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Professional paper

The impact of electromobility on the reduction of external transport costs in urban areas

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Abstract – **Nowadays, electric vehicles are considered as technology that will significantly reduce the total external costs of road traffic in the future. The advantages of electric vehicles can be seen in the areas of climate change, air pollution in congested urban centres and causing less noise. There is a growing need for more detailed analysis and research in the context of the impact of external costs on the population, but also on the globe itself.**

Keywords – **electric vehicles, technology of the future, external traffic costs.**

I. INTRODUCTION

In modern times, when the whole world pays great attention to the preservation and protection of the environment (the effects of global warming, climate change, drastic reduction of fossil fuels, air pollution, etc.), on which traffic itself has a great impact, electromobility stands out as a specific term whose future use is certainly bright. That technology (energy) and the means of transportation that use it (cars, trucks, bicycles, buses, etc.) describe three properties, namely environmental friendliness, quietness and efficiency. But, there are still a number of obstacles that need to be overcome in order to reap the full benefits of electromobility. The main guiding thought or idea in the development of electromobility is the phrase: "Mobility in the future must at all costs become neutral in terms of CO2." Electric and hybrid vehicles emit far less exhaust fumes into the air than vehicles with internal combustion engines. Today, great emphasis is placed on personal electric vehicles. Many states provide incentives for the purchase of electric vehicles, but this does not solve the two biggest problems in traffic, which are traffic safety and congestion in large urban areas. However, what this transition to a completely new form of energy will actually mean and what impact it will have on all areas of human activity, with special reference to urban transport, will be extensively and in detail elaborated and analysed through processing in this paper.

II. ABOUT THE CONCEPT OF ELECTROMOBILITY

Electromobility or “e-mobility” is the use of various electric vehicles such as cars, trucks, bicycles, buses, etc. for transportation on roads around the world. The common characteristics, ie the properties of all of them, are that they are fully or partially driven with the use of an electric drive, they have a space for storing electricity, where they receive it mainly through the electricity network. Electric vehicles are very quiet, efficient, environmentally friendly, and in urban areas they are already used, in addition to private purposes, for the needs of delivery, transport, taxi, etc.

In addition to fully electric vehicles, the category of electromobility can include hybrid vehicles, which use or combine two technologies for propulsion. For slightly shorter distances, especially in urban areas, they mainly use electric drive, while the mileage for longer journeys is taken care of by an internal combustion engine. Hybrid vehicles can collect electricity during braking, but are mainly powered in a way that uses fully electric vehicles, ie at various electric charging stations, as shown above in Figure 1. In the world of technology, hybrid vehicles are treated as transitional, until all cars, trucks, bicycles, buses and other means of transport can be fully supplied with electricity in the future, regardless of any conditions. The comparison between electric and hybrid drive is shown below in Figure 1.

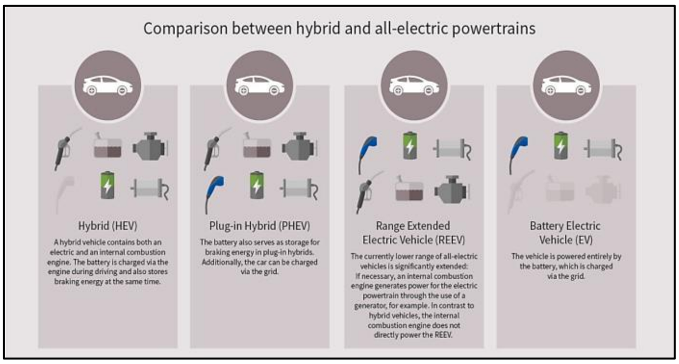

Fig. 1. Comparison of electric and hybrid drive
Source: What you need to know about electromobility. Infineon. München. 2018.

Nowadays, greenhouse gas emissions have a huge negative impact on the climate and our environment. Day by day, more and more CO2 enters the atmosphere, resulting in the Earth getting warmer and warmer. According to research conducted by the International Committee on Climate Change (IPCC), transport and its harmful effects are responsible for as much as 23% of all CO2 emissions in the world. According to estimates, the number of people living in urban areas (cities) will continue to grow more and more, where shall live, about 70% of the total world population, by 2050.

It can be said that e-vehicles are changing the way we move, and not just because they are more environmentally friendly. An electric car costs more than comparable petrol and diesel vehicles - mainly due to the high cost of battery production, although they have fallen slightly over the last few years.

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However, electricity is much cheaper than fossil fuels, and electric-powered vehicles require less frequent maintenance and repairs than those powered by a gasoline or diesel engine. E-vehicles do not require oil changes and various filters, and there is no exhaust system, belts and V-belts on them. An internal combustion engine has about 2,500 components that need to be manufactured and assembled, while an electric motor has only about 250 of them. Electric cars are serviced quickly using software updates (such as cell phones, computers, tablets, smart watches, etc.). The same requires a stable and fast internet connection, which can be a problem in more rural areas.

