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Development of electromobility in Poland through the use of electric road transport

Rozwój elektromobilności w Polsce z wykorzystaniem elektrycznego transportu drogowego

Abstract. The research study presents the subject related to the functioning of individual electric road transport and explains its influence on the development of electromobility in Poland. There were presented the importance of electromobility in the country, kinds of vehicles powered by electricity, the availability of charging infrastructure, advantages, and disadvantages of electric road transport. The conclusion was there are several problems of electromobility market development in Poland. The main barrier is the high price of purchasing an electric vehicle. The other problem includes insufficiently developed charging infrastructure, expensive installation of the individual power station, a limited number of kilometers to be driven on a single charge, and a long time of charging the battery.

Key words: electromobility, electric road transport, electric vehicle

Synopsis. W artykule podjęto tematykę związaną z funkcjonowaniem indywidualnego elektrycznego transportu drogowego oraz wyjaśnieniem jego wpływu na rozwój elektromobilności w Polsce. Przedstawiono znaczenie elektromobilności w kraju, rodzaje pojazdów zasilanych energią elektryczną, dostępność infrastruktury ładowania, wady i zalety elektrycznego transportu drogowego. Stwierdzono, iż istnieją liczne problemy rozwoju rynku elektromobilności w Polsce. Największą barierą jest zbyt wysoka cena zakupu pojazdu elektrycznego. Problemem jest też niewystarczająco rozbudowana infrastruktura ładowania, wysokie koszty instalacji indywidualnej stacji zasilania, ograniczona liczba kilometrów do przejechania na jednym ładowaniu oraz długi czas ładowania akumulatora.

Słowa kluczowe: elektromobilność, elektryczny transport drogowy, pojazd elektryczny

JEL codes: R40, R42

Introduction

Although the concept of electromobility has not been explicitly defined in the literature, some trends may provide directions for the theoretical foundation of this issue [Pilecki 2019]. An example is the recognition of electromobility as transport realized by battery-powered

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electric wheeled vehicles - both collective and individual [Drożdż 2018]. In contrast, another definition of electromobility presents it as the totality of issues related to the application and use of electrically powered means of transport. The concept addresses both technical and operational approaches of electric vehicles, technology, and charging infrastructure. In addition, the concept also covers social, economic, and legal issues related to the design, production, purchase, and use of electric vehicles [Elektromobilność].

The main objective of this paper is to present the functioning of individual electric road transport and to describe its influence on the development of electromobility in Poland.

The following specific objectives were set for the study: to define the significance of electromobility in Poland, to characterize the types of electrically-powered vehicles and the availability of infrastructure, to show the entities and tools assisting in the use of electric vehicle rental, to show the advantages and disadvantages of electric road transport commonly chosen by Polish citizens, to present the directions of electromobility development in the country. One research hypothesis was adopted in the study: The most important barrier to the development of the electromobility market in Poland was the high price of vehicles.

Materials and Methods

For the study, the area related to electromobility in road transport was selected in a targeted manner. The data for the study concerned the years 2017–2021. The study used domestic and foreign literature, scientific articles, legal acts, websites. The descriptive method was used to analyze and present the collected materials.

Results and discussion

Regulatory framework for electromobility in Poland

The Polish government has recognized electromobility as a key area that is essential to ensure sustainable development of Poland based on innovation. The most important Polish strategic documents, developed by the Ministry of Energy together with the Ministry of Development, directly related to the concept of electromobility, include the so-called 'clean transport package', consisting of „Clean Transport Package", consisting of [Drożdż and Starzyński 2018]:

- Plan for Electromobility Development in Poland,
- National policy framework for alternative fuels infrastructure,
- Law of January 11, 2018 on electromobility and alternative fuels,
- Act of June 6, 2018 amending the Act on bio-components and liquid biofuels introducing the Low Emission Transport Fund [Ministerstwo Klimatu i Środowiska 2020].

Referring to the Plan for the Development of Electromobility in Poland "Energy to the Future" [Ministerstwo Energii 2017a], it is a leading document, determining the scope of progress in this field for the next years. The main objective of the project is the development of electromobility for the stability of society, industry, as well as electricity grids, which significantly affects the load shift caused by connecting electric vehicles to charging points.

The latter is an important factor in energy security and aroused the interest of the Polish Transmission System Operator S.A., which is why it was used to formulate an analysis of changes in energy availability. This analysis intended to verify the impact of electricity-powered vehicles on the demand for electricity by 2030, as well as to draw up supposed preventive measures [Drożdż and Starzyński 2018].

