until power generation is totally CO2 free, there will not be a genuine zero emission vehicle. Moreover, there will also continue to be a certain amount of non-exhaust emissions such as particulate matter (PM) that will be emitted into the air due to tire and road surface wear.

Regarding the recharging of EV batteries, intelligent technology strategies are under development that will make it possible for EVs to be recharged in a way that will enable efficient and effective management of electricity demand and the fluctuations that are inherent in the generation of renewable electricity. The recharging of EVs in accordance with electricity production patterns will be enabled by the so-called “smart grids”, however, thee grids requires a completely new form of managing and organizing the interface between the energy sector and the transport sector.

The first limited production of HEVs began in Japan in 1997, followed by plug-in HEVs (PHEVS) in 2004. The general sale of BEVs by a volume car maker first started in Europe in 2011 (Al-Alawi and Bradley, 2013), although, it has to be mentioned that small manufacturers had already introduced a few niche models in certain European countries. Yet, it is clear from the sales data that the vast majority of new car sales, not only in Europe, will continue to be that of vehicles powered by ICE, and it is likely that this will continue to be so in the following decade and beyond. The sales data also show that all other alternative mobility technologies together accounted for less than 4% of new car sales in EU in 2014. Most of these alternative mobility technologies were gas (1.9%), HEVs (1.6%), with BEVs amounting to just 0.3% of new car registrations in the EU (International Council on Clean Transportation, 2015a).

Road vehicles using gas have a long history too, with the first models also being produced towards the end of the 19th century. In the first and second world wars vehicles burning gas were used as an alternative to gasoline, which was in short supply. Sizable gas containers were placed on the vehicle roofs, range was not particularly long because the gas in the containers was not compressed. Among the alternative fuels in Europe, liquid petroleum gas (LPG) is the most widely used. The market share of vehicles using LPG was 3% of motor fuels, and approximately 6 million cars in the EU were running on LPG in 2013 (European Commission, 2013). The refueling infrastructure LPG vehicles is well established, having approximately 28,000 refueling stations in the EU but these are not distributed evenly. Compressed natural gas (CNG) technology is also well-developed and more then 1 million vehicles on the road in Europe are running on it, with around 3,350 filling stations in the EU. However, the CNG infrastructure is also unevenly distributed because more than half of the refiling stations are located in Italy and Germany (European Commission, 2013).

The highest proportion of natural gas cars in the EU can be found in Poland and Italy where approximately 2.5 million and 1 million vehicles respectively are running on natural gas. It is interesting to note that in Poland a significant number of the cars are actually old gasoline cars that have been retrofitted to use LPG, although new LPG car models are available on the market.

Gas vehicles appear to be more popular in certain Asian and South American countries where there is an ample supply of natural gas. However, government policies in the majority of European countries promote the use of EVs (and HEVs) over gas vehicles (Engerer & Horn, 2010).

2. Barriers affecting EV market strategy

Regarding EV market strategy, it has to be emphasized that there are significant market barriers to the purchase and use of BEVs and PHEV (plug-in hybrid electric vehicles). These market barriers include:

Vehicle purchase price

Running costs i.e. the cost of replacement batteries

Fuel/charging infrastructure

Driving range

Charging time

Limited choice of models

Limited consumer acceptance

2.1. Consumer acceptance

Acceptance, which appears to be the main factor affecting sales of alternative fuel vehicles is generally not high in Europe, although there is a number of exceptions. These are the HEV market in the Netherlands, the BEV market in Norway, the natural gas fuel vehicle market in Italy, and the ethanol fueled car market in Sweden. Also, the sales of EVs in France are higher than Norway but their market share is significantly smaller. Government policies regarding the promotion of alternative fuel vehicles in these countries appear to have affected the choice of consumers (International Council on Clean Transportation, 2015b). However, compared to Japan for example, even in these EU markets alternative fuel vehicles are relatively rare. In Japan more than 20% of new car sales are HEVs. Moreover, if "kei" cars which are unique to Japan (light-weight cars with engine capacity less than 0.66 liters) are excluded, HEV will account for 30% of the new car market (International Council on Clean Transportation, 2015c). Similarly to the above-mentioned EU countries, this significant market share is due to government subsidies and other fiscal incentives (Alhulail and Takeuchi, 2014). The strong co-relation between government incentives and EV sales has been shown by a survey of consumer attitudes to BEVs and HEVs in six EU countries, conducted by the European Commission's Joint Research Centre, which revealed that car drivers considered that public incentives are needed in order to increase EV market share (Thiel et al., 2012).

