EVALUATION OF THE INFRASTRUCTURE CONDUCIVE TO THE DEVELOPMENT OF ELECTROMOBILITY IN POLAND

Katarzyna Kosakowska

Summary

Electric cars have appeared in Poland relatively recently. However, they quickly became an important part of the discussion as an ecological alternative to traditional combustion vehicles. In 2018, the law was introduced regulating the use of infrastructure used by electric vehicles, subsidies and benefits for drivers operating such vehicles. Dynamic development of the electric vehicle market in the world, only to some extent, has translated itself into their popularity in Poland. The article deals with issues related to the causes of such a state, evaluating the main elements determining the expansion and popularity of this segment. Its main objective is to present a methodology for evaluating the infrastructure conducive to the development of electromobility in Poland in terms of the number of electric vehicle charging stations.

Key words

electric vehicles, infrastructure, electromobility

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1. Introduction

Due to its high energy consumption, sustainable transport is one of the most important economic challenges in the world. It is shown in numerous publications [1, 13]. Groger, Gasteiger and Suchsland [5] argue in their study that 23% of the global carbon dioxide emissions come from transport, and the reduction of these emissions is necessary to fight global warming. Ślusarczyk [12] claims that electromobility is one of the most effective ways to reduce dependence on fossil fuels and environmental pollution generated by transport. Ellingsen et al. [8] concluded that electric vehicles, together with clean energy sources, help to mitigate the negative impact on the climate. And, according to Kowalski and Depta [7], in 2040, out of 2 billion cars in the world, 500 million will be electric.
Poland has great ambitions in the field of electromobility. The law [14] is now being introduced to help meet the set out objectives. In 2016, the Prime Minister of the Republic of Poland stated that Poland may be the leader of the industrial revolution, an element of which the electromobility is [15]. He hoped that thanks to state support, Polish companies would develop quickly in this area. Therefore, appropriate regulations were passed, objectives were set for central and local authorities in the purchase of electric vehicles, including buses, and an order was introduced to develop the infrastructure necessary for such vehicles. Unfortunately, however, it turned out that the number of electric cars is not growing by as much as it was expected. Therefore, this article attempts to find the cause for this situation by analysing the charging infrastructure for electric vehicles and assessing the number of charging stations available and the demand for them. The purpose of this article is to check if the number of charging stations is sufficient for the needs.

2. Electric vehicles charging infrastructure

Traffic congestion contributes to the increase in fuel consumption, and thus carbon dioxide emissions, but also to the travelling costs [2, 13]. One of the ideas to reduce this negative impact is the concept of developing Intelligent Transport Systems, in which electric cars are an important link that allows road users to obtain information about the movement, increasing their safety and enabling more coordinated use of transport networks [1, 2, 11]. Intelligent Transport Systems are the first step to creating a Smart City, i.e. an urban area or city that uses the Internet to collect the data, based on which the flows of people and goods are improved. This includes data collected from citizens, devices, buildings, etc., which are then monitored and analysed for the purpose of managing traffic, transportation systems, power plants, utilities, water networks, waste disposal and even crime detection. Electric vehicles and their impact on the shaping of Intelligent Transport Systems are crucial for the further development of this market branch. For the functioning and development of these vehicles, an appropriate infrastructure is necessary, including primarily charging stations. An example is presented in Fig. 1.

Fig. 1. Electric vehicles charging station

Source: https://www.greencarreports.com/news/1118774_chargepoint-commits-to-build-charging-stations-for-2-5-million-cars-by-2025

Electrically powered vehicles - BEV (Battery Electric Vehicle) incorporate, among the others, plug-in charging, which involves connecting the car by a cable and plug to a charging point. Depending on the type of charging, a charging with the use of direct current (DC) or alternating AC can be distinguished. Charging can take place in three modes - slow, accelerated or fast. By using slow charging points with a power of about 4kW, the batteries will be fully charged in no less than 6 hours. Accelerated AC charging points with a power of 7 to 22kW can achieve that in 3-4 hours, while quick (or instant) charging points, which usually have a power of around 50kW, (but there also exist some with up to 120kW), fully charge the batteries in about 40 minutes. Slow charging points are the most common. Almost all vehicles can use them. There are also different types of connectors depending on what type of current is being used and which vehicle is being charged. The most popular are J1772 Type 1 and Type 2 using AC, and CCS and CHAdeMO using DC. The most common for public charging stations are the J1772 connectors - Type 1 in the USA and Type 2 in Europe and Asia.

