ELECTRIC VEHICLES: BARRIERS, OPPORTUNITIES AND A FORECAST OF THE MARKET POTENTIAL

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ABSTRACT

Nowadays, electric vehicles receive a lot of attention. However, their market breakthrough does not seem evident. This paper presents the results of a large scale data collection (survey with 1,196 respondents), held in Flanders (Belgium). The results include perceptions on the advantages and disadvantages of battery electric vehicles (BEVs), the acceptable driving range, the acceptable charging time (both slow and fast), the acceptable maximum speed, the role of the government in the introduction of BEVs and the preferred governmental tools to achieve this goal, and the willingness to pay. Also, the market potential for electric vehicles is forecasted with the use of a choice-based conjoint (CBC) analysis. In 2020, BEVs could reach a market share of around 5% of the newly sold vehicles in Flanders, while plug-in hybrid electric vehicles (PHEVs) could have a market share of around 7%. In 2030, these figures could increase to respectively 15% and 29%. A sensitivity analysis reveals that, in order to increase the potential for (PH)EVs, the main focus should be on decreasing the purchase costs.

Keywords: Electric vehicles, market forecast, choice-based conjoint analysis

INTRODUCTION

Environmental challenges force the transportation sector to move to more eco-friendly technologies. Electric vehicles (EVs) are regarded as a green transportation solution (Chan, 2002). The technology behind EVs exists for more than a century (Hoyer, 2008). However, due to the availability and the ease of use of combustion engines, electric driving was put on hold. Today, different (pushing and pulling) factors recover the interest in EVs. On the pushing side, the limited oil supply and the rising awareness of the environmental footprint of conventional combustion engine vehicles lead the way to cleaner EVs. On the pulling side, recent developments in battery technology and electric motors make the EVs a valid contester for conventional cars.

Electrified vehicles exist in different formats, based on the degree of electrification of the drive train and the capacity of the battery (Van Mierlo et al., 2006). In this paper, the main focus is on battery electric vehicles (BEVs). These vehicles have the lowest environmental impact (Messagie et al., 2010), but require the largest mentality change, due to some technology bound features.
As with many emerging technologies, the introduction of BEVs in the transport fleet requires a mentality change of the consumers. This is due to the fact that BEVs have certain characteristics that differ from conventional vehicles. First, the initial purchase price of current BEVs is on average 15-30% higher than conventional vehicles. This is mainly due to the high price of the battery pack. Next, the driving range is limited to approximately 100-200 kilometers. Higher ranges are possible, but these will again drive up the price of the BEV. When it comes to charging your BEV, today you still have to rely on your private or semi-private charging station, as public charging infrastructure is still nascent. Moreover, charging your BEV can take quite some time, depending on the capacity of the battery and the electricity output of the charging station. Finally, the maximum speed of BEVs may not satisfy the requirements of some drivers since it is mostly limited to about 130-140 km/h.
In order to facilitate the introduction of electric vehicles, many countries have initiated large demonstration projects (Lebeau et al., 2010). Here, both electric vehicles and charging infrastructure are implemented in real-life situations in order to understand the technical and economical impact on the transport system. This is also the case in Flanders, the Flemish speaking part of Belgium, where a total financial investment of around 30 million euro is made, equally divided between the government and the private sector (Coosemans et al., 2011). The aim of the demonstration projects is to introduce around 600 new electric vehicles and more than 1,000 charging stations into the market.
In January 2012, the Belgian vehicle fleet consisted of only 323 electric vehicles (SPF Economie, 2012). However, during the first three months of 2012, this number was raised because of the launch of several new electric models. In order to promote the purchase of electric vehicles, the Belgian government launched a financial rebate of 30% of the purchase price of the electric vehicle, with a maximum of 9,190 euro (MINFIN, 2012). However, this financial incentive will be abandoned on January 1st 2013. Belgian citizens can receive a rebate of 40% when installing a charging station for electric vehicles outside the home (limited to 250 euro). As for the public charging infrastructure, in October 2012, there are around 220 stations available in Belgium (ASBE, 2012).

METHODOLOGY

Data collection

The survey was twofold: a discrete choice experiment was conducted and 15 open and multiple questions were asked. Both parts of the study were unrelated to each other. A preliminary survey was tested by personal interviews with visitors of the Brussels Motorshow (January 2011), people usually in the search stage of their purchase behavior. This was done to test the clarity of the questions as well as their relevance and completeness. The final survey was designed to use in an online, user-friendly environment. In order to augment the response rate, the panel data of a Belgian market survey company (iVox) was consulted. The target group for the survey was people older than 18 years (eligible drivers and customers). The area for the data collection was Flanders, the Flemish speaking part of Belgium (Figure 1). Between May 2nd and May 13th 2011, 2,037 surveys were distributed. 1,196 complete surveys were returned, entailing a response rate of 58.7%.

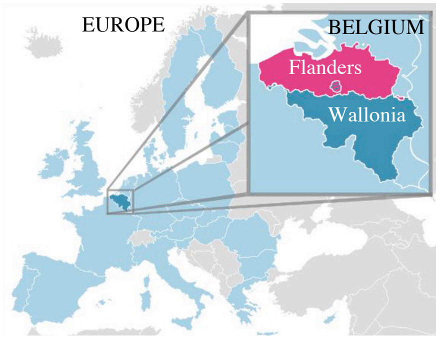


Figure 1: Research area: Flanders (Belgium)

Table 1 illustrates the demographic composition of the survey sample. There was a small bias towards male respondents (56.2%). As for the education level, a small bias is found towards university college education (30%). Finally, the age and region distribution are representative for Flanders.