In the USA, the experience of the state of California which mandated EVs (without significant subsidies) implies that the use of fiscal and other incentives is probably the best method of increasing the market share of low emission vehicles. California has a long history of making attempts to promote low emission vehicles, beginning in 1990 when the California Air Resources Board (CARB) decided that 2% of vehicles on sale in California in 1998 and 10% in 2003 must be zero emission vehicles. Seeing that the car market could not comply with that decision, in 1996 CARB withdrew the 1998 requirement and in 2001 reduced the 10% requirement to 2% electric or hydrogen fuel cell vehicles, 2% HEVs and 6% ultra-clean gasoline vehicles. These demands still could not be met, so in 2003 CARB changed its policy again to include a complex system of banking credits. The final change in 2008 focused on promoting the development of PHEVs (Union of Concerned Scientists, 2015).

The purchase of a new car is a major decision for the average consumer. Drivers are typically skeptical of new automotive technologies because of the high purchase costs and the relative shortage of information on these new technologies, and are generally cautious when choosing new vehicles. For example, resale value appears to be a major source of concern for potential users of EVs. Also, wide acceptance of new car technologies may take years to achieve, as demonstrated by the fact that it took six years for Toyota Prius HEV to begin to have a more global impact after its initial launch (Beltramello, 2012). Moreover, new automotive technologies are generally introduced at the luxury end of the car market before reaching down over time. The length of that time in the EV market appears to be long mainly because these vehicles are usually purchased as replacements for cheaper and smaller cars. Compared to the upper end market, buyers in the lower-end market are often unwilling to risk purchasing a technology they are not familiar with, and therefore it may take longer for these vehicles to gain a wider acceptance. This characteristic of the market may change, however, largely due to the launch of the first premium EVs targeted at the mass market in 2012 (Figenbaum & Kolbenstvedt, 2013). The Tesla Model S has a very rapid acceleration, being able to reach 60 mph in 4.2 seconds, and it became the top selling car in Norway towards the end of 2013.

In 2014 the best selling EVs were made by Renault-Nissan (26% of the world market), Mitsubishi (12%), and Tesla (10%). These car makers each sold more than 30,000 vehicles in many world regions. Next are General Motors, Ford, and Toyota, with 6%-8% each of global sales, which are mainly generated by customers purchasing PHEV in the US market (International Council on Clean Transportation, 2015a).

In the literature it has been suggested that one of the main reasons for the success of the Tesla may be dealer understanding of how to sell EVs. The purchase experience of consumers has been shown by a survey to be the best with Tesla, whereas evidence from California suggests that conventional car dealers do not excel at selling EVs and do not seem to provide enough information for potential buyers. The conclusion is that, compared to conventional car buyers, EV buyers appear to have greater demands that are difficult to meet for most car dealers. This difficulty may partially be explained by the inability of the profits generated by the sale of EVs to convince more car dealers to sell EVs (Cahill et al., 2014).

The existing literature also argues that demonstration projects may facilitate the increase of public awareness regarding BEVs since it appears that a large number of car drivers are not familiar with the characteristics of these cars and their differences from conventional cars (Thiel et al., 2012). A large scale BEV trial was conducted in the UK, involving more than 300 vehicles, which showed that drivers considered BEVs to be smooth and fun to drive, with their acceleration receiving universal acclaim. Moreover, over a third of the people who participated in the trial stated that their EV performed significantly better than their normal car, 80% were inclined to replace one of their vehicles with a BEV, and 50% wanted to purchase an BEV after the end of the trial. However, 60% also said that they would still need to own a conventional vehicle as a backup. Factors that affected the drivers intentions to buy a BEV included the price, which they anticipated to be the same as a conventional car, resale values in the second-hand market, battery life, maintenance costs, insurance, and how quickly the current technology would be further improved (Carroll et al., 2013).

A. Fiscal incentives

The majority of EU countries have introduced forms of fiscal incentives based on the CO2 emissions or the fuel consumption of vehicles and aiming to encourage the purchase and use of vehicles with lower emissions. These incentives are part of a general package of measures aimed at reducing CO2 emissions to meet European Union (EU) and other emission reduction targets. In addition, the widespread adoption of EVs and gas vehicles in urban areas is also expected to influence air quality positively. However, despite the extensive fiscal incentives and ambitious targets adopted by national governments, a broad consensus exists in academic and practitioner circles that EVs will continue to constitute a small proportion of the total vehicle sales for at least the next decade and that gasoline and diesel vehicles will continue to hold the dominant market share (Beltramello, 2012). To give just one example, in 2020 EV sales in Germany and the UK will have to be 1 million and 750,000 respectively to meet the targets of the German and the UK governments (Elkins and Potter, 2010). In comparison, in 2015 the annual new car sales were around 3 million in Germany and 2.5 million in the UK (International Council on Clean Transportation, 2015a).

