



ANALYSIS OF OPPORTUNITIES FOR THE DEVELOPMENT OF ELECTROMOBILITY OF URBAN TRANSPORT ON THE TERRITORY OF PILA DISTRICT

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Abstract

In the transportation industry, electromobility has become an indisputable trend that is not going to go away any time soon. According to analyses of the industry's growth, all signs point to an increase in the number of electric automobiles, which will eventually supplant conventional combustion vehicles. One electric vehicle is now sold every 1,000 people in Poland, where they make up roughly 4.5% of total automobile sales. 20,253 units were sold in 2021, a 93% increase from the previous year (*Elektromobilność...*, 2022). The continued efforts of the world's leading economies to cut greenhouse gas emissions, which are hastening climate change, are unquestionably a significant element supporting this course.

The aim of this article is to analyse the potential for the development of electromobility in the urban transport sector in Piła County. However, the success of this analysis will be possible during a period of transition in a number of important spheres. On the basis of the analysis, it can be concluded that such a possibility exists, as cars and other vehicles powered by electricity are becoming an alternative to traditional combustion vehicles, also reducing emissions of pollutants harmful to the environment. On the other hand, however, there are public concerns about this possibility, due to fires in electric cars, among other things.

ANALIZA MOŻLIWOŚCI ROZWOJU ELEKTROMOBILNOŚCI TRANSPORTU MIEJSKIEGO NA TERENIE POWIATU PILSKIEGO

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Abstrakt

Elektromobilność w transporcie stanowi obecnie trend, który zapewne szybko nie zniknie z przestrzeni gospodarki światowej. Wszelkie wskaźniki odnoszące się do badań rozwoju tej gałęzi przemysłu pokazują, że liczba samochodów z napędem elektrycznym będzie wzrastała coraz szybciej, a z czasem ten typ pojazdów wyprze tradycyjne auta spalinowe. Przykładowo w Polsce auta elektryczne to około 4,5% wszystkich sprzedawanych aut i obecnie na 1000 mieszkańców przypada jeden taki samochód. W 2021 roku sprzedano 20 253 sztuk, czyli o 93% więcej niż w roku poprzednim (*Elektromobilność...*, 2022). Ważnym czynnikiem potwierdzającym tę drogę jest na pewno ciągle dążenie największych gospodarek świata do ograniczenia emisji gazów cieplarnianych, powodujących zbyt szybkie zmiany klimatu.

Celem projektu jest rozwój elektromobilności w sektorze transportu miejskiego na terenie powiatu pilskiego. Sukces tego przedsięwzięcia będzie jednak możliwy w momencie przeobrażeń w wielu istotnych sferach. Być może jest to odniesienie bardziej globalne, lecz rozwój wielu dziedzin sprzyjających elektromobilności na szczeblu krajowym będzie wpływał na przyspieszenie wprowadzania nowych rozwiązań na poziomie mikroregionalnym (samorządowym), czyli w naszym przypadku w transporcie miejskim na terenie powiatu pilskiego.

Introduction

In the world of transportation, electromobility has become an indisputable trend that is not expected to go away any time soon. According to analyses of the industry's growth, all signs point to an increase in the number of electric automobiles, which will eventually supplant conventional combustion vehicles. One electric vehicle is now sold every 1,000 people in Poland, where they make up roughly 4.5% of total automobile sales. 20,253 units were sold in 2021, a 93% increase from the previous year (*Elektromobilność...*, 2022). The continuous efforts of the world's main economies to cut greenhouse gas emissions, which hasten climate change, are undoubtedly a significant element supporting this course.

The creation of a policy for electromobility is crucial. It would actually be more correct to use the word “electrotransport” and even more correct to speak of low-emission transport, but the term “electromobility” is now widely used in the literature (Altenburg *et al.*, 2016; Bartłomiejczyk & Kołacz, 2020; May, 2018; Pietrzak & Pietrzak, 2019) This issue has also been addressed by the following researchers (Połom & Wiśniewski, 2021; Wasik *et al.*, 2018; Yigitcanlar, 2022). By this, we mean all propulsion technologies that guarantee there are no emissions produced throughout the process of supplying the energy required to drive the vehicle, at least initially. Poland used 17% renewable energy in 2020, with the remainder coming from fossil fuels. In terms of statistics, Poland is leading the pack when it comes to the use of fossil fuels to generate power. Sweden, with just 2% of energy output in 2020 came from fossil fuels, was one of the countries with the lowest fossil fuel consumption.