Table 1: Demographic composition of the sample

	Survey		Flanders (STATBEL, 2012)		
	N (number)	% (percentage)	% (percentage)	X^2	φ
Sex				$X^2(1) = 20.62$	0.14
Male	672	56.2	49%		
Female	524	43.8	51%		
Age				$X^2(5) = 10{,}000.20$	0.30
18-25 years	137	11.4	10%	$p < 0.0001$	
26-35 years	182	15.2	15%		
36-45 years	256	21.4	19%		
46-55 years	241	20.2	18%		
56-65 years	263	22.0	16%		
>65 years	117	9.8	22%		
Education				$X^2(4) = 307.08$	0.53
No education	22	1.8	19%	$p < 0.0001$	
Primary school	177	14.8	20%		
High school / secondary school	456	38.1	33%		
University college	359	30	18%		
University	140	11.7	10%		
Post university	42	3.5	no data available		
Region				$X^2(4) = 4.19$	0.06
Antwerp	323	27	28%	$p = 0.3809$	
Limburg	161	13.5	13%		
Oost-Vlaanderen	297	24.8	23%		
Vlaams Brabant	196	16.4	17%		
West-Vlaanderen	219	18.3	19%		
Total	1,196	100			

Choice-based conjoint theory and design

There exist numerous methodologies that use the stated preference approach. Conjoint analysis (Luce and Tukey, 1964) is a multivariate technique in which the respondent trade-offs are evaluated amongst multi-attribute alternatives in order to estimate utility functions of the consumers (Green et al., 2001; Louviere, 1988). If we assume that all consumers choose the alternative with the maximum utility, the conjoint methodology maps the preference structure of consumers based on their evaluation of the product's attributes. Choice-based conjoint (CBC) uses discrete choice models in order to collect the preferences of the consumer (Gustafsson et al., 2007; Hair et al., 2010; Natter and Feurstein, 2002). The respondents have to select the alternative the prefer most. This way, the choice experiment is more realistic and the outcome is more accurate, especially if we make market simulations using this data (Chakraborty et al., 2002; Karniouchina et al., 2009).
In a CBC experiment, the respondent has to evaluate the profiles based on the given attributes. He or she chooses the alternative with the highest personal utility. We assume that respondents process their total utility by summing up the utility brought by each of the attributes. Hence, our experiment needs to include every possible attribute that can influence the total utility of the respondent in order to simulate as close as possible the real decision making process. However, the number of attributes within the survey should be limited. Otherwise, the choice task could become too hard for the respondent to fill in (Hair et al., 2010). Based on a scientific literature review of similar experiments, eight important vehicle attributes were identified (see Table 2): travel cost per 100 km, purchase costs, environmental performance, refuel or charging infrastructure, driving range, refuel or charging time, annual costs and maximum speed (Lebeau et al., 2012).

Table 2: Literature review for vehicle attributes (Lebeau et al., 2012)

	Attributes							
Literature review	Travel cost per 100km	Purchase costs	Environmental performance	Refuel or charging infrastructure	Driving range	Refuel or charging time	Annual costs	Maximum speed
Hidrue et al. (2011)	✓	✓	✓		✓	✓		
Achtnicht et al. (2008)	✓	✓	✓	✓				
Potoglou & Kanaroglou (2007b)	✓	✓	✓	✓			✓	
Horne et al. (2005)	✓	✓	✓	✓				
Brownstone et al. (2000)	✓	✓	✓	✓	✓	✓		✓
Ewing & Sarigollu (1998)	✓	✓	✓		✓	✓	✓	
Bunch et al. (1993)	✓	✓	✓	✓	✓			
This study	✓	✓	✓	✓	✓	✓	✓	✓

Thanks to the test survey, conducted on the yearly Brussels Motorshow (January 2011), we discovered that a factor reflecting the prestige and quality of the car was missing to model the car purchase decision. A 9th attribute was therefore added and called "brand-image-design-quality". Another outcome of the test survey was that it is very important to clearly define all vehicle attributes. It is essential that all survey respondents interpret the vehicle attributes the same way. Hence, in the final survey, right before starting the CBC experiment, the respondents received an overview of all vehicle attributes describing their measurement and definition (see Table 3).

Table 3: Definition of vehicle attributes (Lebeau et al., 2012)

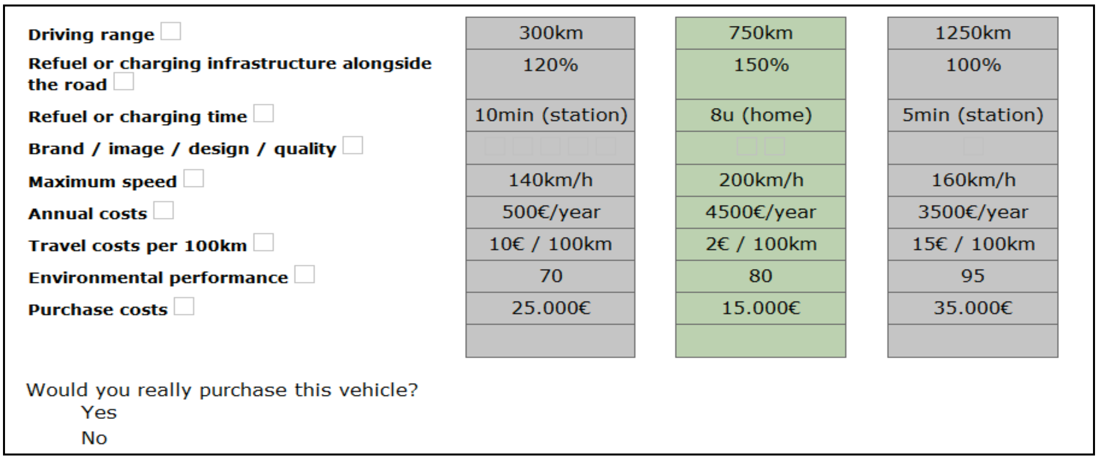
Vehicle attribute	Definition
Purchase costs	Purchase price, VAT, registration tax and possible governmental fiscal incentives
Annual costs	Insurance, maintenance and yearly driving tax
Travel cost for 100km	Fuel or electricity cost for 100km
Environmental performance	Based on Ecoscore (the higher the Ecoscore, the better the environmental performance of the vehicle)
Refuel or charging infrastructure alongside the road	Expressed in percentage of current fuel station coverage
Driving range	Number of kilometers that can be driven without refueling or recharging the battery
Refuel or charging time	Time to refuel or charge the battery
Maximum speed	Maximum speed of the vehicle
Brand / image / design / quality	How does the vehicle fulfill the consumers demand on brand, image, design and quality?

