SOCIO-ECONOMIC BARRIERS AND DEVELOPMENT OPPORTUNITIES OF ELECTROMOBILITY AS KEY TECHNOLOGICAL INNOVATION OF TRANSPORTATION

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ABSTRACT

Electromobility is currently the most dynamic and developing technological innovation in the field of the passenger and freight transportation. Key aspects of its dynamic development include especially the operational costs of electric vehicles and the ecologization of transportation by using electric-drive vehicles. For the above-mentioned key aspects, the more massive increase in the use of electromobility is recorded especially in the field of "city logistics". Our research activities are dedicated to identifying barriers and opportunities of sale promotion and using of electric vehicles by conventional transport users. Consumers consider many factors when buying a car, but in terms of the automotive market, purchasing power of the population and marketing support of electromobility in the Slovak Republic, the aspect of ecology of transportation and long-term cost efficiency are not the primary criteria for their decision-making process. We conducted primary quantitative pre-research by inquiry method via standardized online questionnaire that addressed some topics: (1) consumer interest in environmental protection; (2) consumer awareness and knowledge about electromobility; and (3) consumer buying behaviour in the context of electromobility development. Based on the results of consumer pre-research and analysis of legislative, economic and social conditions, the aim of this paper is to identify barriers and possibilities for development of electromobility and to suggest recommendations for the automotive industry (manufacturers and retailers of electric vehicles, associations of electromobility, companies providing electric vehicle services (charging stations), government institutions and the non-profit sector. The presented paper is output of the research project VEGA No. 1/0380/17 Economic efficiency of electromobility in logistics..

KEY WORDS: electromobility, electric vehicle, consumer awareness, city logistics, ecology.

1. INTRODUCTION

Electromobility is currently the most dynamic and developing technological innovation in the field of the passenger and freight transportation. The increasing costs of oil, global warming caused by greenhouse effect and environmental and air pollution especially in agglomerations have influenced the scientific research, governmental decisions and the markets in direction to electromobility development in order to reduce use of fuel and emissions. It results in increasing importance of electromobility.

Governments around the world are becoming aware that exclusive reliance on petroleum to power the rapidly expanding transportation sector may become very costly in terms of financial, environmental and security impacts. Countries are becoming increasingly aware of the environmental and security implications of their present transportation systems and are looking at alternatives to petroleum, including biofuels, natural gas and electricity. European countries are looking at electric vehicles as the urban car of the future, ameliorating the problems of both conventional and unconventional air pollution (Lee & Lovellette, 2013). As more municipal governments across the globe set target dates for zero-emissions zones in large cities, electromobility will play a more important role in freight transportation (Crissey, 2017).

Furthermore, electromobility is emerging as a global alternative to transportation based on the internal

combustion engine. Battery technology is largely responsible for the recent success of electric vehicles from bicycles to passenger cars and buses. A sustained drop in lithium-ion battery costs and performance improvements are also fueling innovation in electromobility. At the same time, these changes are pushing the limits of design, and designers are looking for ways to maximize the value of lithium-ion energy storage systems (Osio, 2016).

Norway has become a global forerunner in the field of electromobility and the pure battery electric vehicles (BEVs) market share is far higher than in any other countries. One of the reasons is strong incentives for promoting purchase and ownership of BEVs. According to the research results of Bjerkan, Nørbech & Nordtømme (2016) dedicated to the role of incentives in promoting pure battery electric vehicles in Norway, purchase taxes are most critical factors. 84% of BEV owners in Norway consider value added tax and purchase tax exemption to be sufficient.

On the one hand, we can identify many incentives and activities of governments, car producers, non-profit sector that enable to develop electromobility, on the other hand we claim that the most important and main role at the electromobility market plays consumers as electric vehicle users. Although, there are books (Attias, 2016; Lienkamp, 2016; Figenbaum & Kolbenstvedt, 2013) and articles (Dumaine, 2016; Krzak, 2012; Martiny & Schwab, 2011; Shaheen & Chan, 2015; Altenburg, Bhasin & Fischer, 2012) dedicated to the electromobility opportunities and future scenarios, there is a lack of information focused on the consumer awareness, knowledge or attitude in the field of electromobility. Therefore we decided to conduct research focused on consumer interest, awareness, knowledge and their behaviour in the context of electromobility development. It is a preliminary work which is a basis for future deeper research in this field.

