THE EFFECTS OF PURCHASING INCENTIVES ON THE DEMAND FOR ELECTRIC VEHICLES

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ABSTRACT

Electric mobility has become of significant interest as it is a promising alternative to conventional fuels. Worldwide different methods are used to increase the demand for electric vehicles. At this point in time the sales figures of e-vehicles have been below the expectations. So far the highest number of sold e-vehicles per month has been, for example, 364 out of 259,529 total new car registrations in October 2012 in Germany. In the USA 2,040 have been sold in October 2012. As both countries implemented certain incentive measures to increase the (private purchase of e-cars) this shows that the use of subsidies and, thus, their effectiveness is debatable as their effects on the sales seem to be pretty low.

To identify impacts of subsidies onto the purchasing behavior of private households, statistical sales figures of automobiles and e-vehicles are analyzed. A comparative institutional analysis which is based on a case study (Germany) is utilized.

It is shown that although incentives seem to have a great impact on sales in reality it may be smaller than expected. Sales in Germany have been below expectations. For e-mobility many questions with respect to charging infrastructure are still unanswered and may block the market penetration of it.

The findings suggest the areas politicians should focus onto when trying to implement electric mobility. It is best to not spend money on the purchase of electric vehicles but to implement measures that lead customers to exert some pressure on car manufacturer to build vehicles with low or no emissions.

Keywords: electric mobility, subsidies, setbacks

INTRODUCTION

In times of growing environmental pollution and high oil prices car manufacturers try to develop technologies that reduce gasoline consumption and, thus, emissions. Against this backdrop electric vehicles (EVs) seem to be a promising alternative to conventional fuels for governments. Reasons for that are its missing local emissions, its high energy efficiency and the opportunity to use a broader energetic resource basis including renewable energies.[1] In order to promote this type of propulsion governments worldwide support the market penetration and the research and development (R&D) through different kinds of substitution.

The text at hand examines the impact of these substitutions; being either monetary or non-monetary purchasing incentives. In so doing, Germany serves as an example as it has a powerful car manufacturing industry. Thereby, the different substitutions are stated and their impact on the purchasing behavior of customers is analyzed whereby the influence of other variables is examined as well.

PURCHASE OF EVS IN GERMANY

When the history of the car began in 1890, so did the history of the EV. Despite its apparent technical advantage to its rivals – the steam and gasoline cars – it became uncompetitive compared to the gasoline driven car due to the combination of several technical and economic factors between 1900 and 1905. There has been renewed interest in e-cars between 1973 and the 1990s. Due to the low capacity of the batteries and the high costs EVs could not penetrate the market.[2] In the last few years new interest in e-cars – especially in hybrid electric vehicles (HEVs) – developed.[3]

According to the Kraftfahrtbundesamt (Federal Motor Transport Authority) in Germany, however, only 162 and 541 EVs have been sold in 2009 and 2010 respectively. The number of HEVs sold during the same period has been by far higher (2009: 8,374; 2010: 10,661). The following table shows the sales figures for both types of vehicles as well as the number of total new car registrations and the share of all alternative drives since 2011:

[1] See Schill, W.-P. (2010).
[2] See Cowan, E./Hultén, S. (1996).
[3] See Kraftfahrtbundesamt (2013).

Table I – Sales figures of EVs and HEVs in Germany

Year	Total new car registrations	EVs	HEVs	Share of all alter-native drives in percent
2011	3.174 mio	2,154	12,622	1
2012	3.08 mio.	2,956	21,438	1.3
2013[4]	192,090	362	1,768	1.6

The example shows that the number of (sold) EVs is increasing. The rate at which this is happening is, however, rather low and contrary to the expectations of – especially – governments (see figure 1). In Germany, one million EVs are supposed to be sold by 2020.[5]