The attribute levels have to be communicable (Hair et al., 2010). The selected levels, as illustrated in Table 4, were therefore indicated by quantitative measures that can easily be understood by respondents.

Table 4: Measurement, number and magnitudes of attribute levels (Lebeau et al., 2012)

Purchase costs	Annual costs	Travel costs per 100km	Environmental performance (Ecoscore)	Refuel or charging infrastructure	Driving range	Refuel or charging time	Maximum speed	Brand/ image/ design/ quality
10.000€	500€/year	0€/100km	60	5%	100km	Never	80km/h	1 star
12.500€	1.000€/year	2€/100km	65	10%	150km	5min (station)	100 km/h	2 stars
15.000€	1.500€/year	4€/100km	70	20%	200km	10min (station)	120 km/h	3 stars
17.500€	2.000€/year	6€/100km	75	40%	300km	2h (home) & 10min (station)	140 km/h	4 stars
20.000€	2.500€/year	8€/100km	80	60%	500km	8h (home) & 5min (station)	160 km/h	5 stars
22.500€	3.000€/year	10€/100km	85	80%	750km	8h (home) & 30min (station)	180 km/h	
25.000€	3.500€/year	12€/100km	90	100%	1.000km	8h (home)	200 km/h	
30.000€	4.000€/year	15€/100km	95	120%	1.250km			
35.000€	4.500€/year			150%				
> 35.000€	> 4.500€/year							

The entire survey was conducted on a user friendly internet based system in order to minimize the respondents' effort. Figure 2 illustrates a task for the CBC experiment. Respondents had to choose the vehicle that maximizes their utility and then indicate whether or not they would purchase the vehicle.



Driving range	300km	750km	1250km
Refuel or charging infrastructure alongside the road	120%	150%	100%
Refuel or charging time	10min (station)	8u (home)	5min (station)
Brand / image / design / quality			
Maximum speed	140km/h	200km/h	160km/h
Annual costs	500€/year	4500€/year	3500€/year
Travel costs per 100km	10€ / 100km	2€ / 100km	15€ / 100km
Environmental performance	70	80	95
Purchase costs	25.000€	15.000€	35.000€

Would you really purchase this vehicle?
Yes
No

Figure 2: Screenshot of CBC task

After the results of the conjoint analysis have been gathered, we need to process the information, using a utility estimation method. During many years, multiple regression and multinomial logit models have been a standard for estimating the conjoint model. However, for this study, we opted for the Bayesian estimation method (Hierarchical Bayes, HB) in which individual level utilities are estimated. This keeps the heterogeneity of the population intact (Gelman et al., 2009; Karniouchina et al., 2009; Moore, 2004). In particular, HB was proofed to be efficient and accurate with CBC experiments.

RESULTS

Results of CBC experiment

We used a choice simulator in order to estimate the demand for a specified market scenario in which different vehicles are created. These cars are simulated using a combination of the different attribute levels. Afterwards, the simulator uses the associated part-worths to calculate the preferred vehicle for each individual. The market shares are then deduced from the simulated individual choices. As we want to predict the potential sales of (plug-in hybrid) electric vehicles in Flanders, we built different market scenarios: the years 2012, 2020 and 2030. In all these scenarios, 8 types of vehicles are identified in order to simulate the market: city petroleum car (City P), medium class petroleum car (Medium P), premium class petroleum car (Premium P), city diesel car (City D), medium class diesel car (Medium D), premium class diesel car (Premium D), BEV and PHEV. Through expert consultation, we included the expected technological evolution as well as the expected evolution of the energy prices when assessing the levels for each type of vehicle. Table 5 illustrates these assumptions as well as all the used levels for each scenario. This results into the forecasted market shares derived from the CBC experiment. These shares are percentages of the number of newly sold vehicles in Flanders, not of the entire Flemish car fleet.
Conjoint simulation does not take into account sales factors such as marketing tools (advertising and promotion). It is based on an essential assumption that consumers choose their new car based on its attributes. Hence, the market shares depicted below illustrate the potential market shares. It is common for new technologies to take some time before they reach their potential market share.