2. BARRIERS AND POSSIBILITIES OF ELECTROMOBILITY DEVELOPMENT IN SLOVAKIA

2.1. Methodology

Selection of scientific methods depends on the paper content focus and the paper aim. To elaborate theoretical knowledge we primarily used theoretical scientific methods, including a method of analysis and synthesis, a method of induction and deduction, abstraction and concretization, but also a comparative method. As a method of collecting primary data we conducted research. We evaluated and interpreted the obtained quantitative data through statistical and graphical methods in the Statgraphics software and MS Excel.

The basis for identification of barriers and opportunities for development of electromobility is represented by the results of primary pre-research that we conducted by the inquiry method through the standardized online questionnaire in August 2017. We focused on three topics: (1) consumer interest in environmental protection; (2) consumer awareness and knowledge about electromobility; and (3) consumer buying behaviour in the context of electromobility development. However, this paper focuses on the analysis of partial results concerning the consumer attitude toward development of electromobility. The aim of this paper is to identify barriers and possibilities for development of electromobility and to suggest recommendations for the automotive industry (manufacturers and retailers of electric vehicles, associations of electromobility, companies providing electric vehicle services (charging stations), government institutions and the non-profit sector. We set the following research questions:

What are the most important barriers of mass implementation of electromobility in passenger transportation?

Which factors discourage consumers to buy an electric car?

What factors would convince consumers to buy an electric car?

The questionnaire consisted of 24 closed-ended and open-ended questions (including 5 classification questions). The respondent´s answers were evaluated through frequency tables and cross tabulations, in some cases relevant descriptive statistics (e.g. average, standard deviation) were calculated.

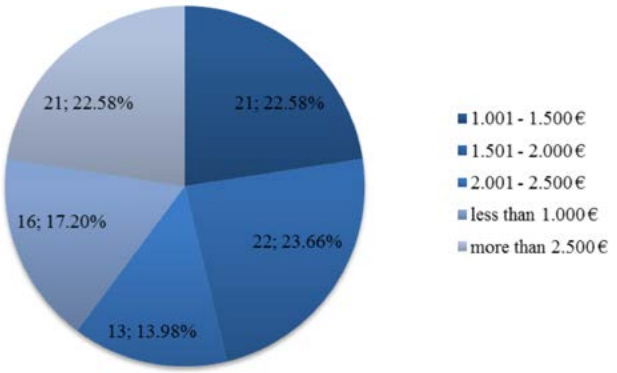
After testing for complexity, accuracy, validity, reliability and consistency, we analysed 93 questionnaires. We can consider our results to be representative. We calculated the sample size of 71 respondents with confidence level 95%, margin of error 7% and population proportion 0.9.

2.2. Results and Discussion

In this part of the paper, we present partial results of the pre-research which provide us with answers to the research questions and also testify to consumer attitude toward development of electromobility.

A total of 93 consumers participated in the pre-research, of which 48 (51.61%) were men and 45 (48.39%) women. In terms of age structure, there was the largest representation of consumers aged 26 –35 (36, i.e. 38.71%) and 36 –50-year-olds (28, i.e. 30.11%). 18 –25-year-olds were represented by 23 consumers (i.e. 24.73%), and more than 51-year-olds by 6 consumers (i.e. 6.45%). In terms of net monthly household income (see figure 1), there were three levels of income with similar representation of consumers: 22 consumers (i.e. 23.66%) declared €1,501 – 2,000; 21 (22.58%) consumers declared €1,001 – 1,500 and the same amount of consumers (21, i.e. 22.58%) more than €2,500.