1. Electrification

Lars-Erik Aroy, former president of Toyota, says that „it takes time and a huge investment to keep up with electrification" [3]. In the interview, he emphasizes the benefits of using electric vehicles, but also points to the proper management at a strategic level, allowing electric vehicles to be attractive also for mass production. He believes that this will only be possible with tangible benefits for the users and a well-deployed infrastructure. He gives Norway as an example, where apart from an easy access to the necessary infrastructure, owners of electric vehicles can enjoy the absence of Value Added Tax and VRT (Vehicle Registration Tax) on electric cars, the 84% reduction in road tax, no tolls, free ferry crossings, parking lots and an access to bus lanes. He also noted that after a sufficiently high development of the electric vehicles market, the diesel propelled vehicles entry bans were introduced, and fuel charges were increased. He also emphasized the need to properly arrange this infrastructure, stating that if it is located only in large cities, and not in smaller towns and near roads, it will definitely reduce the interest in electric vehicles and limit the development of the industry.
Poland has great ambitions, but looking at the example of Norway, it approaches the problem in a controversial way. Figenbaum and Kolbenstvedt [4] claim that the first step to reduce the barriers to electromobility in Norway was numerous financial support not only for private users, but also for entrepreneurs showing interest in investing in charging stations intended for the public use. Therefore, this article evaluates the infrastructure for charging electric vehicles in Poland, checking whether it is sufficient in relation to the number of vehicles in use.

2. Electric vehicles in Poland

According to the Polish Automotive Industry Association (as at the beginning of 2020), 9,803 electric cars are registered in Poland [10]. These vehicles are mainly used in the cities, due to their limited range and the need to use chargers, which are located mainly within larger towns. All over Poland in 2018. there were 646 charging points, including 366 in provincial cities and about 200 within 50 kilometres from these cities [17]. That is why it was assumed later in the study that all electric cars registered in Poland are only located in the capital cities.
Since 2017, the Norwegian government has launched a program to build at least two fast charging stations for every 50 km on all major roads in Norway. Being successful in this regard, it already has over 230,000 electric vehicles on the road and around 10,000 charging stations [16], and the ratio of charging stations to electric vehicles is roughly 1:23. In Poland it is around 1:16 (i.e. the border set by Norway has been exceeded). The article also aims to prove that the next step in the expansion of the electric vehicle market should be to increase their number on the roads prior to further expansion of the infrastructure.
The present state analysis
In order to test whether the infrastructure of electric vehicles is sufficient, the data provided by the Central Statistical Office concerning the population and the number of registered public charging stations (as of February 2019) was used. The assumption that all electric vehicles are located in the cities allowed to calculate how many electric vehicles there are per driver in these cities, and thus to estimate how many drivers of such vehicles there are in Warsaw.

The population in capital cities is presented in the Tab. 1 [6].

Table. 1 Population of the capitals of Polish voivodships

City	Population (as of June 30, 2018)
Warszawa	1769529
Kraków	769498
Katowice	295449
Wrocław	639258
Poznań	537643
Gdańsk	464829
Szczecin	403274
Łódź	687702
Bydgoszcz	351254
Opole	128224
Rzeszów	190849
Lublin	339811
Kielce	196335
Białystok	297403
Zielona Góra	140113
Olsztyn	173125
Total	**7384296**

Source: own study based on the Central Statistical Office, Demographic Yearbook, Warsaw 2019, p. 36

The number of electric vehicles in Poland is estimated at 9,803 cars [10]. This allows to determine their number per one person by dividing the population by the number of electric cars in Poland - formula (1).

$$O = \frac{\text{population of voivodeship capital cities}}{\text{number of electric cars}} \quad (1)$$

where:

O-number of electric cars per person

thus we get:

$$O = \frac{7384296}{9803}$$

$$O \approx 754$$

Thus, the number of cars per one person is 754. This value will be used in further calculations.