Table 5: Scenario setup and results (Lebeau et al., 2012)

Scenario 2012	Purchase costs	Annual costs	Travel costs per 100km	Environmental performance	Refuel or charging infrastructure	Driving range	Refuel or charging time	Maximum speed	Quality /Design /Brand /Image	Market shares
City P	12,500€	2,000€/year	6€ / 100km	65	100%	500km	5min (station)	140km/h	2 stars	
Medium P	17,500€	2,500€/year	8€ / 100km	65	100%	500km	5min (station)	160km/h	3 stars	18%
Premium P	25,000€	2,500€/year	10€ / 100km	60	100%	750km	5min (station)	160km/h	3 stars	
City D	12,500€	2,000€/year	4€ / 100km	65	100%	750km	5min (station)	140km/h	3 stars	
Medium D	17,500€	2,000€/year	4€ / 100km	60	100%	750km	5min (station)	160km/h	4 stars	77%
Premium D	25,000€	2,500€/year	8€ / 100km	60	100%	1,000km	5min (station)	160km/h	4 stars	
BEV	30,000€	1,500€/year	2€ / 100km	90	5%	100km	8h (home)	120km/h	1 star	1%
PHEV	35,000€	2,000€/year	4€ / 100km	80	100%	750km	5min (station)	160km/h	2 stars	4%

Scenario 2020	Purchase costs	Annual costs	Travel costs per 100km	Environmental performance	Refuel or charging infrastructure	Driving range	Refuel or charging time	Maximum speed	Quality /Design /Brand /Image	Market shares
City P	12,500 €	2,000€/year	6€ / 100km	70	100%	500km	5min (station)	140km/h	2 stars	
Medium P	17,500 €	2,500€/year	8€ / 100km	70	100%	500km	5min (station)	160km/h	3 stars	18%
Premium P	25,000 €	2,500€/year	10€ / 100km	65	100%	750km	5min (station)	160km/h	3 stars	
City D	12500 €	2,000€/year	4€ / 100km	70	100%	750km	5min (station)	140km/h	3 stars	
Medium D	17,500 €	2,000€/year	6€ / 100km	65	100%	750km	5min (station)	160km/h	4 stars	70%
Premium D	25,000 €	2,500€/year	8€ / 100km	65	100%	1,000km	5min (station)	160km/h	4 stars	
BEV	25,000 €	1,500€/year	2€ / 100km	90	20%	150km	8h (home) / 30m (station)	140km/h	2 stars	5%
PHEV	25,000 €	2,000€/year	4€ / 100km	80	100%	750km	5min (station)	160km/h	2 stars	7%

Scenario 2030	Purchase costs	Annual costs	Travel costs per 100km	Environmental performance	Refuel or charging infrastructure	Driving range	Refuel or charging time	Maximum speed	Quality /Design /Brand /Image	Market shares
City P	15,000€	1,500€/year	8€ / 100km	80	100%	750km	5min (station)	140km/h	3 stars	
Medium P	20,000€	1,500€/year	10€ / 100km	80	100%	750km	5min (station)	160km/h	4 stars	28%
Premium P	25,000€	1,500€/year	12€ / 100km	80	100%	1,000km	5min (station)	160km/h	4 stars	
City D	15,000€	1,500€/year	8€ / 100km	80	100%	750km	5min (station)	140km/h	3 stars	
Medium D	20,000€	1,500€/year	10€ / 100km	80	100%	750km	5min (station)	160km/h	4 stars	28%
Premium D	25,000€	1,500€/year	12€ / 100km	80	100%	1,000km	5min (station)	160km/h	4 stars	
BEV	25,000€	1,500€/year	4€ / 100km	95	60%	200km	8h (home) / 5m (station)	140km/h	3 stars	15%
PHEV	25,000€	1,500€/year	6€ / 100km	90	100%	1,000km	5min (station)	160km/h	3 stars	29%

We use the results for 2012 as a validation for our model. When comparing the 2012 results with the 2010 Belgian market shares for newly sold vehicles, we find that, in reality, diesel vehicles had a market share of 76%, petroleum cars consists for 23.3% and BEVs are only 0.01% (SPF Mobilité & Transports, 2011). The results of our study show that diesel would have a market share of 77%, petroleum 18%, BEVs 1% and PHEVs 4% (under the assumption that there is a large offer of BEV and PHEV models). We conclude that the results of our study approximate the real market situation for Flanders.

We are also able to explain the underlying reasons of the market shares based on the influences of the part-worth utilities. PHEVs have a low market share because of their high purchase price (a premium of €5,000 to €10,000 compared to a conventional car) but it benefits from a higher environmental score and cheaper driving costs (when running purely on the electric motor). However, even though they are more expensive than battery electric vehicles, their market share is higher. This could be because PHEVs are more flexible: their range is similar compared to conventional cars, they can use the existing fuelling stations to fill up their tank and they can refuel in merely five minutes. Still, the market shares of PHEVs and EVs remain marginal compared to conventional petrol and diesel vehicles.

As from 2020, the market share for BEVs and PHEVs could increase, mostly because of different technical and economic enhancements: lower battery costs, increased BEV range and shorter charging times. The market share for PHEVs will still be higher than that of BEVs (7% versus 5%). In 2030, BEVs and PHEVs can really become a valid alternative for the conventional cars. Based on our simulation results, their market share will increase to 15% for BEVs and 29% for PHEVs. Next to the continuous technical improvements (increased driving range, better developed charging infrastructure, shorter charging times, more supply), the main driver is the rising energy price. Even when we take into account the potentially increased electricity prices, the market potential for conventional cars still decreases.

We produce several sensitivity analyses in order to better understand consumer acceptance for BEVs and PHEVs. The base scenario is the year 2012. Next table indicates the results for the sensitivity analyses.