Figure 1. Net monthly household income of respondents

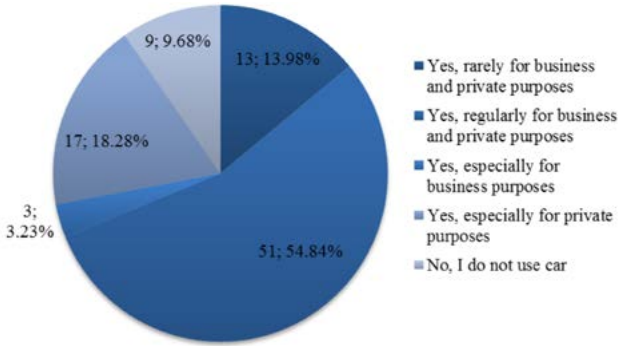


n=93

Source: own results

The research results (see figure 2) show us that 90% of consumers in Slovakia use car as a means of transport. Furthermore, a half of consumers (51, i.e. 54.84%) use the car for private and business purposes regularly.

Figure 2. Car as a means of transport

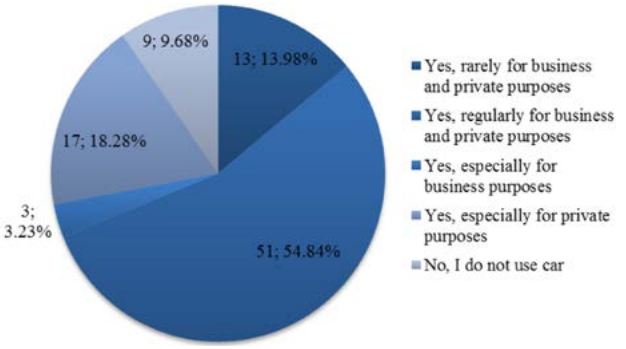


n=93

Source: own results

As results in Figure 2 show, a vast majority of consumers use the car, we focused on whether consumers know someone who drives an electric car. We found out that only one third of consumers (29.03%) do know.

Figure 3. Do you know someone who drives an electric car?



n=93

Source: own results

Within the same part of the pre-research we focused on finding out factors that would convince consumers to buy an electric car. When evaluating the pre-research, points were assigned to each option (1 – Yes, certainly; 4 – No, certainly not, excluding the option I do not know) and based on setting the average values for certain factors we determined their order of importance from the consumers´ perspective. As shown in Table 1, we have found out that consumers consider price of a new electric car as the most important factor. Operational costs rank the 2nd place and state subsidy the 3rd place. We would like to point out recommendations of the relatives, friends, etc. and/or recommendations of sales representatives or advertisement do not play an important role for consumers when deciding to buy an electric car. The results also reveal that majority of consumers (62.37%) are not strictly focused on conventional cars. They do not prefer them. There is also a group of undecided consumers (30.11%) that do not know if they prefer conventional cars.

Table 1. What factors would convince you to buy an electric car?

Factor	1 - Yes, certainly	2 - Yes, maybe	I do not know	3 - No, probably not	4 - No, certainly not	Average	Rank
Price of a new electric car	57	20	4	12	0	1,49	1
	61.29%	21.51%	4.30%	12.90%	0.00%		
Operational costs (car maintenance costs)	50	33	4	6	0	1,51	2
	53.76%	35.48%	4.30%	6.45%	0.00%		
State subsidy (i. e. for the purchase of the new electric car)	43	35	5	8	2	1,65	3
	46.24%	37.63%	5.38%	8.60%	2.15%		
Car performance	30	45	5	13	0	1,81	4
	32.26%	48.39%	5.38%	13.98%	0.00%		

Positive previous experience with electric car, i. e. testing drive	24	46	12	9	2	1,86	5
	25.81%	49.46%	12.90%	9.68%	2.15%		
Professional articles, papers about electromobility	22	36	8	19	8	2,15	6
	23.66%	38.71%	8.60%	20.43%	8.60%		
Recommendations of relatives, friends, etc.	8	33	19	26	7	2,43	7
	8.60%	35.48%	20.43%	27.96%	7.53%		
Personal contact with sales representative and her/his recommendations	11	21	19	27	15	2,62	8
	11.83%	22.58%	20.43%	29.03%	16.13%		
Advertisement	1	16	15	40	21	3,04	9
	1.08%	17.20%	16.13%	43.01%	22.58%		
No matter what, I prefer conventional cars	6	1	28	28	30	3,26	10
	6.45%	1.08%	30.11%	30.11%	32.26%		

Source: own results n=93

The data in the Table 3 dedicated to factors that discourages consumers to buy an electric car confirm the previous results. We found out that the price of an electric car is the most important factor. Consumers lack the charging infrastructure and consider driving range per one charging cycle to be short.