As mentioned previously, fiscal incentives appear to be effective in increasing the market share of EVs, which is supported by evidence from Norway, Japan, and the US. For example, the relative efficacy of US income tax credits, sales tax waivers, and non-tax incentives aimed at increasing HEV sales was investigated by Gallagher & Muehlegger (2011) who found that the most effective fiscal incentive was state tax waivers even in situations where the income tax credits were more significant. According to an estimation in that study, sales tax waivers generated a more than ten-fold increase in HEV sales compared to income tax credits.

B. Non-fiscal incentives

In the literature there is also evidence that in certain cases the popularity of EVs can be increased with the help of non-fiscal benefits. Gallagher & Muehlegger (2011) found that permitting single occupancy HEVs to be driven in high occupancy vehicle (HOV) lanes in general did not increase HEV sales. There is one exception, however, in the state of Virginia, where access to HOV lanes generated a 92% increase in HEV sales, which also reflects the fact that a number of HEV owners in that state use these lanes to commute to and from Washington DC. Bus lane access increasing BEV sales around Oslo in Norway also provides similar evidence. It appears that access to bus lanes is a significant form of time-related incentive whose effectiveness is co-related to the degree of congestion in urban areas.

Apart from taxation policy which is usually decided nationally, other fiscal and non-fiscal incentives can be found at the regional or local level. These may include exemptions from toll and parking chargers, the above-mentioned access to bus lanes, and, last but not least, reduced restrictions on parking .

2.2. Fuel/charging infrastructure

Another existing barrier to BEVs and PHEVs is the still inadequate recharging network in many world regions (Thiel et al., 2012). Although a large part of the infrastructure is present because electricity grids are relatively well-developed, a satisfactory network of charging points remains to be developed. In the EU for example, the estimation is that at the end of 2012 there were more than 25,000 private and almost 30,000 public charging points dedicated for EVs. Most of these are found in France. According to government public announcements, the network of charging points is supposed to increase significantly in France, where in 2020 it is expected that there will be more than 4,000,000 charging points. In the rest of EU, however, only 600,000 points are expected to be ready by 2020 (European Commission, 2013). A new EU Directive on the deployment of infrastructure for alternative fuel vehicles was adopted in October 2014, aimed at encouraging the development of fueling and recharging networks.

However, evidence from Norway suggests that a relatively small number of BEV drivers actually use the public charging network, being more inclined to re-charge their vehicle batteries at work or home (Haugneland and Kvisle, 2013). In the above-mentioned UK trial, 75% of the BEV drivers stated that they prefer charging their vehicle at home to going to a petrol station, due to the associated freedom of doing the procedure at home. Before the trial, 87% of the non-corporate drivers (people who privately own EVs) said that public charging infrastructure is need, but this proportion decreased to 71% after three months, even though 79% of the drivers stated that they could finish their journeys without using a public charging infrastructure. It was also revealed that the distance covered between two charging stops increased over time as drivers became more reassured of the battery capacity (Carroll et al., 2013).

2.3. Limited choice of models

Another constraint to increasing the EV market share has been the relatively small number of EV models on the market. For example, in 2001 there were only two HEV models on the market in the EU (Toyota Prius and Honda Civic), and only 2,200 vehicles were sold. In more recent years 30 HEV and PHEV models are available and more than 200,000 are sold. However, these vehicles account for only 1.6% of new vehicle sales in the EU. Despite this, nearly 25% of all new Toyota cars sold in the EU were HEVs (International Council on Clean Transportation, 2015a).

One characteristic of the modern car market is that it is highly segmented, with buyers frequently deciding the category (which can be from compact to sports and luxury) before the model and the make. The current production of HEV, PHEVs, BEVs and gas vehicle models is still limited from the perspective of brands and vehicle segments. Consumer requirements for practicality, comfort and size to determine the choice of vehicle segment to a large degree on one side, and brand choice reflects more emotional factors such as vehicle image, perceived reliability and brand attachment on the other. It has to be pointed out, however, that the model diversity of alternative fuel vehicles displays considerable variety across alternative fuel types and vehicle segments.