Table 6: Sensitivity analyses: the effect on the market shares (Lebeau et al., 2012)

Action	**Effect on attribute levels**	**Market share BEVs**	**Market share PHEVs**	**Total market share**
Base scenario 2012		1.23%	3.61%	4.84%
Higher reduction in purchasing costs	Purchase price of BEVs and PHEVs decrease with 5,000€	2.74%	6.57%	9.31%
More charging infrastructure	Infrastructure coverage develops from 5% to 10%	1.99%	3.52%	5.51%
Rise of fuel prices	Travel costs for diesel and petroleum cars rise with 2€ per 100km	1.68%	6.08%	7.76%
Battery leasing	Purchase price of BEVs decrease with 10,000€ and annual costs increase with 1,000€	1.64%	3.73%	5.37%
More battery capacity	Driving range for BEVs increases from 100km to 200km	1.63%	3.51%	5.14%
More battery capacity	Driving range for BEVs increases from 100km to 300km	2.82%	3.33%	6.15%
Faster charging time	Fast chargers are available in public areas and take 30minutes to recharge the battery	1.36%	3.73%	5.09%

A reduction of the purchase costs and an increase of the driving range to 300 km have the largest impact on the market potential in 2012 for BEVs. These twee factors are indeed two often named bottlenecks for the successful market introduction of BEVs. For PHEVs, the market potential would increase the most when purchase costs would be lower and when fuel prices would increase. How can this scenario become reality? Here, the government could play an important role: by offering incentives for the purchase of electrified vehicles, they could lower the total cost for the consumer. Also, technological improvements and economies of scale can contribute in reducing the cost of the battery, which is still the most expensive component of BEVs (Delucchi and Lipman, 2001).

In the sensitivity analyses, we observe that the market prices of conventional fuels have an influence on the adoption rate of BEVs and PHEVs (see third sensitivity scenario in Figure 6). Again, the government could impact these prices and stimulate the purchase of EVs, for example by internalising the external costs of conventional vehicles (Verhoef, 1994).

If the driving range of BEVs would increase to 200km and the charging time would be limited to 30 minutes, the total market share for electric vehicles could rise respectively to 5.09% and 5.14%. If the global network of charging stations would increase, this would only have an impact on the market potential for BEVs (1.23% to 1.99%). The PHEV market potential is not affected much because these cars are most often charged at home.

Attitudes towards battery electric vehicles

The second part of the study includes a survey on the consumer attitudes towards BEVs. As mentioned before, BEVs have some technology specific characteristics that differ from internal combustion engine vehicles. Based on literature, we distinguished a list of advantages and disadvantages of BEVs (Chéron and Zins, 1997; Dijk and Yarime, 2010; Lieven et al., 2011; Skippon and Garwood, 2011).

In the survey, participants were asked to rate 15 advantages and 14 disadvantages on a scale of importance. Figure 3 (advantages) and Figure 4 (disadvantages) illustrate the results. The low cost per kilometer is regarded as the biggest advantage of BEVs. Based on an electricity price of 0.15 euro per kWh, a BEV with an electricity consumption of 20 kWh/100 km spends 3 euro for 100km driven. This is relatively low compared to a modern petrol (6.5 liters/100 km, 1.55 euro/ liter, 10.1 euro/100 km) and diesel (5.5 liters/100 km, 1.45 euro/ liter, 8 euro/100 km) car. Next, the eco-friendly character of BEVs attracts consumers in buying BEVs. However, literature (Young et al., 2009; Mairesse et al., 2011) reveals that there is a so called attitude-action gap between environmental perception of green vehicles and the actual purchase behavior of consumers. On third place we find the possibility to charge the vehicle at home, eliminating the regular visits to the filling station. The governmental subsidy when purchasing a BEV also attracts consumers, as well as the possibility to charge at work (given that the employer facilitates such an infrastructure and that a clear agreement on who is paying for the electricity has been made). At the lower side of the chart, we find some remarkable results. Acceleration and smart phone applications are perceived as a not important advantage of BEVs. This is in contrast with other findings (Skippon and Garwood, 2011). This could be explained by the fact that few people have experienced the swift acceleration of BEVs and are unaware of the smart phone applications that are available (battery status check, personalized battery charging agenda, remote controlled acclimatization of the vehicle, etc.).