Table 3: Which factors discourage you to buy an electric car?

Factor	Average	Rank
High price of electric vehicles	1.72	1
Lack of charging stations	2.12	2
Short driving range per one charging cycle	2.31	3
Low level of technological advancement in the field of electromobility	3.09	4

Source: own results n=93

In accordance with the aims of this paper we dedicated the pre-research to identify the barriers of electromobility development. We focused on consumer´s point of view. The research question "What are the barriers of the mass implementation of electromobility in the passenger transportation?" reveals what consumers consider barriers to the development of electromobility. We have to pay special attention to these factors, to remove them or improve them in order to support electromobility. As results in table 4 show, from the consumers' point of view the most important barriers are (1) high price of electric cars, (2) economic and political interests of mining companies and producers of conventional fuels and (3) network of charging stations alongside road infrastructure.

Table 4. Barriers of the mass implementation of electromobility

Barrier	1 - Yes, certainly	2 - Yes, maybe	I do not know	3 - No, probably not	4 - No, certainly not	Average
High price of electric vehicles - cars	52	29	5	5	2	1.43
	55.91%	31.18%	5.38%	5.38%	2.15%	
Low power drive	8	19	20	31	15	2.14
	8.60%	20.43%	21.51%	33.33%	16.13%	
All-electric range of batteries, i.e. short driving range per one charging cycle, too	33	43	10	7	0	1.51
	35.48%	46.24%	10.75%	7.53%	0.00%	
Network of charging stations alongside road infrastructure	50	34	3	6	0	1.46
	53.76%	36.56%	3.23%	6.45%	0.00%	
Economic and political interests of mining companies and producers of conventional fuels (diesel, gasoline)	39	32	12	9	1	1.44
	41.94%	34.41%	12.90%	9.68%	1.08%	

Disinterest of consumers caused by their low awareness about electric vehicles	14	31	23	23	2	1.65
	15.05%	33.33%	24.73%	24.73%	2.15%	

Source: own results n=93

New registrations of electric cars hit a new record in 2016, with over 750 thousand sales worldwide. Scenarios on electric car deployment seem to confirm the positive signals, indicating a good chance that the electric car stock will range between 9 million and 20 million by 2020 and between 40 million and 70 million by 2025. Therefore we were also interested whether the consumers consider buying an electric car in the future; what facts can influence their decision to buy an electric car in the future. Based on the results evaluation (see Table 4) we can conclude that for the vast majority of consumers (75.27%) the main problem relates to battery charging in their place of residence. At present the majority of population lives in flats with no possibility to charge the car battery at the parking lots. Moreover, consumers could express their opinion on other facts that should change their consumer decision making process. They were supposed to add the claim "I would buy an electric car in the future if …" We would like to pinpoint the claims with which more than one half of consumers agree:

- 62.37% of consumers agreed that charging infrastructure would be developed sufficiently,
- 58.06% of consumers would buy an electric car if the operational costs would be lower by 50% compared to the conventional cars,
- 55.91% of consumers prefer the battery life to be longer than 7 years,
- 54.84% of consumers expect state subsidy of 5.000 € at least for buying an electric car,
- 51.61% of consumers would buy an electric car if the price would be lower compared to the similar conventional car model.