Lithium-ion batteries used in e-vehicles have a long service life, high energy density and can be constantly recharged. Batteries lose some of their capacity after 8 to 10 years, but that doesn't mean they are damaged, they simply store slightly less energy. Most electric cars today have batteries with a capacity of 20 to 60 kWh. In the future, batteries will be used in e-cars for the conception and stabilization of the so-called smart grids. If, for example, the sun and wind provide most of the energy supply capacity, a problem will arise - supply and demand for it will vary, depending on the weather and inconvenience. Therefore, intelligent technology, which will be incorporated into e-cars in the future, should be used to absorb and store excess energy, eg when there are many sunny days or the weather is extremely windy. On the other hand, with intelligent technology, excess energy could be transferred from the e-car back to the smart grid. By installing a photovoltaic system on the roof of their home, e-car owners can greatly reduce their dependence on external energy sources. Also, by implementing a wall box, unnecessary driving with an electric car to a service station can be eliminated.

According to BNEF, there are currently 4,000 e-buses in Europe (not only battery electric buses but also plugin hybrids, trolleybus IMC and fuel cell buses). However, 98% of electric buses are used in Chinese cities. Also, according to EV Volumes, there are 10.8 million battery-electric and plug-in hybrid vehicles in the world today. This number indicates approximately 0.5% of the total number of passenger cars traveling the world. Some forecasts say that by 2030 the number of such vehicles will increase by the next 30%. Some developed European countries are well above that average, so the percentage of electric vehicles in Norway is around 16%, while in Sweden and the Netherlands it is between 3 and 4%.

According to the European Environment Agency, as of the end of 2019, the largest number of BEV vehicles was in Germany, accounting for 34,280 vehicles. Germany was followed by the United Kingdom, which had more PHEV vehicles than Germany, with 44,334 thousand. Table 1 shows an overview by type of vehicle from 2010 to 2018 for EU-28. Share od electric vehicles id still to small to be significant.

Some countries in the European Union have introduced incentives to buy electric vehicles and install electric chargers. For example, some of them offers tax benefits, some certain percentage of the price or fixed incentives from €3000-5000.

Table 1
NUMBER OF ELECTRIC VEHICLES IN THE EU 28 FROM 2010 TO 2018

YEAR	BATTERY ELECTRIC	ELECTRIC PLUG-IN	SHARE OD ELECTRIC VEHICLES
2010	734	0	0.006
2011	7,759	0	0.06
2012	13,986	9,000	0.191
2013	24,175	31,167	0.466
2014	37,855	68,180	0.845
2015	56,756	103,553	1.074
2016	64,316	93,707	1.164
2017	97,143	126,898	1.481
2018	148,454	145,898	2.002

Source: author's work, data from: European Environment Agency. Electric vehicles as a proportion of the total fleet. Available on: https://www.eea.europa.eu/data-and-maps/indicators/proportion-of-vehicle-fleet-meeting-4/assessment-4

Although the Covid-19 pandemic slowed many branches and stunted the economy, micromobility seized the opportunity. The service of public e-scooters, e-bikes and e-mopeds is available in more than 600 cities in more than 50 countries around the world. Although it is impossible to get an accurate figure, as the number is increasing day by day, it is estimated that there are about 350 million such vehicles, which is about 25% of all two / three wheels in traffic worldwide. Most of them are in China.

Light commercial vehicles reached 380,000 units in 2019, and most truck manufacturers are still upgrading existing ones and testing larger and larger trucks for electricity.

III. ESTIMATED EXTERNAL COSTS FOR ELECTRIC VEHICLES

The external costs for which electric vehicles are responsible differ from those for vehicles with internal combustion engines mainly in two areas - air pollution and climate change. These two types of external costs largely depend on the method of estimation, the basic portfolio of power plants in a particular area, and the charging time of electric vehicles. Each of these segments increases the level of uncertainty in the final cost estimate. Another difference is in the creation of noise during the night, especially for traffic in urban areas.

Due to the need for comparison, it is assumed that the further development of components affecting the external costs of electric vehicles will be comparable to those generated by vehicles with internal combustion engines. The same applies to the external costs of components related to traffic safety, noise, vehicle production and traffic congestion. The cost of the component based on the development of the core power plant portfolio is related to air pollution and climate change.

As CO_2 emission costs are generally very high, it is considered that the external costs of climate change will remain constant as far as electric vehicles are concerned. However, as far as air pollution is concerned, external costs will be reduced to some extent, due to changes that will occur in the production (generation) of electricity.