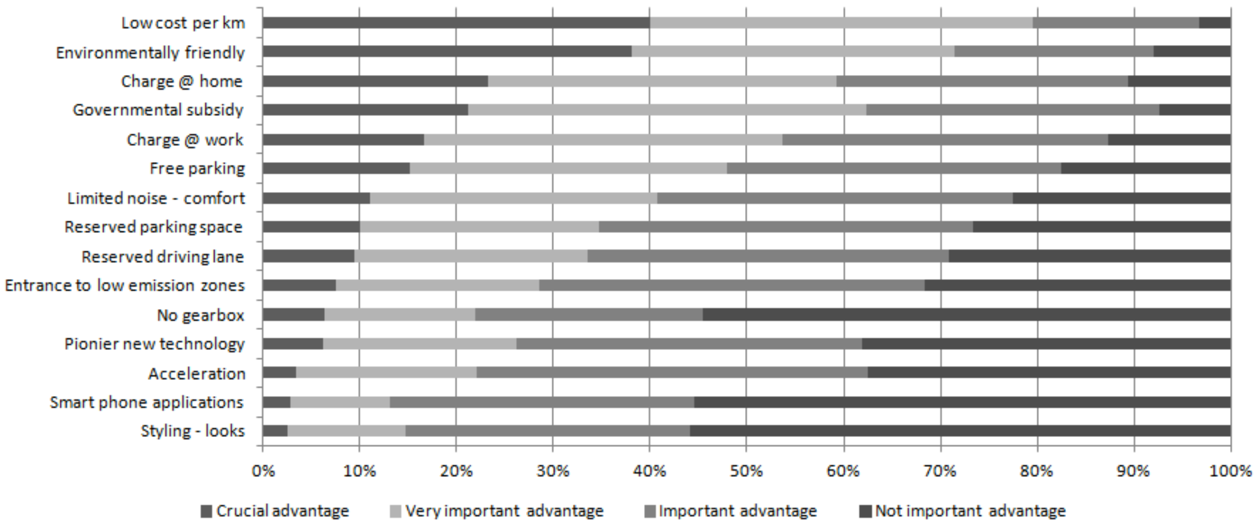


Figure 3: Advantages of battery electric vehicles

Figure 4 shows that, according to our survey, there are five main disadvantages related to BEVs. First, the high purchase price is a hurdle that holds back many consumers, not taking into account the total cost of ownership (TCO) of the vehicle, which, due to the lower running costs, can be more interesting than it first looks. Next, the limited driving range of BEVs is perceived as a large obstacle for consumers. Even though only 35% of all Flemish citizens travel more than 40 kilometers per day by car (Cools et al., 2011)), consumers perceive the limitation of around 100 – 200 kilometers as a struggle. This distance equals the amount of kilometers one can drive when the fuel warning light pops up in a conventional vehicle. According to the survey, charging the BEV includes three limitations: there is a lack of public charging infrastructure, it takes too much time to fill the battery and people who do not own a garage or a private parking space cannot charge at home. Next up are three disadvantages that could change in the upcoming years: the uncertainty about the residual value, the limited supply of BEV models at car dealerships, and the uncertainty for a new technology. As the electrification of the transport system continues, all these three limitations are bound to improve.

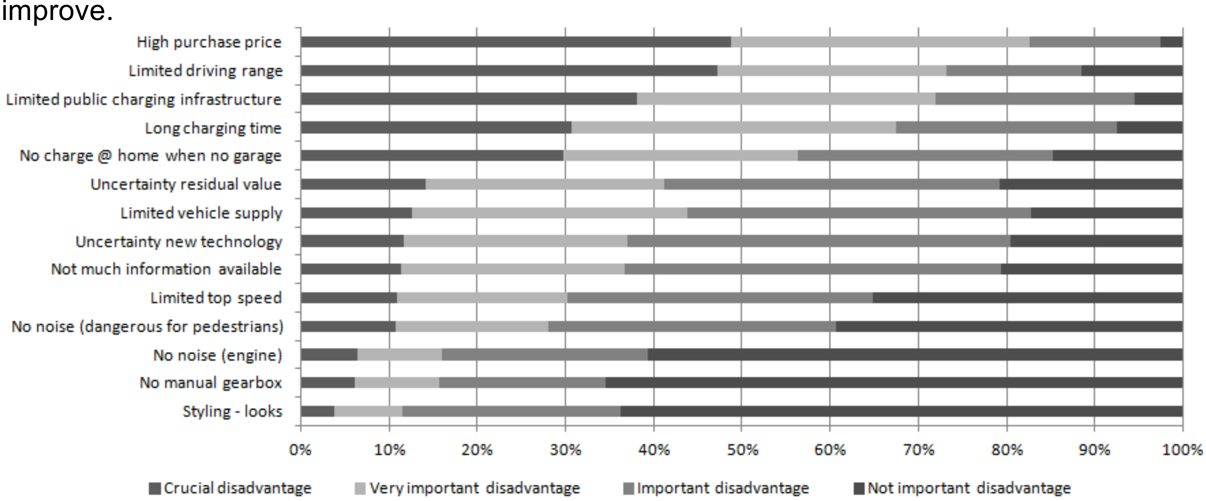


Figure 4: Disadvantages of battery electric vehicles

Next, the acceptable level of the driving range and the maximum speed of BEVs, as well as the duration of both slow and quick charging were questioned. Results are depicted in Figure

5. Consumers indicate that the current driving range of BEVs is not acceptable: only 10.4% of the sample is satisfied with a range lower than 200 kilometers. If, through technological improvements, the driving range would improve to 300 kilometers, 400 kilometers or 500 kilometers, the percentage of satisfied consumers would increase to respectively 32.6%, 49.5% and 71.1%. Current BEVs have a maximum speed of around 130 km/h (Nissan Leaf: 145 km/h; Peugeot iOn, Citroen C-Zero and Mitsubishi iMiev: 130 km/h). In our survey, the consumers indicate that a driving speed of 140 km/h is sufficient for 81.9% of the population. Even though modern petrol and diesel vehicles have a higher maximum speed, the limited maximum speed for BEVs is not perceived as an important disadvantage. Charging a BEV with a standard plug can take some time. However, 70.4% of the sample is willing to wait 4 to 8 hours for the battery to recharge connected to a slow charger. This could be explained by the fact that slow charging is often related with home charging and night-time charging (Li, Ogden and Kurani, 2009; Skippon and Garwood, 2011). However, for fast chargers, often implemented alongside the road and on highways, consumers are still accustomed to the short time that is needed to fill up the petrol or diesel tank. 68.8% of the population wants fast chargers to finish within 15 minutes and 91% wants it to finish in less than half an hour. Compared to today's fast charger market (30 minutes for 80% charge), these values could be achieved, be it with a possible negative effect on the battery pack lifetime (Choi and Lim, 2002).