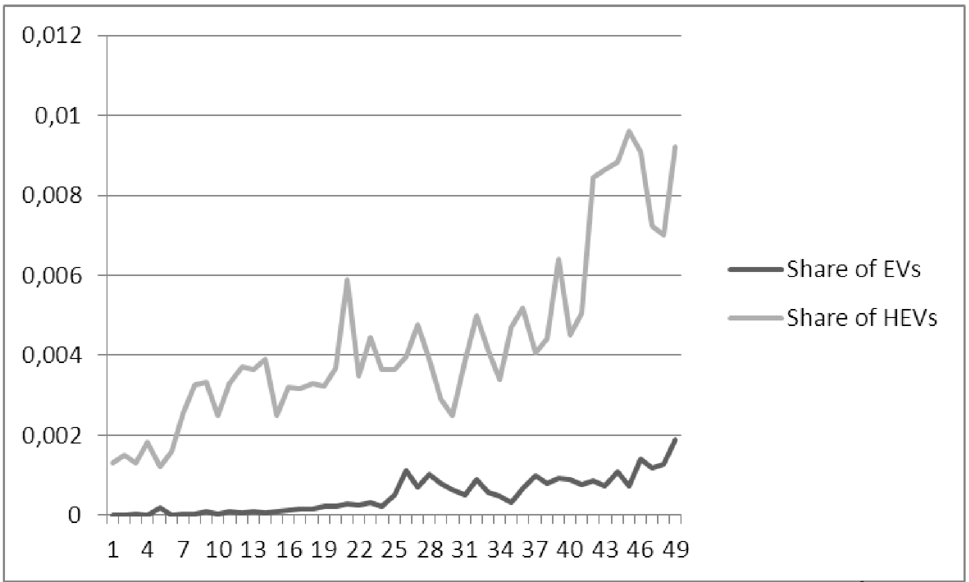

Figure 1 – Share of EVs and HEVs in new car registrations in Germany[6]

Both table I as well as figure 1 indicate that this goal will not be reached by the respective year. The low sales figures suggest various problems of EVs that hinder their market penetration. The following chapter summarizes the main obstacles discussed in the literature and in the media.

[4] The numbers refer to January 2013.
[5] See Schill, W.-P. (2010).
[6] The numbers on the abscissa refer to the months January 2009 until January 2013.

OBSTACLES

Range

Potential consumers want to have the same advantages of a conventional vehicle in the EVs, i.e. the same quality and quantity of the good “mobility” concerning range and time availability. The biggest obstacle for EVs is the range of one battery charge which was about 150-200 kilometers in 2012 – compared to 600-1000 kilometers of a conventional vehicle. This range is additionally depending on the topographic and climatic factors and the number of electric appliances used during trips (e.g. heating, air conditioning). Another concern is the flexibility of mobility needs that is not fully given for EVs as it is dependent on the battery’s condition.[7]

Nevertheless, when looking at the car user behavior in Germany (see figure 2), for example, it is obvious that the range of EVs, developed and sold so far, totally matches the current car user behavior.

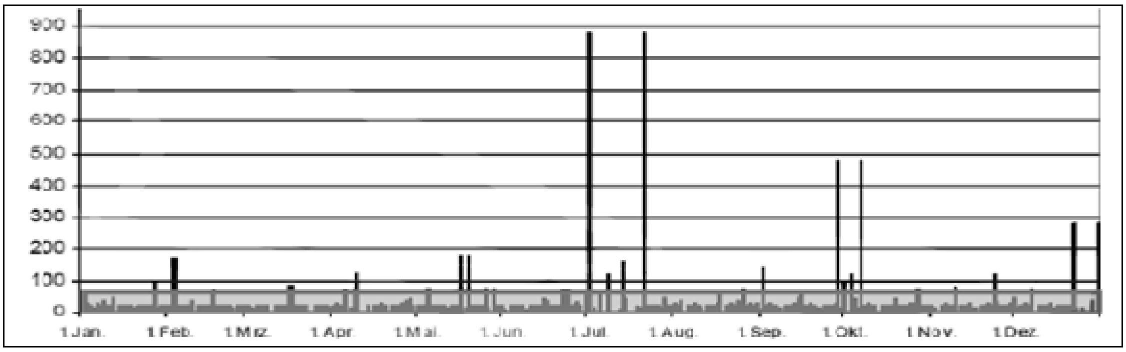

Figure 2 – Car user behavior in kilometer in Germany

At 80 per cent of the days per year cars are driven less than 40 kilometers in Germany. Thus, they do not have to be charged ever so often.[8]