Table 4. I would buy an electric car in the future if …

Claim	Yes, certainly	Yes, probably	I do not know / It is not important	No, probably not	No, certainly not
the battery charging would last max. 30 minutes	54	27	7	4	1
	58.06%	29.03%	7.53%	4.30%	1.08%
operational costs of the electric car would be lower by 20% compared to the conventional cars	48	26	11	6	2
	51.61%	27.96%	11.83%	6.45%	2.15%
operational costs of the electric car would be lower by 50% compared to the conventional cars	52	26	11	4	0
	55.91%	27.96%	11.83%	4.30%	0.00%
price of the electric car would be lower compared to the similar conventional car model	40	32	18	3	0
	43.01%	34.41%	19.35%	3.23%	0.00%
the battery life would be longer than 7 years	27	34	13	16	3
	29.03%	36.56%	13.98%	17.20%	3.23%
the costs of battery changing would be lower	30	30	13	13	7
	32.26%	32.26%	13.98%	13.98%	7,53%
the range of the electric vehicle models of the specific manufacturer would be wider	24	24	30	10	5
	25.81%	25.81%	32.26%	10.75%	5.38%
the model of electric and conventional car would be the same	33	23	17	14	6
	35.48%	24.73%	18.28%	15.05%	6.45%
the bus lanes would serve for electric cars	16	43	15	11	8
	17.20%	46.24%	16.13%	11.83%	8.60%
there is free parking in the city	51	23	8	9	2
	54.84%	24.73%	8.60%	9.68%	2.15%
I would get at least 2.000 € as a state subsidy	58	28	5	1	1
	62.37%	30.11%	5.38%	1.08%	1.08%

I would get at least 5.000 € as a state subsidy	70	17	4	1	1
	75.27%	18.28%	4.30%	1.08%	1.08%
the network of charging station would be sufficiently developed	1	16	15	40	21
	1.08%	17.20%	16.13%	43.01%	22.58%
I would have no problem to charge the battery in my place of residence	6	1	28	28	30
	6.45%	1.08%	30.11%	30.11%	32.26%

Source: own results n=93

2.3. Suggestions and Recommendations

Based on the pre-research results, we propose suggestions and recommendations designed to support the development of electromobility in Slovakia. While their processing we took into account the views and suggestions of consumers, but also the current state of electromobility in Slovakia. Based on identified barriers and interested parties that are responsible for and influence the development of electromobility we divided our suggestions and recommendations into three categories (see table 5).

Table 5. Barriers and recommendations of electromobility development

Interested Party	Barriers	Recommendations
Automotive industry (manufacturer and retailers)	• High investments in production technology and development of electric vehicles • Stocks and production plans of conventional cars • Customer demand for conventional cars	• To promote electric car models equally to car models with conventional drive • To provide service programmes and complementary services for electric cars • To offer completed information about electromobility and its advantages and benefits for customers • To inform customers about electric car models and conventional cars during purchasing equally
Charging stations	• Lack of charging stations network in the city districts, at the public parking lots and city parking zones, • Inadequate awareness on localization of charging stations alongside road infrastructure in Slovakia	• To develop and to expand network of charging stations at the public parking lots in densely populated areas • To simplify system of payments for electricity in the way that the payments would be included in the bills/invoices for household electricity consumption (at present customers use special pre-paid cards) • To strengthen cooperation with electricity distribution providers in the field of education activities and benefits for households
Government institutions and non-profit sector	• Relate to recommendations • Harmonization process of legislation • Electromobility is not subject of strategic documents (Strategy of energetic safety of the Slovak Republic)	• To provide benefits to the customers (discounts for electricity consumption, tax reduction, implementation of green taxes, permission to access downtowns • To increase % of state subsidy for electric vehicle purchase • To raise awareness about electric vehicles and their global benefits, i.e. via public media • Communication campaigns dedicated to increasing consumer awareness

Source: own results

We pinpoint some facts concerning our recommendations:

- For automotive industry – over the last decades the automotive industry has invested considerable amount of financial sources in technological development. This fact can limit the car producers in diversification of their product portfolio to modern technologies, including the electromobility. The expected return on investments does not enable transition to electromobility as dynamically as society would desire. Consumers' opinions may cause discrepancies between plans and possibilities of car producers and social demand for new technologies based on electromobility. Car producers which have recently decided to increase their investments in electromobility should also follow the trends at the consumer markets by adequate

presentation of the electric vehicle and conventional car models. Our pre-research results reveal that consumers expect to be more aware of electromobility even in points-of-sale, i.e. where supply meets demand for cars. The consumers perceive an electric car buying not only as a possibility to reduce operating costs but also as a social responsibility. This fact should be taken into account by car producers and dealers when promoting the benefits of electric vehicles. Precise and consumer-friendly information greatly encourages consumers to buy an electric car.