Three key stages of electromobility development in Poland can be identified. The first stage of preparation was carried out in 2016–2018, covering all work related to laws and regulations on public transport, including the implementation of research projects, the creation of the first experimental projects, the creation of a prototype of Polish electric vehicles, and public funding in this area. In the second phase, carried out in 2019–2020, it was planned to create business concepts for the dissemination of infrastructure and vehicles, to build infrastructure in designated agglomeration areas and along the Trans-European Transport Network TEN-T, to start project research in the preparatory phase, and for manufacturers to move from the prototype phase to production and support the purchase of electric cars. The target path of the plan is a five-year period between 2020 and 2025, during which the electromobility market in Poland will unify with the help of tools supporting the purchase of electric vehicles, creating stable industrial entities operating towards electric vehicles. There will be widespread use of electric vehicles by the social administration, completion of the preparation of the electricity network towards cooperation with electric vehicles, and inclusion of electric transport in the scenery of Polish cities [Drożdż and Starzyński 2018].

Another document, entitled National Policy Framework for Alternative Fuels Infrastructure, concerns infrastructure for alternative fuels, which are substitutes for crude oil [Ministerstwo Energii 2017b]. The most important determinant of the adopted document was setting targets in terms of the number of charging zones for electric power. The assumption of the document was the creation of 50 thousand electric vehicles by 2020 in Polish agglomerations, while the concept by 2025 is the dissemination of 1 million electric vehicles moving on Polish streets [Drożdż and Starzyński 2018].

The third document is the Act on amending the Act on bio-components and liquid biofuels of June 6, 2018 [Ustawa z dnia 6 czerwca 2018 r.], in which one of the important provisions was the development of the Low Carbon Transport Fund. The intention of this law was primarily to support the improvement of alternative fuel infrastructure, manufacturers of low-emission vehicles and public transport, as well as to co-finance the costs of parking public transport vehicles and to co-finance the costs for parking EVs [Drożdż and Starzyński 2018].

Subsequently, based on the above two documents, the Law on Electromobility and Alternative Fuels [Ustawa z dnia 11 stycznia 2018 r.] was drafted and came into force on February 22, 2018. The drafting of the Act by the Ministry of Energy had the objective of initiating the implementation of the Directive 2014/94/EU of the European Parliament and of the Council of October 22, 2014 on the development of alternative fuels infrastructure, determining the conditions and rules of application, moreover, the rules for the location of alternative fuels infrastructure in means of transport, the rules for the implementation of charging services for electric vehicles, as well as the refueling of natural gas vehicle tanks. In addition, the Act formulates the tasks of public entities in the area of the progress of alternative fuel infrastructure, as well as the related obligations in the area of dissemination of all necessary information. The Directive imposed an obligation on the Member States to construct charging infrastructure for electric vehicles by December 31, 2020, which should contribute to the free

movement of electric vehicles within urban and densely populated areas [Drożdż and Starzyński 2018].

The model created focused on the development of an appropriate legal framework for the expected development of charging infrastructure for electric, hybrid, and natural gas or hydrogen-powered cars, and to date has proliferated without adequate regulation. The legislator establishes regulations to draw up specific infrastructure for charging points. According to the current regulations, by the end of 2020 in Poland, there were to be about 6 thousand stations for electric means of transport with a maximum power of 22 kW and 400 stations with power above 22 kW. These are located in 32 urban centers and in densely populated areas. If such a minimum infrastructure is not created at that time, the responsibility for its creation will fall to the distribution system operators. The Act provides the autonomous government with the ability to separate clean transport areas. It will allow local governments to designate an area to which only electric, hydrogen, and natural gas-powered vehicles will have free access. In addition, the legislature provides a system of incentives, including, but not limited to, the elimination of parking fees, the elimination of a consumption tax on electric vehicles, increased depreciation fees for businesses, and the ability for electric vehicles to travel by bus lanes [Drożdż and Starzyński 2018].

The Act on Electromobility and Alternative Fuels also requires local governments to develop green transport, with a guarantee of a 50% share of powered vehicles in the national fleet. Further regulations, included in the decree, include the obligation to design and construct public buildings, multi-family residential buildings, to equip parking spaces with charging points, or to remove the obligation to obtain permits for the construction of stations and vehicle charging points. The implementation of the designated provisions has been scheduled in time and will be implemented in stages until 2028. The legislator also assumes transition periods, which will allow the business to adapt to the new regulations [Drożdż and Starzyński 2018].

