A C T A U N I V E R S I T A T I S N I C O L A I C O P E R N I C I
DOI:http://dx.doi.org/10.12775/AUNC_ZARZ.2020.1.001 ZARZĄDZANIE XLVII–NR 1 (2020)

Pierwsza wersja złożona 09.06.2020
Ostatnia wersja zaakceptowana 15.07.2020

ISSN (print) 1689-8966
ISSN (online) 2450-7040

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WHETHER THE DEVELOPMENT OF ELECTROMOBILITY POSITIVELY INFLUENCES THE QUALITY OF TRANSPORT SERVICES IN CITIES - CRITICAL ANALYSIS

A b s t r a c t: Interest in electromobility among the public has been growing over the last years. In order to determine the impact of the development of electric cars on the quality of urban transport services, factors that may affect the transport of passengers and cargo and related facilities or disadvantages should be analysed. The article presents electromobility characteristics and analyses of conditions related to this modernization. The shortcomings and risks of what is often referred to as the technology of the future - electromobility - are also presented.

K e y w o r d s: electromobility, transport.

J E L C o d e : O30, L90, R40

INTRODUCTION

The issue of electromobility is currently arousing a lot of emotion and is definitely timely in the era of consideration of environmental protection and sustainable development. Actually the transport revolution - electrification is already taking place before our eyes. Interestingly, not for the first time. The history of electric vehicles dates back to 1837 when Scottish chemist Robert Davidson constructed a vehicle powered by galvanic cells. 22 years later lead-acid batteries were invented and could be recharged [www.orpa.pl, 22.04.2020]. The first vehicles appeared in the 1880s and for those times they were relatively relia -ble, while motors were more efficient than internal combustion motors [www. leonardo-energy.pl, 22.04.2020]. Then gradually people were moving away from electric to combustion cars which became cheaper and began to reach further ranges also had better performance.

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In the years 1960-1980, environmental awareness and the willingness of Western countries to become independent of oil imports was growing, and more and more people expressed interest in electric cars [Survey of the Gallup Institute 1966]. But the biggest revolution came later. The 21st century brought a significant renaissance in electromobility and the emergence of a major player in the market - Tesla and the start of research and production of hybrids and electric cars. In 2014, more than 845,000 electric cars were registered worldwide, while four years later the number increased to 5,6 millions [www.electrive.net, 22.04.2020].

In 2018, the largest number of such cars was on the roads in China (2610000), the USA (1102450), and Norway (298210). In terms of market share, the companies'; individual market shares are most represented by Chinese BYD (517230), American Tesla (500390) and Japanese Nissan (379910), and, due to the increase in their sales in 2030, an expected share of electric cars in total vehicle sales forecast will be 15% [www.electrive.net, 22.04.2020].

It is clear that the development of electromobility is progressing, but will this have a positive impact on the quality of transport services in cities? This needs to be verified taking into account the many aspects related to the use of emission-free vehicles. The paper will attempt to analyse these considerations.

1. ELECTROMOBILITY, TRANSPORT SERVICE AND QUALITY

It is important to start by clarifying the concept of electromobility. It can be defined as the deliberate crossing of space using any means of transport with main or auxiliary electric propulsion [Załoga, 2013, p. 134]. „Electromobility or e-mobility is the use of electric cars as well as electric bicycles, electric motorcycles, e-buses and e-trucks. The common feature of all of them is that they are fully or partially electrically driven, have the means to store energy on board and derive energy mainly from the power grid" [www.elektromobilnosc.pl, 22.04.2020]. Furthermore, the concept covers manufacturing, marketing and distribution logistics issues related to the design, manufacture, acquisition and use of electric vehicles [www.terazsrodowisko.pl, 22.04.2020].

The undoubted advantages of electromobility are [Rzeczycki, Malinowska, Pokorska, 2018]:

- No emissions of pollutants and noise to the environment,
- High efficiency of motor structures,
- Possibility of recuperation of braking energy, thus enabling recharging of batteries and increasing efficiency from 5 to 20%,
- Low operating costs,
- Increased safety in case of an accident

As far as the other concepts in the subject are concerned, quality can be defined in many ways because of the relativity of the concept. According to the Polish Standard (PN-EN 9000:2001) „quality is the degree in which a set of inherent properties meets the requirements". The Greek philosopher Plato, on the other hand, spoke of it as „quality is a degree of perfection", while Philip Crosby, a well-known entrepreneur and pioneer of TQM's philosophy, said: „Quality is compliance with requirements".