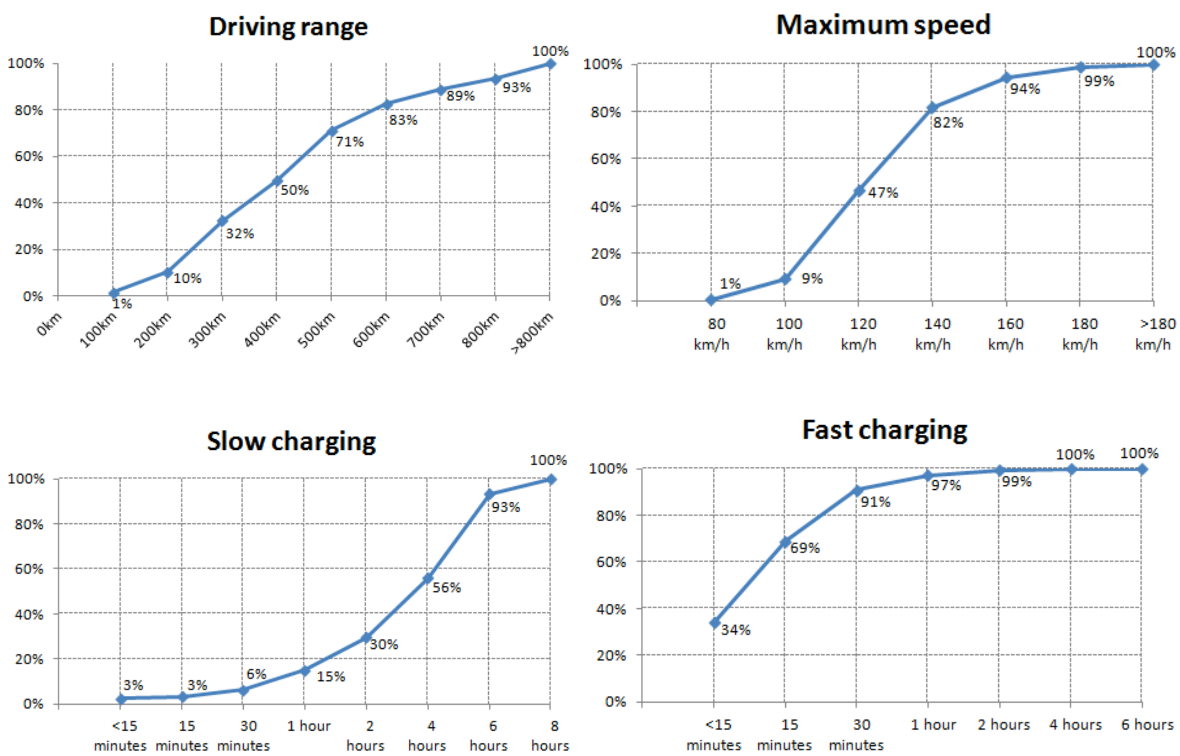


Figure 5: Consumers' acceptable driving range, maximum speed and slow/fast charging time (cumulative %)

Charging a BEV can take place at many different locations (Skippon and Garwood, 2011). According to our survey, home charging will be dominant (45%). Interesting is that 19% of our sample would like to charge their BEV at the same location as the conventional filling stations. 17% wants to charge the vehicle at their working space.

When asking the respondents on the timeframe in which they think a BEV could be a viable alternative to a conventional car, 3.5% indicated between now and 2 years, 15.1% indicated between 3 and 4 years, 29.6% indicated between 5 and 6 years, 25.3% indicated between 7 and 10 years and 26.6% indicated after 10 years.

Attitudes towards governmental interference and willingness to pay

The government plays an important role in the introduction of BEVs (Ahman, 2006). According to our survey, 71.3% of the respondents think the government should intervene in the implementation of EVs on the Flemish market. In addition, Figure 6 illustrates how this intervention should be done. The standardization of the charging infrastructure and the installation of fast chargers alongside the road are top priorities. Today, standardization landscape for electric vehicles is still complex (Van den Bossche et al., 2008). The government should make sure that the market for electric vehicles agrees on a common charging infrastructure standard before too many types have entered the market. Through the installation of fast chargers, the range anxiety could be lowered and BEV drivers could be allowed to make longer trips. However, as these charging devices are still very expensive, the government could install the first basic coverage of fast chargers across the nation. Next in line are three financial incentives, alleviating the purchase of the BEV and its charging equipment: the exemption of registration and road tax, a financial incentive when purchasing a BEV and a financial incentive when installing a charging station at home. Interesting to see is that the usage of bus lanes to provide journey time benefits does not attract the respondents of our survey. This could be caused by the fact that in Flanders bus lanes not yet fully installed throughout the road network.

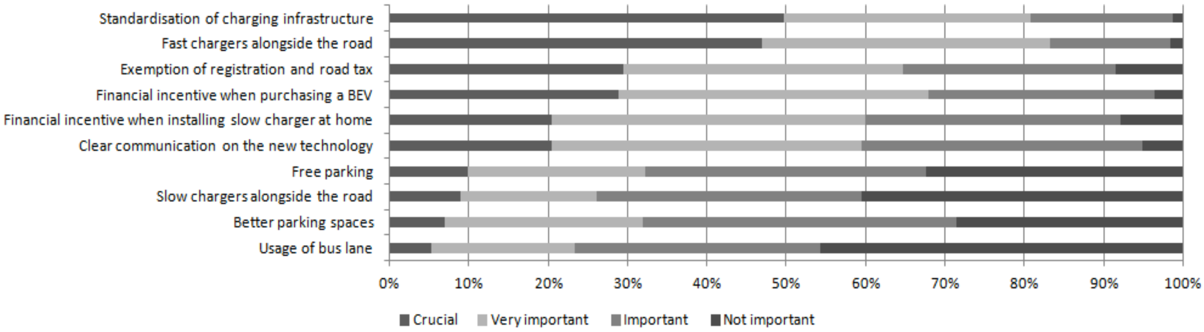


Figure 6: Governmental intervention for the introduction of BEVs in Flanders

Currently, BEVs are on average 15-30% more expensive compared to a similar conventional vehicle. Young et al. (2009) found that the price of electric vehicles greatly influences the consumers' attitude towards it. If prices would lower, more consumers could become interested. These price drops could be achieved through economies of scale and mass production (Cowan and Hulten, 1996).