Price

Another major obstacle is the high price of EVs which is caused by the expensive battery which costs between 15,000 and 20,000 Euro depending on the battery’s capacity. As these additional costs exceed the savings due to the elimination of conventional drive components EVs costs are about 50 percent higher than conventional fuels.[9]

The costs of owning a car, furthermore, include next to purchasing costs also operating costs (total cost of ownership, TCO). As EVs have a better fuel economy

[7] See Döring, T. (2012).
[8] See Bieberbach, F. (2010).
[9] See Focus (2012); VDA (2011).

than conventional gasoline powered vehicles they save on operating costs. According to Döring/Aigner (2011) the energy costs amount on average four Euro for 100 kilometers if an EV is used. A conventional car will amount to about twice as much. This is, however, counteracted by about 20 Euro per 100 kilometers due to the abrasion of the battery.[10] Additionally, it takes up quite some time until the costs owning an EV are amortized: It is only worthwhile to switch to an EV when the mileage of about 180,000 kilometers for a conventional gasoline car and about 270,000 for a diesel drive respectively is reached.[11]

In order to overcome this problem countries worldwide have implemented some measures like a buyer's premium or tax concessions and exemptions respectively. These incentives and substitutions will be discussed later on. Germany is used as an example as it has "among the highest motorization rates in the world, and almost all adults are licensed drivers".[12]

Infrastructure

Another drawback is the missing net of infrastructure which originates in a way in a problem that has not yet been solved: The missing standardization of type of charging station that will be used in the future. There are three possible charging techniques:[13]

- The conductive charging in which a cable connects the car with the electricity grid,
- The inductive charging in which an electromagnetic field is used to charge the battery and
- The exchange of the battery.

All of the above mentioned charging techniques have their pros and cons.[14] So far no decision has been made about what charging technique is to be used and where the stations should be placed. The conductive charging, however, seems to be the most favored charging technique up to now "mostly because it allows [the] connection of electric vehicles to existing electric power supplies [..] without the necessity for extra infrastructure".[15]

Other technological uncertainties equally important to an effective rollout with respect to infrastructure are:[16]

- Concept of payment: The fuelled energy can be paid directly or on account.

[10] See Döring, T./Aigner, B. (2011).
[11] See Handelsblatt (2011).
[12] Buehler, R./Nobis, C. (2010).
[13] See Report (2011).
[14] The discussion of these advantages (or otherwise) are not part of the paper at hand.
[15] Van den Bossche, I. P. (2000).
[16] See Bieberbach, F. (2010); Wagner, M. (2011).

- Authorization and authentication: The identification by means of card or plug are possible alternatives.

- All the same, there is no determination about what pricing scheme is to be used. Possibilities are payment per kilowatt hour (kWh) or per hour, charge by length of time, fixed rate per utilization and fixed rate per time period.

The at least Europe-wide (technical) standardization of charging infrastructure is necessary for a successful market launch of electric mobility.

Next to conditions like operator convenience, physical safety of vehicle users every time they charge their car and non-discriminatory use of especially the public infrastructure there is a further aspect that has been criticized widely with respect to the charging stations: Respective car service stations count among infrastructure and are currently likewise insufficient.[17]

The varying charging time represents another drawback that is connected to the charging infrastructure. To fully charge the battery the standard charging needs five to eight hours whereas quick charging can take up to 20 minutes. The exchange of the battery needs a few minutes as well as the inductive charging.[18] Quick charging, inductive charging and the exchange of the battery may help to alleviate the problem of long length of charging to some degree – especially when considering long distance travels. For day to day vehicle use the long charging time, however, does not represent a problem: The management consultancy Roland Berger found out that customers of EVs live in the city or in conurbations, they own two automobiles – at least one of which is a small car they often use for short routes (like trips to work and shopping respectively). If the typical car user behavior in Germany (see figure 1) is added it is evident that automobiles are not used 95 percent or 23 hours per day on average (the share of parked cars is always more than 88 percent). Moreover, the share of cars that are driven reaches its maximum at seven am and between four and six pm. Future EV drivers are, consequently, mainly commuters that use their car at predictable trips with periodically (scheduled) car down times. Charging will, thus, predominantly take place at home and at the workplace or on the way to work (i.e. Park & Ride).[19]

Against this background, public charging stations appear dispensable. They are nevertheless necessary in a sufficient number in order to spread e-mobility as car owners without a fixed vehicle parking space are dependent on this public infrastructure. Further, it is important due to public perception: with this type of infrastructure e-mobility takes place in public space and is perceived by a large population. In addition, the felt safety to reach every location and to be able to leave it as well as to be able to charge the car any time and, therefore, to use it freely is increased. A big challenge in this respect represents the sufficient number of available parking space for the loading vehicles.[20] The number of publicly accessible charging stations that allow for a preferable quick charging are also inadequately built out.