A transport service is the result of the need of moving goods from one place to another in order to meet a specific need. An intensive increase in the exchange of goods, including international trade, progressive specialisation in labour contributes to a significant development of transport services resulting in the movement of people, goods and also the provision of directly related additional services. If transport is a production process, the result of that will be the transport service [Przybylska, 2011, p. 239-240]. This service, like any other, is immaterial, and the image of it is being build on the quality of its performance. So it could be the appearance of the vehicles, the price, the professionalism of the staff and the final result. Transport services can be divided into:

- Passenger transport,
- Cargo transport.

Although urban transport services point to a focus on passenger transport, for example through public transport, taxi companies, or the increasingly popular car sharing services, in other words temporary, paid access to vehicles for people, and car pooling which is the gathering of several people together to commute to work by one means of transport. In April 2019 almost 4000 cars were available in car sharing systems in Poland [www.transport-publiczny.pl, 22.04.2020]. It is necessary to promote such behaviour in order to reduce the use of passenger cars by only one person. The development of these ideas may even result in a 10-fold decrease in the number of cars, while maintaining equal passenger satisfaction, based on forecasts showing that people would rather buy access to mobility services than invest in owning a car that is 90% of the time unused in a car park or garage. Thus, the user would not pay directly for insurance and periodic checks, and the parking spaces could be used for other kind of zoning.

According to the authors opinion, transport services related to cargo transport such as deliveries to shops, courier services or those related to move-in services should not be excluded. Especially courier companies are interested in electromobility, because with such a number of kilometers traveled every day it is economically profitable for them. For example, UPS declared that by 2040 they are planning to convert 40% of their fleet to alternative or high-tech vehicles [Rzeczycki, Malinowska, Pokorska, 2018].

In terms of marketing of transport services, attention is paid to the benefits for the customer, who is the traveller or the recipient of transport services. They

are often quite exceptional. It can be, for example, the prestige associated with travelling by expensive means of transport, or the respect felt in connection with a flight on a business class site, or the satisfaction of desire by driving the latest car. Undoubtedly, the electric car, which is still seen as a rarity in our society, would play an important role here and the possibility of such an experience would be unique for many people [Mindur, Rosa, 2014, p. 589]. The way the service is delivered is also important and nowadays customers appreciate the modernity, computerization of service purchase and easy availability via Internet or smartphone apps. It is hard to imagine that a customer would find such a modern service like electric car transport in a newspaper or heard on the radio. Information about modern technologies should be provided through the most popular information channel

2. ADDITIONAL BENEFITS OF DEVELOPING ELECTROMOBILITY

The electrification of transport brings with it something more, it will also be a decisive modernization of whole transport and all transport services determined simply by the desire for change and supported by the idea that since so much money has already been invested in the purchase of electric cars, why not also invest in infrastructure and all things related to these services. This is also related to innovative marketing, for example the use of telematics. This is why technologies for remote access and control of vehicles or loads via the telematics network are used. This is particularly important in the transport of a live load or dangerous goods. Providing the customer with information about the location, speed and direction of movement of specific vehicles, thanks to GPS technology increases the competitiveness of the service provider, as it increases clients level of satisfaction, making the service more pleasant to receive. Apart from the fact that electromobility is about moving electric vehicles using related infrastructure, the concept must also be linked to other components that are linked to e-mobility or stimulate each other.

Therefore, other technologies and social trends are developing in parallel with electromobility. It is worth noting the robotics and autonomous cars, where their progress is a result of the combination of electromobility and vehicle autonomy. A co-sharing economy is developing, based on sparing, for example means of transport and co-creation [Drożdż, 2018, p. 46], where the joint development of certain solutions is an example, and here it is worth mentioning Tesla, who made its patents on solutions in its electric cars available free of charge [www.mlodytechnik.pl, 25.04.2020].