Table 1: Fiscal incentives for electric vehicles in a number of EU countries (European Environment Agency, 2014)

Country	Annual/ monthly circulation vehicle tax	Purchase/ registration subsidy or tax	Fuel tax	Company car taxation	Business incentives	Other	EV + PHEV market share (%)[c]
Austria			Yes				0.6
Belgium	Yes	Yes		Yes			0.4
Czech Republic					Yes		N/a
Germany	Yes						0.4
Denmark		Yes					0.9
Finland		Yes					0.4
France		Yes		Yes			0.7
Greece	Yes	Yes				Yes	0.1
Hungary	Yes	Yes					N/a
Ireland		Yes					0.2
Italy	Yes						0.1
Latvia		Yes					N/a
Netherlands	Yes	Yes					6.8
Portugal	Yes	Yes					0.2
Romania		Yes					N/a
Sweden	Yes	Yes		Yes			1.6
UK	Yes	Yes		Yes	Yes		0.6

Table 2 Alternative Fuel Market Share (%) of New Passenger Cars in the Netherlands and the UK (International Council on Clean Transportation, 2015a)

Market share of new passenger cars (%)								
Netherlands					**UK**			
Year	**Hybrid**	**Natural Gas**	**Flexi Fuel**	**Electric** (including PHEVs)	**Hybrid**	**Natural Gas**	**Flexi Fuel**	**Electric** (including PHEVs)
2003	0	0	0	0	0	0.1	0	0
2004	0.2	0	0	0	0.1	0.1	0	0
2005	0.6	0	0	0	0.2	0	0	0
2006	0.7	0	0.1	0	0.4	0	0	0.0
2007	0.7	0	0.1	0	0.7	0	0	0.0
2008	2.4	0	0.1	0	0.7	0	0	0.0
2009	4.2	0	0	0	0.7	0	0	0
2010	3.3	0.4	0	0.	1.1	0	0	0.0
2011	2.7	1.1	0.1	0.2	1.2	0	0	0.1
2012	4.5	1.8	0.1	0.2	1.2	0	0	0.1
2013	5.7	0.6	0	5.4	1.3	0	0	0.2
2014	3.7	1.0	0	4.0	1.5	0	0	0.6

REFERENCES

Al-Alawi B., and Bradley T.H., 2013, Review of hybrid, plug-in hybrid, and electric vehicle market modelling studies, Renewable and Sustainable Energy Review, 21 190-203.

Alhulail I., and Takeuchi K., 2014, Effects of Tax Incentives on Sales of Eco-Friendly Vehicles: Evidence from Japan. Discussion paper no. 1412. Graduate School of Economics, Kobe University.

Beltramello, A., 2012, Market Development for Green Cars, OECD Green Growth Papers, No 2012-03, OECD Publishing, Paris doi:10.1787/5k95xtcmxltc-en

Boer den E., Aarnink S., Kleiner F., and Pagenkopf J., 2013, Zero emissions trucks: an overview of state-of-art technologies and their potential, CE, Delft.

Cahill E., Davies-Shawhyde J., and Turrentine T. S., 2014. New Car Dealers and Retail Innovation in California's Plug-In Electric Vehicle Market. Univeristy of California Davis, Institute of Transportation. Working Paper – UCD-ITS-WP-14-04.

Carroll, S., Walsh C., Burgess M., Harris M., Mansbridge S., King N., and Bunce L, 2013, Assessing the viability of EVs in daily life, ultra low emission demonstrator programme, Technology Strategy Board, Swindon.

Elkins P., and Potter S., 2010, Reducing carbon emissions through transport taxation, Green Fiscal Commission, London, UK.

Engerer H, and Horn M., 2010, Natural Gas Vehicles: An Option for Europe, Energy Policy, 38, 1017-1029.

European Commission, 2013, Commission staff working document, Impact assessment Accompanying the Proposal for a Directive on the deployment of alternative fuels infrastructure, SWD(2013) 5 /2, Brussels.

Figenbaum E., and Kolbenstvedt M., 2013, Electromobility in Norway – experiences and opportunities with electric vehicles, Summary, Report 1276/2013, Transportøkon0misk Institute, Oslo.

Gallagher K. S., and Muehleggger, E., 2011, Giving green to get green? Incentives and consumer adoption of hybrid vehicle technology, Journal of Environmental Economics and Management, 61, 1-15.

Haugneland P., and Kvisle H. H., 2013, Norwegian electric car user experience, EVS27, Barcelona, Spain, November 17-20m 2013.

International Council on Clean Transportation, 2015a, European Vehicle Market Statistics: Pocketbook 2015/16. Berlin.

International Council on Clean Transportation, 2015b. Transition to a global zero-emission vehicle fleet: a collaborative agenda for governments. Washington DC.

International Council on Clean Transportation, 2015c. Hybrid Vehicles: Technology development and cost reduction. Technical Brief no. 1. A series on Technology Trends in passenger vehicles in The United States. Washington.

Thiel C., Alemanno A., Scarcella G., Zubaryeva A., Pasaoglu G., 2012, Attitude of European car drivers towards electric vehicles : a survey, Joint Research Centre, European Commission, Luxembourg

Union of Concerned Scientists, 2015, https://www.ucsusa.org/clean-vehicles/california-and-western-states/what-is-zev. Accessed 1 March 2018.