In the area that includes the transport of people with different types of motor vehicles, no significant innovations are expected before the beginning of 2030, and this mainly refers to: driving cycles, vehicle design, population density, payment options, etc. There will be some changes in overall external traffic costs per individual vehicle should be based on the following assumptions (with the increasing use of electric vehicles, ie efforts to replace the current conventional vehicles):

1. **Traffic safety** - that area is being addressed with the increasing use of advanced in-vehicle technologies and the principles of the European Safety Vision for zero transport deaths by 2050. Therefore, it is assumed that by 2030 there will be about 50% fewer traffic deaths, which will directly affect the reduction of external costs of traffic accidents in the same amount.
2. **Air pollution** - as external costs in that area are already at a very low level (2.8% of total external costs in 2010), and technological progress is in a limited zone, ie at its peak, with more massive with the use of electric vehicles, only a marginal reduction of external costs of about 10% is expected by the beginning of 2030.
3. **Climate change** - although technological improvements in vehicles are foreseen in terms of fuel efficiency by around 40% (impact of new laws), on the other hand, the total unit cost per tonne of CO_2 is expected to increase from 120 to 200 euros, which will be ultimately identified as a balanced effect. However, the change in the value of external costs in this area could be more drastically affected by the potential breakthrough of biofuels in the automotive market.
4. **Noise pollution** - it is assumed that further developments in engine and tire technology will result in even "quieter" vehicles, which will have a positive impact on the reduction of traffic noise, as well as on external costs in the area, where it is expected to fall from about 10% by the beginning of 2030.
5. **Vehicle production** - assumptions are that the trend of reducing CO_2 emissions during vehicle production will continue (mainly due to the reduction of specific emissions for electricity production). Calculated, the figure should be reduced from 6 to 5 tons per e-vehicle by the beginning of 2030. However, the previously mentioned increase in unit costs of CO_2 to 200 euros will be reflected in an increase in external costs of as much as 1,000 euros per individual vehicle, which could seriously worry everyone in the automotive industry, including buyers (users) of vehicles.
6. **Traffic congestion** - external costs in this area will change differently in urban and rural areas. Thus, it will decrease in cities by about 10% by 2030 due to technological advances and various innovations in public transport systems, alternative modes of transport and IT systems, as well as more restrictive regulations for vehicles powered by internal combustion engines (petrol, diesel). On the other hand, it is assumed that external costs in rural areas will increase by the same amount, ie by 10%.

Table 2
E-VEHICLE APPLICATION AND EXPECTED EXTERNAL COST REDUCTION

External costs	Reduction until 2030
Safety	-50%
Air pollution	-10%
Climate change - fuel efficiency - total unit cost per tonne of CO_2	0% -40% +40%
Noise pollution	-10%
Vehicle production - reducing CO_2 emissions during vehicle production - total unit cost per tonne of CO_2	+25% -15% +40%
Traffic congestion - urban areas - rural areas	~ -10% -10% +10%
Urban VS rural areas	-6%
Ascending and descending processes	-10%

Source: author's work, data from: Jochem, P.; Doll, C.; Fichnter, W.: External costs of electric vehicles. Transportation Research Part D: Transport and Environment (Volume 42). MPRA. Karlsruhe. 2016.

7. **Urban Vs. rural areas** - on the roads between urban and rural areas, the share of total travel (number of total trips) is expected to decrease from 0.26 to 0.20, as well as within urban areas, which may ultimately be reflected in the reduction of external transport costs.
8. **Ascending and descending processes** - in this area, external costs are expected to be reduced by about 10%, mainly due to the growing awareness of the associated problems, which have so far been ignored.

With the declaration of a pandemic and global lockdown, many people were left at home, and thus, the otherwise congested streets as the biggest producers of air pollution, became empty. That lack of passenger cars on the streets caused a drop-in emissions of carbon dioxide, nitrogen dioxide and fine particulate matter. According to Google Population Mobility Report data, during lockdown, population mobility in many countries decreased by more than 50% compared to the same period last year, which certainly affected the reduction of external transport costs.

IV. Conclusion

According to the current situation in technical and technological development, electric vehicles certainly stand out as a promising technology for facing future challenges in road transport, but also for reducing the total external costs in the same branch of transport. For this purpose, a differentiation was made for electric vehicles and vehicles with internal combustion engines, from the economic and environmental aspect, and an analysis of external costs for both parties was made. Although we are aware that there are large uncertainties in estimating external costs according to the current situation, the differentiation is made based on the type of fuel, vehicle size, emission location, and time of day. According to the results of the calculation, the main advantages of using electric vehicles in terms of reducing external costs in urban areas can be: less pronounced impact on climate change, significantly lower emissions of pollutants into the air and causing less noise (night hours).

However, in the end

in the current situation the external costs of traffic generated by electric vehicles and vehicles with internal combustion engines (petrol, diesel, natural gas) do not differ significantly. However, in addition to all these small advantages for electric vehicles, the depletion of the current supply of fossil fuels on Earth, which according to current estimates should last until 2050, can be highlighted as a fundamental problem for vehicles with internal combustion engines. Also, the external costs of transport themselves largely depend on the portfolio of power plants for the production of motor fuels (different from country to country), as well as on the chosen strategy of users for charging electric vehicles. According to all the above, it can be said that with the implementation and increasing use of e-vehicles on roads, the basic challenges of motorized traffic have not yet been solved, while external costs with the largest share are still dominated by traffic congestion (81.4%). Therefore, as the main tool for reducing them, we will still have to use the reduction of the motorization rate, ie the replacement of travel with vehicles with some form of active mobility (walking, cycling, use of public transport, etc.), and thus affect the improvement of living conditions in urban areas (cities).

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