The idea of Smart Cites which is. the cities' aspirations to use digital technology and automation for the needs of the local community, the use of autonomy,

wide implementation of telematics to raise citizens' lives, mass implementation of electric vehicles and development of energy infrastructure cannot be omitted either [Drożdż, 2018, p. 80]. In short, it can be said that this is an attempt to create symbiosis between information technologies and people. A related concept is also intelligent urban transport, which combines advanced information and communication technologies with the existing infrastructure to improve safety, environmental protection and efficiency of transport processes. This involves dynamic traffic control through traffic and incident monitoring systems, the introduction of telematics, like on displays at communication stops and the possibility to purchase electronic tickets and parking tickets. Intelligient Transport System (ITS) also influences drivers behaviour through the installation of devices measuring speed or warning against danger. Additional advantages are Park&Ride systems and GPS receivers in public transport and emergency vehicles [Drożdż, 2018, p. 160-161].

All of these solutions result in a number of benefits, which include [Drożdż, 2018, p. 166]:

- increase transport infrastructure capacity by 22.5%,
- increased safety - less accidents by about 50%,
- 40% reduction in urban emissions,
- Improving the comfort of individual, collective and pedestrian travel.

3. ELECTROMOBILITY CHARACTERISTICS AND CONDITIONS

The construction of an electric car does not differ significantly from the construction of classic combustion cars. Differences are noticeable in the motor and transmission systems, as well as the energy tank (battery) often located in the chassis. In a combustion car, the tank is designed to store fuel with a capacity of several tens of litres, while in electric cars, the battery is a complex device for storing energy, allowing it to be replenished by means of charging. It is the heaviest and most expensive element, often accounting for 20-30% (according to some data even 50%) of the vehicle's value and weighing up to 500kg. The weight of the battery can be an advantage when it comes to the right centre of gravity to improve driving characteristics and steering precision. The cells give engineers the opportunity to achieve the right centre of gravity, but also to design crumple zones, which are decisive in improving safety in possible accidents [www.pim.pl, 23.04.2020]. This is a further argument in support of the idea that electromobility can have a positive impact on the quality of transport services, in this case by increasing safety. Today, lithium-ion batteries are used.

An unquestionable incentive for the development of electromobility is the desire to reduce the external costs of transport with a particular emphasis on the costs associated with climate change.

In order to measure their impact, carbon dioxide emissions are taken into account, where the cost of 1 tonne emission is 70-200 euro and, in relation to climate change, 135 euro [Wielądek, 2014, p. 728]. Electric means of transport have great potential for successive reduction of CO_2 emissions from transport activities, but it is important to assume that electricity will be sourced from renewable sources and that vehicles and, above all, cells will be made more environmentally friendly.

There are three milestones in the development of electromobility:

- the appearance of Tesla in the automotive market,
- Improved transport services such as Uber, Bolt and the dissemination of the idea of sparing like car sharing and car pooling,
- market entry of autonomous vehicle solutions and traffic control.

The electrification of the transport system is a long-term goal and challenge for Poland and Europe, but it is gradually being pursued on the basis of the implementation of air pollution reduction policy. More over, the citizens themselves see the economic and environmental advantages of electric cars and decide to buy them. Possible economic benefits that may arise around electromobility are the emergence of additional services related to vehicle servicing and charging. It is necessary to involve all opearators in creating this innovative transport system on the basis of existing regulations. Development must be stable and sustainable so that all citizens benefit from it, not just individuals or groups [Drożdż, 2018, p. 113]. Governments' stimulation to inform citizens about the benefits of electrification of transport and subsidies for those who choose to buy electric cars plays a major role in this. Many countries argue that the electromobility associated with the use of new technologies may be a necessary solution to problems such as the overloading of urban infrastructure by cars or environmental pressures [Gajewski, Paprocki, Pieriegud, 2019, p. 67]. The number of passenger cars per capita is constantly increasing. Of course, it is possible to encourage at least part of the population to use public transport if it is efficient, but it is not always possible to completely dispense with individual means of transport. Therefore, the aim is to make the cars as little of a nuisance as possible to the environment and electric vehicles meet this requirement.