[17] See Döring, T. (2012).
[18] See Report (2011).
[19] See BMVIT (2010); Roland Berger (2009); Rehtanz, C. (2010).
[20] See Rehtanz, C. (2010).

Especially stations for quick charging are comparatively expensive and, therefrom, currently only financeable for companies and for research purposes.[21]

Others

A further problem with respect to the battery is concerned with safety reasons like explosions and fire prevention.[22] Further, there are no long-term experiences and tests with a mileage of EVs of over 100,000 kilometers. It is also not proven how long the battery holds and how much it will cost to remove it in – hypothetical – five years.[23]

In order to overcome all of these setbacks as well as uncertainties and to help establish e-mobility governments worldwide have implemented some measures like a buyer's premium or tax exemptions respectively and non-monetary incentives for consumers.

PROMOTION IN GERMANY

German politicians still oppose the idea of monetary incentives in terms of a buyer's premium. Nevertheless, Germany implemented some kind of monetary promotion: Since July 2009 cars with first-time registration between November 5th, 2008 and June 30th, 2009 were exempted from taxes for five years.[24] Since May 2012 the German government decided that EVs, commercial vehicles and microcars being registered for the first time between May 18th, 2011 until December 31st, 2015 shall be exempted from taxes for ten years. This is also valid for passenger cars and commercial vehicles having a carbon-dioxide type approval test of less than 50 gram per kilometer. Afterwards the tax exemption is again reduced to five years – for cars with first-time registration between January 1st, 2016 until December 31st, 2020. The federal government departments, furthermore, target an emission value of less than 50 gram CO_2 of ten percent of its newly purchased or rented vehicles. The government also decided that the company car taxation is reduced.[25]

Non-monetary incentives (like free parking or the usage of priority/bus lanes) do not yet exist but are tested in the so called Schaufenster (shopwindows).[26] These exist since autumn 2012 and are endowed with 180 mio Euro by the German government.[27] The predecessor of these "shopwindows" were eight model regions throughout Germany that have been financed by the government with 130 mio Euro

[21] See Döring, T. (2012).
[22] Lithium ion batteries used in EVs recently started to burn three weeks after a crash test. See Stern (2011).
[23] See Handelsblatt (2011).
[24] Elektroauto-fahren (2012).
[25] See BMBF (2011); Spiegel Online (2012).
[26] See Spiegel Online (2012).
[27] See BMVBS (2013a).

since 2009. The principle task of both is to test electric mobility with respect to the integration into day to day traffic and to establish it in public space.[28]

ANALYSIS

Data

In order to analyze whether incentives for demand have any effect on the purchase of EVs a multiple regression analysis is carried out. Variables that might also have an effect on the demand for EVs are next to purchase incentives the number of available EV models, environmental regulations as well as the price of gasoline.

Therefore, monthly sales figures since 2009 (49 months) have been utilized as the incentive program on behalf of the German government has been implemented in the middle of 2009. The available sales figures for EVs present total numbers; a differentiation between commercially, privately and publicly purchased EVs will be performed in the future. Especially in light of the “self-commitment” of the German government that ten percent of its newly purchased or rented vehicles have an emission value of less than 50 gram CO_2 a more detailed examination of the effects of a purchasing subsidy on private sales as well as commercial sales of EVs is necessary.