In the survey, the people that were willing to buy a BEV (n = 1,066) were asked to indicate their willingness to pay (WTP) for this technology. Over 50% of the respondents demand a comparable price tag as current conventional cars. 27% is willing to pay more than a conventional car, indicating that a new technology and a green image should be paid for, while 20% thinks BEVs should be sold at a lower price, mainly because of its disadvantages like the limited range and the charging issues. This result differs from previous research on the willingness to pay for hybrid vehicles (Das et al., 2011)

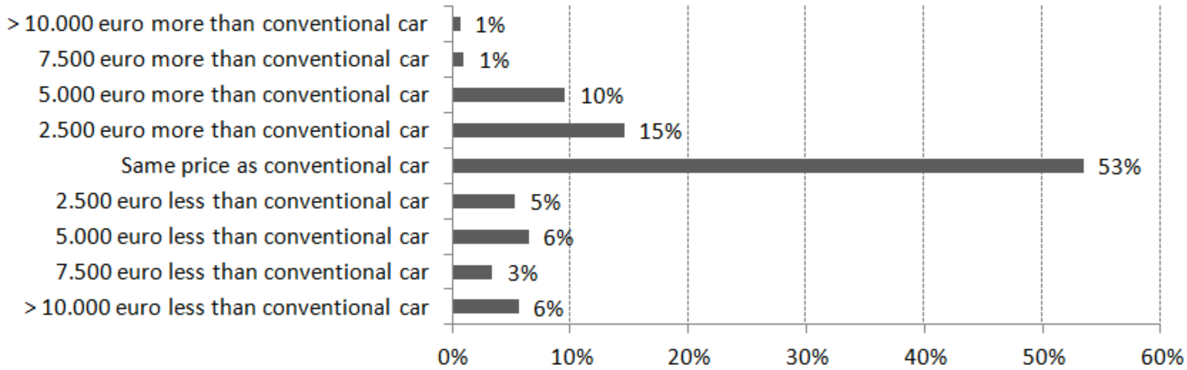


Figure 7: Willingness to pay for BEVs

CONCLUSIONS AND IMPLICATIONS FOR RESEARCH/POLICY

The results of our survey (n=1,196) show that the low cost per kilometre, the environmental performance and the ability to charge at home are perceived as the most important advantages of BEVs, while the high purchase price, the limited driving range and the limited charging infrastructure are the most important disadvantages of BEVs. For 49.50% of the respondents, a range of 400 km would be acceptable. The maximum speed of BEVs is not an issue: 82% of the sample is satisfied with a 140 km/h maximum speed, which many modern BEVs already deliver. We found that 70% of the sample is willing to wait 4 to 8 hours for the battery to recharge connected to a slow charger, while 69% of the population wants fast chargers to finish in a maximum of 15 minutes. The government plays an important role in the introduction phase of BEVs, and, according to our survey, they should stimulate standardization of the charging infrastructure, the installation of fast chargers alongside the road and make an exemption of taxes (registration and road tax). Finally, we questioned the willingness to pay for BEVs. Here, only 27% is willing to pay more than a conventional car.

We also forecasted the market potential for battery electric and plug-in hybrid electric vehicles using a choice-based conjoint experiment. We first identified the most important vehicle attributes within the decision-making process for a new car: purchase costs, travel cost for 100 km, annual costs, environmental performance of the vehicle, refuel or charging infrastructure, driving range, refuel or charging time, maximum speed and quality/design/brand/image. We found all part-worth utilities for the vehicle attributes levels, enabling us to set up different scenarios for the years 2012, 2020 and 2030. This way, we were able to forecast the future market potential for BEVs and PHEVs. In 2012, sales figures will still be limited (1.2% for BEVs and 3.6% for PHEVs; under the assumption that there is a large offer of BEV and PHEV models). In 2020, these figures could increase to respectively 5% and 7%, due to technological improvements and a decrease in purchase costs. Finally, in 2030, electrified transport could really set off with market shares of 15% (BEVs) and 29% (PHEVs).

Based on the scenario for 2012, we analyzed different actions to improve BEV and PHEV adoption in order to draw the prior deployment needs. The results show that the most sensitive factors for both technologies are the reduction of the high purchase costs and the increase of the fuel prices for conventional cars. When improving one of these two attribute levels, the market shares for electrified transport (BEV + PHEV) rise from 4.8% to 9.3% (lower purchase costs) and 7.7% (higher conventional fuel prices). Increasing the driving range for BEVs to 300km would entail an increase to 6.1%.
The results of this study focus on Flanders, but can, to some extent, be representative for other markets. We need to emphasize that many parameters such as taxation, subsidies, travel behaviour, topography, etc. have an impact on the perception towards electric vehicles. Therefore, it would be very interesting to compare the results of this study to similar studies from other countries in order to investigate the impact of these parameters. Further research could include cluster analysis, which would increase the level of significance of the study.
We conclude by stressing the need for further research in battery development. More specific, the focus should be on decreasing the battery costs in order to leverage our findings for both BEV and PHEVs. Also, governments should regulate more efficiently travel costs by internalizing the external costs of conventional cars. This could be an efficient incentive for consumers to switch to electric vehicles.

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