Another important document for the progress of electromobility in Poland is the Strategy for Responsible Development until 2025 [Ministerstwo Środowiska 1999]. In terms of electric transport, the priority is to increase transport convenience and improve passenger and freight services, while limiting the negative impact of the use of electric vehicles on the environment. The strategy assumes that by 2030 buses powered by alternative fuels (including electricity) will account for 16% of all buses used in public transport [Drożdż and Starzyński 2018].

Types and kinds of electrically powered vehicles

There is a division of electric vehicles into two main categories, which are distinguished by whether they are powered mainly by electric propulsion or, in addition, are also powered by a traditional internal combustion engine [Rzędowska et al. 2017, Rokicki et al. 2021]:

- A BEV is a type of standard electric vehicle. They are powered “from the socket” using a so-called fast charger (via a dedicated cable and plug), induction, or pantograph. Within this type of vehicle, there are cars, buses, bicycles, and scooters;
- A PHEV is a plug-in hybrid means of transport with two types of engines – both electric and combustion - plug-in hybrids are distinguished from normal hybrid ve-

hicles by the fact that they can be powered by a charger. This facility enables vehicles to cover significantly longer distances without the need to activate the combustion engine.

The above-mentioned types of vehicles are capable of recovering energy through braking, which they store in their energy reservoirs – in batteries. In this way, part of the energy is self-produced [Rzędowska et al. 2017].

One of the most common types of vehicle-powered by electricity is the passenger car. An electric car is a vehicle with at least one electric motor as its propulsion system. The Act on Electromobility and Alternative Fuels of January 11, 2018 introduced the existing definition of electric passenger cars (i.e. Article 317 of the Official Journal 2018) [Ustawa z dnia 11 stycznia 2018 r.]. According to its provisions, an electric car is a means of transport that uses only electric energy for driving and its accumulation consists in connecting it to a publicly available power source [EFL 2017]. An example of this type of vehicle is the BMW i3 94 Ah produced in 2018. What is worth knowing about electric cars is that [EFL 2017]:

- compared to classic internal combustion vehicles, they run quieter and produce less noise and vibration when driving,
- have a narrow kilometer range – depending on the technology, they can achieve a distance of around 300–500 kilometers on a single charge,
- they do not release environmental pollutants during driving and operation,
- Their production produces more carbon dioxide emissions than vehicles with combustion engines,
- running costs are favorable, but prices are higher than for equivalent cars with combustion engines.

Electric vehicle market in Poland

The Polish market already offers more than 100 models of electric vehicles, and BEV and PHEV cars are available in every major city. Battery capacity, efficiency, and charging power are increasing all the time. The average range of fully electric vehicles in Poland exceeds 380 km. According to the latest Catalogue of Electric Vehicles 2020/2021, the price of a new electric car is between PLN 80,000 and almost PLN 800,000. Almost all BEV and PHEV models in Western Europe are available for purchase in Poland. It should be emphasized that electric cars are becoming more and more practical and comfortable, and for many buyers, they may now constitute a real alternative to traditional cars powered by combustion engines [Kenig 2020].

Data presented at the end of February 2021 shows that a total of 20,504 passenger electric cars were registered in Poland. In the first two months of 2021, their number increased by 1,793, which is an increase of 51% compared to the same period in 2020, which is the result of the introduction of electric vehicle meters thanks to PZPM and PSPA. By the end of February 2021, 20,504 electric vehicles were circulating in Polish agglomerations, 51% of which consisted of battery-driven vehicles (BEV) – 10,471 units, while the remainder consisted of plug-in hybrid vehicles (PHEV) – 10,033 units [PSPA 2021].

Simultaneously with the increase in the number of electric vehicles, the charging infrastructure is also developing. As of the end of January 2021, 1,410 public car charging stations were in use in Poland. Among them, 33% consist of "fast" charging stations with power above 22 kW. On February, 15 new universal charging stations were introduced [PSPA 2021].

Advantages and disadvantages of electric road transport

Electric-powered vehicles during operation are referred to as zero-emission, which means that they do not produce fumes or other substances harmful to the environment and human health. They are characterized by advantages, the most significant of which is [Judzińska-Kłodawska 2014, Feckova Skrabulakova et al. 2021]:

- an uncomplicated vehicle design that contributes to minimizing the probability of failure,
- the ability to acquire energy during the braking process,
- no need to have the gearbox lever and clutch in the vehicle, which contributes to better traveling comfort,
- no emission of pathogenic compounds into the atmosphere during vehicle operation,
- unobtrusive operation of the engine and absence of transmission of damaging noise,
- low maintenance fees.