The number of available EV models has been approximated from data collected of the internet. The first EVs available in Germany were the Tesla and the Karabag in 2009. Both types – as well as the types of EVs that followed – are four-wheelded. Nowadays 18 EV models are supposed to be available in Germany.[29]

In Germany no non-monetary incentive that is implemented by the federal government exists throughout the whole country. Therefore, only monetary incentives could be analyzed: Purchase incentives in terms of tax exemptions have been calculated on the basis of a publication of the Verkehrsclub Deutschland (German Traffic Club) in October 2010: Usually battery-electric cars are taxed on the basis of their gross vehicle weight. For a light vehicle with a weight of 1,000 kilogram the tax rate amounts to 28.13 Euro per year (according to the currently prevailing five-year tax exemption), 33.75 Euro for a smart fortwo electric and about 50 Euro for a heavy sedan. Due to the extension of the tax exemption from five to ten years this leads to additional savings for owners of EVs of 140 to 250 Euro – for the additional five years.[30] In order to cover all these possible outcomes and the increase in the incentive measure the average of these savings was taken leading to 37.29 Euro per year and, thus, to 186.47 Euro for five years and 372.93 Euro for ten years.

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[28] See BMVBS (2013b).
[29] See ADAC (2013).
[30] See VCD (2012a).

Environmental regulations for Germany refer to CO_2 emission standards of 130 gram per kilometer that have to be met by new passenger cars until 2015 and have been formally adopted by the European Union in April 2009 in order to reduce CO_2 emissions in passenger vehicles. The implementation is staggered since 2012 where certain shares of the new car fleet of each producer have to meet the average limit of 130 gram per kilometer.[31] EVs can also be included into the calculation and count threefold. If these shares are not met certain penalty payments have to be paid by the car producers (between 2012 and 2018 these account for five Euro for one gram, 15 Euros for the second gram, 25 Euro for the third gram and 95 Euro from the fourth gram).[32]

Another environmental regulation in Germany is the motor vehicle tax which has been realigned at the beginning of 2009 (for all passenger cars newly registered since July 1st, 2009). Next to the cylinder capacity also the CO_2 emissions serve as assessment basis. For every gram CO_2 per kilometer that exceeds the exemption limit of 120 gram two Euro must be paid. In 2012 the exemption limit was decreased to 110 gram per kilometer. In 2014, another decrease to 95 gram per kilometer will be the limit for no taxation.[33]

Additionally to the motor vehicle tax, there is the so called eco-tax/green tax.[34] As its last raise took place in 2003 its effects onto the sales of EVs can be neglected in the analysis at hand.[35]

On the same subject the price of gasoline can be named: As a consequence of the global economic crisis the price of diesel fuel/gasoline has been decreased in 2009. Since then the prices have risen strongly due to the increased demand on the international market (one liter gasoline cost on average 1.4 Euro in 2008, 1.28 Euro in 2009 and 1.65 Euro in 2012; diesel fuel was about 1.33 Euro per liter in 2008 and 1.49 Euro in 2012). This additionally shows that favorable gasoline prices are gone by. Price jumps are to be expected if measures for a sustainable policy are not adopted.[36] Data used are the gasoline and diesel fuel prices as well as the price of premium gas which has a higher octane number. Data for gasoline exists until the end of 2011. From this point in time, gas stations were equipped with only premium gas as the prices of both premium gas and gasoline have been almost identical the months before.

Moreover, the question whether Germany participates in international environmental agreements, like the Kyoto Protocol, was considered. As the Protocol is in force since 1997 this variable has no obvious effect on the sales figures of EVs and

[31] A 65 percent share has to be met from 2012 on; 75 percent from 2013; 80 percent from 2014 and 100 percent from 2015 on.
[32] See EU (2011).
[33] See VCD (2012b).
[34] This tax is a fixed amount per liter that are independent from the product's price.
[35] See VCD (2012c).
[36] See VCD (2012c).

alternative drives respectively. Another variable "the existence (and time of introduction) of model regions" has been considered as dummy variable.

Results and discussion

For the German data a strong correlation exists between the number of EV models that are available (0.852, very significant), the price of diesel fuel (0.873, very significant) as well as the price of premium fuel (0.841, very significant) and the demand for EVs. An average correlation to the demand for EVs could be found for the monetary purchase incentives (0.653, very significant). Also the logarithm-based relationship of the demand for EVs and the gasoline price are strongly correlated (0.835, very significant). A weak correlation, however, exists when the existence of environmental regulation and car taxes are considered (0.291 and 0.388 respectively); former being significant and latter very significant. The variable "existence of model regions" did not provide any results.