The role of electromobility in transport is currently growing rapidly. This is due to decarbonisation policies and sustainable development trends imposed mainly by the European Union. Legislative changes are expected to result in a desire and obligation to replace the rolling stock with electric one, and thus reduce the problem of smog and noise in urban areas to improve living conditions [Rzeczycki, Malinowska, Pokorska, 2018]. Programmes supporting the production and implementation of electric vehicles include the E-bus programme, which stimulates the design and production of Polish electric public transport vehicles. It assumes the creation of a market worth of a leatst 2.5 billion PLN,

which means about thousand produced electric buses per year. The programme is to influence the development of new technologies and business models related to electric city buses and charging infrastructure. A similar programme for rail transport is Luxtorpeda 2.0, which stimulates the development of technology and production of Polish rail vehicles, mainly passenger vehicles [Drożdż, 2018, p. 186]. Many cities have already decided to introduce steps to encourage electric car use, such as subsidies to purchase a vehicle, the possibility of using bus lines for zero-emission car users, or free city parking lots and many others. An example is the Dutch city of Utrecht, where the entry of lorries and vans into the city is to be restricted by legal changes. By 2025, however, electric lorries and vans are to be used in the city centre, while for the rest, entry will be prohibited [Rzeczycki, Malinowska, Pokorska, 2018].

However, studies in logistics so far have shown that it is profitable to use electric cars to transport loads not heavier than 1 tonne, for larger loads, so far diesel cars have been performing better. Due to the low payload, it is suggested to use these solutions for municipal distribution centres, postal and courier companies. For example, in Poland, the Ursus company has prepared for the Polish Post vehicles with a load capacity of 600kg and range of 140km. The fact that the profitability of owning an electric car increases with the increase of exploitation intensity makes them attractive as a fleet of company vehicles [Rzeczycki, Malinowska, Pokorska, 2018].

The public transport sector also needs to be mentioned, because it is now experiencing a dynamic increase in the use of low-carbon vehicles, and this trend may be exacerbated by EU subsidies and requirements. These measures have the potential to reduce dust and gas emissions that are harmful to health and the environment [Gajewski, Paprocki, Pieriegud, 2019, p. 19-20]. So far, more than 40% of buses in Poland are over 10 years old, and almost 20% meet the old Euro 1 and Euro 2 standards, so they are suitable for replacement [www.cire.pl, 25.04.2020]. Among the low-emission buses, the most are those powered by CNG and LNG, but it is electric buses that record the highest sales growth, they best meet the latest environmental requirements of cities regarding noise and pollution emissions. According to the assumptions of the Electromobility Development Plan adopted in 2017, 1000 electric buses are to be used in Poland by 2025 [Gajewski, Paprocki, Pieriegud, 2019, p. 21]. Many of them are to be manufactured by the Polish company Solaris, which has gained global respect thanks to its products. Thanks to this company, Poland is the leader in the region in terms of the number of electric buses purchased by local authorities. It is a factor that favours electrification of public transport in Poland.

4. CHALLENGES FOR ELECTROMOBILITY

Currently, the biggest challenges and problems facing the implementation of electromobility are to improve three factors:

- of the range,
- the speed of charging,
- prices.

These parameters are currently practically unacceptable in relation to combustion cars, but given the development of technology, they will improve in a short time.

In terms of price, for example, in 2017 with a capacity of 1 kWh it cost about 209 US dollars, while in 2025 it is projected to fall to 100 dollars [Witkowski, Wiśniewski, 2018, p. 51]. At present, the majority of transport and transport services are based on tariff prices. The use of electric cars in transport could significantly reduce these prices. For example, the aim is for passenger cars to consume no more than 15 kWh/100km, which gives a cost of about 8 PLN/100km [www.info-car.pl, 25.04.2020], while courier vans to a maximum of 45 kWh/100km or about 24 PLN/100km [www.wysokienapiecie.pl, 25.04.2020].