The use of electric vehicles is becoming increasingly popular (Chinoracky *et al.*, 2022) and the e-concept’s proposed solutions are seen to be the answer to the environmental issues that face contemporary cities. The need to find solutions that lessen congestion, road is influenced by the intensification of travel, especially urban travel using transportation modes, as well as the increase in travel related to the distribution of goods and incident transport in cities (Diana *et al.*, 2020), as a result of the growth of e-commerce and the expansion of the package of courier services, especially in recent years as a result of COVID-19 (Kuzior *et al.*, 2022) and the continued growth of the urban population.

Electromobility principally refers to the use of electric vehicles for transportation of people and goods, such as e-cars, e-bikes, e-motorcycles, e-buses, or e-tractors (Bielski & Bednarczyk, 2020; Ebenezer *et al.*, 2021; Gao & Zhu, 2022; Netzer *et al.*, 2022). The prefix “e” makes it obvious that these cars are either entirely or partially powered by electricity, drawing power from the electric grid and storing it in batteries with the proper design. Such vehicles are perfectly suited for usage as delivery vehicles, taxis, shared automobiles, and eventually autonomous vehicles in urban environments (Campisi *et al.*, 2022). The absence of noise pollution, zero emissions, and efficiency are unquestionably benefits of such cars (Jung & Koo, 2018) It is also important to note that COVID-19 has altered Polish inhabitants’ mobility (Gorzelańczyk, 2020; 2022).

The aim of the analysis is to develop electromobility in the urban transport sector in Pila District. However, the success of this analysis will be possible at the moment of transformation in many important spheres. This may be a more global reference, but the development of many areas favorable to electromobility at the national level, will accelerate the introduction of new solutions at the micro-regional (local government) level, i.e. in the analyzed case in Pila District in urban transport.

Assumptions of the Urban Transport Electromobility Development Analysis

In the case of the development of electromobility of urban transport, the public administration plays an important dual role. On the one hand, it must coordinate the entire undertaking, keeping in mind the appropriate pace of change in individual spheres. On the other hand, it is the recipient of transformations whose impetus is the design, use and development of the emerging infrastructure and vehicle market. The full cooperation of the central and local administrations is important. The good examples of countries where electromobility has been doing well for years (Norway, Germany, the Netherlands) show that the driving force behind the development of the market is both the long-term economic and environmental policies of governments and the response to local needs.

Means of Transport in Electromobile Urban Transport

In the planned analysis of electromobility opportunities in urban transportation, we can identify several means of transportation that can contribute to increasing its offer and attractiveness in public space.

The first means of transportation, the most popular, which has been in operation for several years in Pila District, is the electric bus, which is the largest vehicle among those available and possible to introduce in urban space. The zero-emission fleet of urban transportation in this size range includes all electric buses, namely: battery vehicles, hydrogen vehicles and trolleybuses. The first two types seem to be the most feasible proposal for introduction in the urban transportation space of Pila District. On the other hand, the third type of vehicles – trolleybuses, in the case of the study area, would generate very high costs for the preparation of infrastructure facilities that do not currently exist.

At this point it is worth mentioning how an electric vehicle works. Its most important component, of course, is the system responsible for supplying electricity to the vehicle. The traction battery, commonly known as the battery, is the heart of the vehicle and its energy storage. It is what keeps the vehicle powered. The battery works by interconnected cells, the number of which varies from a few to many thousands, or even in the form of whole blocks of cells. Their parallel or series arrangement means that the traction battery in electric vehicles can reach considerable size, and for this reason it is usually placed in the chassis. Batteries differ primarily in their life cycle length, chemical composition and weight. Currently, lithium-ion batteries are the most popular, and the range of a vehicle on a single charge can reach about 200 km, considering buses (*Strategia rozwoju elektromobilności...*, 2022).

Let's also look at the types of batteries, which we can divide by chemical composition. The first group is lithium-ion batteries, which are divided into (*Strategia rozwoju elektromobilności...*, 2022):

- NMC (lithium-nickel-cobalt-manganese);
- LTO (lithium-titanium);
- LMO (lithium-manganese);
- LFP (lithium-iron-phosphate);
- NCA (lithium-nickel-cobalt-aluminum).

Of the aforementioned types, lithium-nickel-cobalt-manganese batteries are the most popular among electric vehicle manufacturers (Chargers, 2022). Traction batteries (and the materials used to build them) must meet a number of properties that are often difficult to reconcile. These include:

- performance and operational reliability;
- trouble-free operation and the absence of noticeable changes that degrade performance characteristics;
- relatively low production and operating costs;
- no or the least possible burden on the environment;
- high energy density and useful dispatchable power, which translates into the distance that can be covered.