It is not surprising that the demand for EVs is correlated to the number of EV models that are available. The first EVs in Germany have been the Tesla and the Karabag which are – even compared to other EVs – very expensive. Thus, consumers hardly had a variety to choose from. Until the beginning of 2013 about 18 types of EVs are offered and further types – especially from German automobile producers – will follow in 2013. Thus, the customer has a broader choice of types of EVs.

Although the price of gasoline is strongly correlated to the demand of EVs it can be argued that car drivers react on gas price changes. But for all that this effect is mainly forfeited by the increase in income and the associated rise in vehicle kilometers.[37] Comparing the current prices of gasoline with the ones 40 years ago they more than quadrupled but the same increase was observable for the average household income. The same applies to the car tax (being a part of the German price of gasoline) which has curbed the rise in the traffic volume and, therefore, reduced the CO_2 emissions. The effect, however, is low and cannot stop the long-term trend of increasing use of motor vehicles.[38]

The altogether higher price of gas not only increases the demand for EVs but also of alternative fuels in general that use less or no gasoline and, hence, emit lower CO_2 due to the number of setbacks that are connected to electric mobility. A much higher tax is needed to really change consumer behavior.

To sum, environmental regulation had a rather small effect onto the attractiveness of EVs. The maximum emission standards had a correlation of 0.291. One reason might be the fact that car producers are affected by that regulation. They can include EVs that count threefold into the calculation of the standard. However, so far just a few new types of EVs are produced. Audi even stopped the production of its EV at the

[37] See DIW (2010).
[38] See VCD (2012c).

beginning of 2013. This shows that the production of e-cars is pretty expensive compared to the reduction of CO_2 emissions in conventional drives. Another reason might be the low future sales expectations. This can be underlined by a study of the Verkehrsclub Deutschland that showed that the model range of conventional drives of automobile producers has become more economical.[39]

A correlation between the monetary incentive (in form of a tax exemption) and the demand is given. However, it cannot be caused by the amount of the incentive. The savings are between 280 and 500 Euro for the whole time period of ten years. Additionally, compared to the Volkswagen eco up that is driven with natural gas and the Toyota Prius – a HEV – the savings of a tax exemption are relatively low. Both cars can be referred as being competing products to the EV as both have low emissions. The car tax for the former is 20 Euro per year; the one of the latter 36 Euro leading to 200 and 360 Euro respectively that need to be paid in ten years for a low emission vehicle that, furthermore, is cheaper in purchasing costs than e-cars (12,950 Euro and 29.900 Euro respectively).[40]

To sum up, almost all variables together and the growing debate lead to an increase of electric mobility which is probably partly to the increased number of EVs in the vehicle fleet of governments as well as companies – especially car producers. The many setbacks and unanswered questions give reason for the still low sales figures. Customers might also be skeptical about the future prospects of EVs as still many systems compete with each other (e.g. fuel cells, hydrogen).

CONCLUSION

EVs and there provision are associated with many questions and uncertainties. They give reason for the low sale figures of this technology. In order to promote electric mobility governments worldwide implemented certain monetary incentives which as well seem to have a low impact on the sales of e-cars. The analytical results, therefore, reflect the current debate that the early adopters of EVs pay attention to status and not to the price that needs to be paid. One reason is that they are endowed with plenty of money and do not rely on (low) monetary incentives. Other measures, like free parking or the usage of priority/bus lanes, are needed to attract these customers.

In order to reach the environmental goal of lower emissions a number of efficient measures is necessary. First of all, the car and/or green tax have to be increased whereby the car tax should mainly be calculated on the basis of CO_2 emissions. Thus, some pressure will be exerted by the customers onto car manufacturers. Additionally, the emission standards should be further reduced in order to make the automobile producers build more efficient vehicles.

[39] See VCD (2012d).
[40] See VCD (2012a).

To conclude, the promotion of EVs entails risks as politicians do not know which technology is best suitable to reach the goal of lower emission in the countries car fleet. It is recommended that measures which cause a certain steering effect should be implemented. In case of EVs it would be a higher CO_2 tax in order to reduce emissions in traffic. Thus, government will save money and the customers and engineers decide which technology is best suitable.

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