Tesla presented a Tesla Semi truck, whose distribution is to start in 2020. Its range has been defined as over 800 km and the cost of 100 km is to be around 30 PLN, which is what the users of traditional diesel-powered passenger cars are currently paying. The performance of the Tesla truck is impressive and the time to fully charge the vehicle is expected to be about 30 minutes thanks to the use of the Tesla Megacharger charging station at the manufacturer's declaration that they are to be installed worldwide at a fixed price per 1 kWh of 7 cents which is about 0,25 PLN. This is a very small price, since in Poland 1 kWh costs more than 0.5 PLN [www.leftlane.pl, 25.04.2020].

The speed of recharging can be improved by the increasingly sophisticated and high-performance chargers and the development of batteries that would become more susceptible to rapid recharging.

Work is also in progress on solid electrolyte batteries that are safer than standard lithium-ion batteries and have a double energy density. The highest possible density value is desirable. The commercialization of TeraWatt's high energy density lithium-polymer and solid-state cells is important [www. elektrowoz.pl, 09.02.2020]. Their introduction on the market can provide a range comparable to that of a diesel car, up to 800km on a single charge [www.orpa.pl, 09.02.2020].

5. RISKS AND DISADVANTAGES OF E-MOBILITY

On the other hand, it is worth mentioning the disadvantages of electromobility, which are undeniable and may affect the quality of transport services. The most frequently mentioned are the definitely high cost of purchase in relation to

a traditional car and the periodic replacement of batteries, whose price is also still high. Moreover, the infrastructure for electric vehicles is not yet as dense as it should be. There is a lack of chargers distributed throughout the city, mainly those allowing for quick recharging. It is worth adding that the purchase of chargers is also expensive, and unfortunately even necessary for the individual user, unless the vehicle can be charged with an ordinary mains socket and the person does not expect increased charging power to accelerate the process.

Many people, especially the elderly, are afraid of new technologies and are not necessarily willing to invest in an electric vehicle, especially when this investment has little potential for return. There is also a premise that as long as finite oil reserves are being extracted, this extraction lobby may block significant advances in electromobile technology to protect against the loss of huge amounts of money. Currently few countries use mostly renewable energy sources. Actually, only Scandinavian countries use 40-60% of renewable energy, while in Poland it is only about 10% [www.ec.europa.eu, 22.04.2020]. There are also many indications that the production of electric cars is harmful, especially cells - currently lithium-ion ones. It is estimated that it will take about 7 years for the environmental value produced by one electric car to exceed the environmental costs of producing components. It should not be forgotten that the production of an electric car itself absorbs certain resources, the extraction of which is harmful, the production processes emit huge amounts of pollutants, headed by carbon dioxide, whose emission reduced to zero is to be the main postulate of electromobility. This creates a paradox. This is compounded by the over-intrusive action of some authorities, for example, forcing local governments to purchase a certain amount of electric public transport vehicles without realising the economic calculation that this entails. This can lead to an unreasonable use of public funds [Gajewski, Paprocki, Pieriegud, 2019, p. 98–99].

The interest in electromobility can be seen as part of the fascination with the development and diffusion of new technologies, including digital technologies, and technologies for the generation, transmission and use of electricity. This technology is gaining momentum through an increasing emphasis on ecology in the education of young people. It seems that electrification of transport will be inevitable, as many facts indicate, especially the current increase in interest in electromobility. There is no doubt that in many ways, with today's development of this technology, guided by economic calculation and consumer freedom of choice, it can be said that the concept of electromobility in a sense is utopian [Gajewski, Paprocki, Pieriegud, 2019, p. 99]. However, there may be an unexpected innovation in the near future that will quickly make us forget about combustion vehicles. Until there is a revolution in reducing the weight of the battery while at the same time increasing its potential, it will be difficult to talk about a breakthrough and a massive shift to this technology. Environmental

issues are widely discussed by governmental and non-governmental organisations and the emphasis on this also affects the search for alternative transport solutions. The solution to the issue of high emissivity of means of transport can be the large-scale use of electric cars with the necessary infrastructure. There is no doubt that electromobility is crucial for the future development of economic systems both globally and at European and national level. However, Poland is still at the beginning of a long path of electromobility development. Whether the development of electromobility will have a positive impact on the quality of transport services in cities is difficult to make a clear statement. It all depends on whether the development is responsible and well managed. However, if most of the disadvantages of electromobility can be ruled out, there is great potential for a revolution in urban transport services on a large scale.

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