- The comfort of electric vehicle operation represents a key factor that consumers take into consideration when buying an electric car. We found out that consumers consider network of charging stations to be one of the most important barriers of the electromobility development. Charging stations in cooperation with electricity distribution providers are key players in the development of electromobility in Slovakia. The development of modern charging technologies (especially fast-charging stations) that guarantee higher comfort of the electric vehicle operation and the sophisticated payment options will greatly influence the electromobility market in Slovakia. In our opinion the potential benefit for consumers would be to create system of payments for electricity in the way that the payments for electric vehicle charging would be included in the bills/invoices for household electricity consumption.
- As there is no complex strategic document for the development of electromobility in Slovakia at the national level, there is no precise vision and scenarios of the Slovak electromobility market in the future. Government institutions should actively pursue a common dialogue with the key players of the electromobility market in order to create common platform for decision-making process and support of electromobility development. Table 5 includes the main recommendations for the public sector that are in compliance with the results of the socio-economic environment analysis and the conducted pre-research.

3. CONCLUSION

Based on the results of pre-research, the aim of this paper was to identify barriers and possibilities for development of electromobility and to suggest recommendations for the automotive industry (manufacturers and retailers of electric vehicles), associations of electromobility, companies providing electric vehicle services (charging stations), government institutions and the non-profit sector.

We conclude that 90% of consumers use car as a means of transport. The results also reveal that majority of consumers (62.37%) are not loyal to conventional cars at all. Only 7.53% consumers strictly prefer conventional cars. These results can be understood as positive signal for future of electromobility. According to Lauko, CEO of Greenway Infrastructure, electromobility will be significantly expanded in our region around the year 2020, when the price of new electric vehicle should be lower than a conventional car. He also expects increasing number of electric car by the year 2020 caused by decreasing of battery price. The number of electric cars may be around 20 million compared to present 2 million worldwide and thousands, probably ten thousand of electric cars at Slovak market (TASR, 2017).

In terms of electromobility development we focused on identifying the factors that discourage consumers to buy electric car. Consumers consider high price of electric car, lack of charging stations and short driving range per one charging cycle to be the most important factors why they do not want to buy electric car. However, based on current trends and predictions, we know that these factors will be improved in expected manner. It means the electric cars will be cheaper, the charging infrastructure will be developed and driving range of an electric car will be longer.

On the one hand, we identified the most important barriers of mass implementation of electromobility in urban transport from the consumers' point of view as follow: (1) high price of electric cars, (2) economic and political interests of mining companies and producers of conventional fuels (diesel, gasoline); and (3) lack of charging stations. Only one third of consumers (33.33%) probably agree that their disinterest caused by low awareness about electric vehicles is the barrier to develop electromobility.

On the other hand, we have found out what would motivate consumers to buy electric car at present. As the lower price of electric car, lower operational costs of electric car and state subsidy would motivate consumers the most, we can claim that these motivation factors correspond to the above mentioned results. Furthermore, we focused also on the consumer attitude toward using and/or buying electric vehicle in the future. If we generalize the results, consumers will be willing to buy an electric car if the charging infrastructure will be developed sufficiently, the operational costs will be lower by 50% compared to the conventional cars, the battery life will be longer than 7 years, state subsidy for purchasing electric car will be at least 5.000 € and the price of electric car will be lower compared to the similar conventional car model.

Based on the pre-research results and identified barriers, we propose suggestions and recommendations that can support electromobility development in Slovakia. Based on the interested parties that are responsible or play the main role in electromobility development, we divided our suggestions into 3 categories: (1) suggestions for manufacturers and retailers; (2) suggestions for charging stations; and (3) recommendations for government institutions and non-profit sector.

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