Undoubtedly, the lack of car exhaust emissions and favorable running expenses are the biggest benefits of owning an electric vehicle. This makes these vehicles increasingly popular in the market. By no means can it be fully stated that these cars are 100% emission-free. Although these vehicles do not emit exhaust fumes while they are being driven, they do create atmospheric pollution when they produce the electricity that is needed to power the vehicle. If the electricity used to power the vehicle came solely from renewable energy sources, its emissions would be reduced to a minimal level. However, almost 80% of electricity in Poland comes from traditional sources, namely coal combustion. This phenomenon causes significant emissions of pollutants. In addition to extracting indirect emissions, electric-powered vehicles have disadvantages such as [Judzińska-Kłodawska 2014]:

- high purchase price of the vehicle,
- the high cost of the battery, which lasts about 8–10 years and then needs to be replaced,
- the relatively short distance to be covered on a single charge, which depends on the battery capacity,
- limited network of charging stations, switching on the air conditioning in the vehicle can reduce the battery capacity by about half,
- long battery life,
- battery capacity is reduced by approximately 50% at outdoor temperatures below –20°C.

A significant disadvantage of electric cars is the price – almost twice as high as the diesel variant and more than twice as expensive as the petrol version. Juxtaposing utility and economic characteristics, the electric motor compares extremely impeccably with the traditional internal combustion engine, and with long-term continuous use, the difference in the purchase price will be returned to the disposer within 3–5 years from the date of purchase [Nürnberg and Iwan 2017].

The costs of using electric cars were ambiguous to determine and depending on how the vehicle was used. Indeed, the purchase price of such a car was more than twice as high as the price of a vehicle with a combustion engine, however, the price of technical services was

several times lower, which is due to the absence of numerous systems, such as the exhaust system, fuel filters, clutch, as well as the lack of need to replace engine oil, fluids and consumables after every 20–30 thousand km. On the other hand, after the achieved mileage, mufflers, turbine, clutch, and brake pads need to be replaced every 150,000 km or so. In the case of electric cars, most of these devices are not in the vehicle, and the durability of an electric motor is calculated at around 1.5 million km. Moreover, the fuel (which is electricity) needed to travel a certain distance costs about 5 to 8 times less. The implication is that cost considerations and energy production components may contribute to the preferred choice of power engine type [Nürnberg and Iwan 2017].

Considering the advantages as well as the disadvantages of electric vehicles, they are rated as beneficial for the environment. The maximum driving distance of the vehicle is much shorter than for the internal combustion engine and usually depends on weather conditions. However, an unquestionable advantage is the absence of exhaust emissions during operation [Judzińska-Kłodawska 2014].

Conclusions

The paper deals with the functioning of individual electric road transport and explains its influence on the development of electromobility in Poland. The importance of electromobility in the country, types of vehicles powered by electricity, the availability of charging infrastructure, advantages and disadvantages of electric road transport are shown.

Considering the research hypothesis, it was found that there are numerous problems with the development of the electromobility market in Poland. This is due to factors, the most important of which was the too-high purchase price of an electric vehicle. Other factors include insufficiently developed charging infrastructure, high costs of installing individual charging stations (e.g. in housing estates and households), a considerably limited number of kilometres to be traveled on a single charge, and long battery charging times when there is no station with the possibility of fast DC charging available in the vicinity.

Several generalizations can be made based on the research conducted.

1. Electric transport is the vision of the future on Polish roads, but because of the barriers to development outlined earlier, it will take several or even more years to abandon motorized vehicles in favour of electric vehicles.
2. Implementation of the Electromobility Development Programme, prepared by the Ministry of Energy and the Ministry of Development, did not bring the expected result due to an insufficient number of registered electric vehicles and available charging stations. The assumption that over one million EVs will be available in Poland by 2025 does not currently correspond to the actual situation on the market.

Electric transport has more positives than negatives. These include the simple construction of the vehicle, which reduces the possibility of breakdowns, the generation of energy when braking, the increased comfort of travel, the smoothness of driving and the absence of noise pollution, the low operating costs. The investment in an electric car is worthwhile, both because of the lower running costs and the environmental improvement due to the lack of release of environmental pollutants.

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