In order to serve an area covered by urban transportation, a battery with a capacity of at least 120 kWh should be selected. In this case, charging time is estimated at 7.4 minutes in summer and 12.7 minutes in winter, with a possible mileage of 30-50 km.

As for the former means of urban transportation, it is worth noting that an electric scooter is definitely more economical than an internal combustion engine, as it consumes 2.5 kWh per 100 km, while an internal combustion engine uses about 3 liters of gasoline per 100 km. Electric scooters are equipped with gel or lithium-ion batteries. In addition, it can ride at a top speed of up to 45 km/h. The scooter is able to travel about 80 km on a single battery, which is a very good result in an urban space, since the city of Sawtooth itself and its surroundings is not a large metropolitan area. According to some data, sustainable urban planning definitely reduces the number of necessary daily transportation of city residents by up to 40-50% (Karlik, 2022).

Another proposal for the use of an electromobile vehicle in urban transportation is the electric scooter. It is worth mentioning that this means of transportation is not at all an invention of the 21st century, as the first electric scooter was developed as early as 1895 in the United States. In the modern development of scooters in our country, 2018 was a breakthrough year, when e-scooters with the possibility of mobile rental appeared in the space of Polish cities. The new lithium-ion batteries used at that time allowed them to move for 3-4 hours at a speed of 30 km/h. The first Polish city where an e-scooter system appeared was Wrocław (Jarosiński, 2021).

The use of electric scooters brings with it a number of advantages that may determine their success in the urban transportation electromobility space (Jarosiński, 2021):

- they are among the vehicles with high maneuverability and compact size, which allows them to move freely around the city, including overcoming any obstacles;
- can cover distances three times faster than moving on foot (accelerating to speeds of about 25 km/h);
- contribute to greater environmental protection compared to the car;
- allow you to bypass traffic jams;
- using a scooter you do not have to worry about parking and incur additional parking costs in the city;
- riding a scooter benefits from the pleasure caused by the ride itself and is a form of recreation.

Electric bicycles also have the potential to become another transportation alternative for people going about their daily lives in urban spaces. It is a means of locomotion classified as a single-track vehicle similar in design to a regular bicycle, which, as in its traditional form, is powered by human muscle power, but the additional source of energy is an electric motor.

In addition to lower maintenance costs, electric bicycles have many other advantages. This vehicle does not generate the exhaust fumes that are produced when using vehicles with internal combustion engines. This is a big plus for the environment. Electric bicycles contribute to fitness and well-being by providing a daily dose of outdoor exercise while reducing physical exertion, which is very beneficial during hot weather, for example. Using electric bicycles is also convenient, thanks to the ease of changing the battery and the ease of charging. Charging can be done anywhere with access to the electric grid, and the most important advantage is that it does not require specialized equipment (Wasik *et al.*, 2018).

Another vehicle in urban transportation is also an electric car, which, thanks to its longer range, can be a transportation alternative not only for residents of Tartak, but also for neighboring towns and the entire county.

Electromobility Infrastructure for Urban Transport

An essential element for the success of electromobility development in urban transport in Pila District will also be a properly prepared infrastructure.

The necessary infrastructure for urban transportation, which is the basis for the operation of electric buses in Pila District, includes charging stations. The current options on the market, which apply to all vehicles, are (Rajé *et al.*, 2018):

– solar charging – made possible by photovoltaic panels mounted on the roof of the vehicle; for now, however, the energy from a day's charging only allows the vehicle to travel up to 5 km;

– pantograph charging – mainly used in buses; involves automatic connection of the installation on the roof of the vehicle to the charging station by means of a retractable pantograph;

– wireless (inductive) charging – wireless charging installations most often use inductive energy transfer, thanks to inductance or magnetic resonance technology, which are currently in the testing phase; this solution could be used in electric vehicles;

– in the testing phase; this solution could replace traditional charging, but could also help extend vehicle range – for example, by charging buses while they are stationary;

– wired charging – involves connecting the car itself to the charging device via a cable.

In Pila, pantograph chargers – on the order of 400 kW – should be installed on selected loops outside the Municipal Transport Company depot. In addition, stationary chargers could be installed at depots to fully charge and stabilize the batteries on a daily basis, and these would be assigned to each electric bus. Over time, as more vehicles of this type are gradually deployed, further supporting investments should be made, if only in the form of building more charging stations (*Strategia rozwoju elektromobilności...*, 2021):

– stations with an inverted pantograph, set up on a selected loop, with enough power to charge a bus, which should make a minimum of two runs and go down to the depot;

– free charging – at the Municipal Transport Company headquarters on Łączna Street, with enough power to charge a bus in no more than 4 hours; while implementing appropriate expansion of distribution and power supply networks and transformer stations, if necessary.

The process of implementing the infrastructure needed for a new fleet of electric buses in Pila District will be the biggest challenge for electromobility development. Significant cash outlays are needed to purchase new electric vehicles and build charging stations. It is also necessary to implement appropriate logistical solutions – the deployment of chargers throughout the district, as well as the reconstruction of the bus depot in Pila.

As for the implementation of other means of transportation into urban space, the outlay may be small. In the case of scooters and electric scooters, local government approvals will suffice, allowing companies that currently have a very well-developed service offer of this type to exist. To encourage investors, concessions such as tax exemptions can be introduced.

The infrastructure for scooters, bicycles and scooters is basically already in place, as vehicles of this type can travel on current streets and bike paths (in the case of scooters and bicycles). In order to increase the attractiveness and speed

of movement of these vehicles around the city, the construction of more bicycle paths or the separation of additional lanes on the roadway could be included in the planning of the space of Pila. Of course, there is also a need for spaces dedicated to parking such vehicles, which will not interfere with the movement of pedestrians and other means of transport.

In the case of electric cars, the urban transportation market can also operate on the basis of mobile rental of these vehicles. This process is made possible by so-called car-sharing, a mobile service that allows use through an app. Unlike traditional car rental, the user does not have to return the car to the place where it was picked up, but leave it at any convenient location. The service is particularly useful for occasional car users who drive less than 10,000 kilometers a year. According to some views, the car-sharing service may also eventually reduce the number of cars in cities through more efficient use of transportation (Olejniczak & Mendakiewicz, 2018).

The Economics of Electromobility

What continues to discourage vehicle users from choosing the electric version is undoubtedly the price. In order to popularize electric vehicles on a wider scale, it is necessary to significantly reduce the difference in the price of obtaining such vehicles compared to combustion cars, given that for a group of players, the subsequent cost of operation is also as important as the purchase price.

For example, the cost of driving 100 kilometers in an electric car is primarily influenced by the price of electricity (1 kWh). Many studies also take into account the cost of battery operation. According to calculations by Ministry of Energy experts, the cost of driving 100 kilometers in an electric car is about PLN 10, assuming that such a car will consume up to 20 kWh of energy per 100 km. However, these are the costs of electricity itself and do not take into account any fees or commissions associated with the electric car charging service and the costs arising from battery consumption.

An important criterion for the development of electromobility is the electrification of the bus fleet in cities. An adequately expanded network of electric buses would manage to become a showcase for electromobility, and thus advertise and at the same time play an important role in spreading the idea to the public. Money for the replacement of the bus fleet used in urban transportation could also come from the proceeds of the emission fee, which is often included in environmental regulations and documents.

Summary

Road transport is one of the key factors in the proper development and functioning of the country's economy. Thanks to the expanded road infrastructure, it is constantly booming. It constantly leads the way, and what is more, it is the most frequently chosen form of moving people, as well as goods. Individual passenger transportation, resulting from the enrichment of society, as well as wide access to passenger cars, is considered the most convenient and fastest mode of communication over medium distances. Moreover, users are in no way constrained by public transport schedules. However, such movement is causing an increasing environmental impact. Nowadays, cars and other electric-powered vehicles are becoming an alternative to traditional internal combustion vehicles, also reducing emissions of environmentally harmful pollutants.

The awareness of Polish society is improving year by year, which at the same time encourages the development of electromobility, which is becoming increasingly popular. The understanding of the need to care for the environment is also growing. Thus, people themselves are striving to change their existing habits. In addition, the availability of various means of transportation, such as an electric scooter, electric scooter, electric bicycle or electric car rental, makes the choice easier and "within reach".

The prospect of future benefits and conveniences associated with the use of electric vehicles is very attractive, so electromobility in transportation is expected to grow even faster. Among the many positive factors, it is worth mentioning, for example, the convenience and speed of movement, the fuel savings, the lower expenses associated with the lack of repairs or replacement of equipment components without which traditional cars cannot function, the possibility of additional subsidies, as well as a number of mobility privileges.

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