Using the value assessing the number of electric cars calculated per one person, it can be estimated that there are about 2,637 of them in Warsaw - formula (2).

$$K = \frac{Warsaw\ population}{O} \quad (2)$$

where:

K-number of electric cars in Warsaw

$$K = \frac{\text{population of Warsaw}}{754}$$

thus we get:

$$K = \frac{1769529}{754}$$

$$K \approx 2637$$

Therefore, the number of electric cars in Warsaw is 2,637.

It was assumed in the study that all tested stations were 50kW DC devices. Charging takes 40 minutes and the vehicle is able to travel about 200 kilometres after being charged. If to assume that car traffic starts at 5 am and ends at 23, it is possible to calculate the maximum number of charged vehicles.

$$J = \frac{total\ time}{charging\ time\ for\ one\ vehicle} \quad (3)$$

where:

J - maximum number of vehicles charged

thus we get:

$$J = \frac{1080}{40}$$

$$J = 27$$

Which means that during one day of car traffic, one charging point can handle 27 electric vehicles.

The use of infrastructure by Warsaw drivers

Based on the Santander Consumer Bank's [9] statistics on the annual mileage of Polish cars, Warsaw drivers were divided into three groups according to the frequency of covering the assumed distance (Table 2). Drivers covering 200 kilometres every day, three times a week and once a week were distinguished. Then the number of electric cars was calculated, corresponding to the assigned percentage share of drivers. The next column shows the number of vehicles that use chargers during the week. The first group of drivers travels 200 kilometres a day, so they need to recharge their batteries every day. The second group uses the chargers three times a week, and the third group only once.

Table 2. Number of electric cars requiring charging per week

Distance covered by electric car	Percentage share of the drivers	Corresponding number of cars	Number of discharged electric cars per week
200 km every day	15%	395	2769
200 km three times a week	45%	1187	3560
200 km once a week	40%	1055	1055

Source: own study based on https://dzienniklodzki.pl/przecietny-polski-kierowca--ile-wydaje-na-paliwo-ile-kilometrow-rocznie-pokonuje/ar/11599326 (accessed on 28/11/2019)

The number of electric cars using the charging station during the week is as follows:

$$2769 + 3560 + 1055 = 7384$$

In 2019, 144 electric vehicle charging stations were registered in Warsaw. During the week, the number of available charging points is the number of charging stations multiplied by 7.

$$144*7 = 1008$$

Taking into account the above data, it is possible to calculate how many cars can be handled by one charger without queues.

$$E = \frac{number\ of\ electric\ cars\ using\ chargers}{chargers\ available} \quad (4)$$

where:

E-number of cars required to be serviced by one charger

thus we get:

$$E = \frac{7384}{1008}$$

$$E \approx 8$$

This means that the number of cars that should be handled by one charger in order to avoid queues is 8. As shown in the previous calculations of the index, the charger is able to service 27 vehicles within 18 hours, which means that the current number of charging stations is able to ensure sufficient supply for the adopted number of electric vehicles. Private home chargers were not included in the calculations, which allows to conclude that the result will be even more favourable. A strong investment in the infrastructure has been successful, but unfortunately, due to many factors, there are still too few electric vehicles on the road, which means that it is not fully used. In addition, the focus on the expansion of infrastructure in the cities has led to the neglect of such places as motorways and provincial roads, so many drivers still have doubts about buying an electric vehicle.

5. Conclusion

The development of electromobility is fostered by the implementation of modern solutions related to the infrastructure for charging vehicles, as well as the introduction of new energy systems not based on conventional fuels, but on renewable energy sources. Policymakers must therefore find a balance between competing objectives: mitigating climate change and urban air pollution, with enhancing the competitiveness of the domestic car and energy industries. A coordinated investment in new vehicles, more efficient batteries and road infrastructure is also a must.

In 2016, the government presented ambitious plans for the intensive development of electromobility in Poland, assuming that by the 2025 there will be one million electric cars on Polish roads. In 2018, the first Polish prototypes of electric cars were to be tested, which were then to be mass-produced. In addition, the 2017 electromobility development plan assumed, among the others, the expansion of the charging station network and greater involvement in the development of this sector. However, most of these provisions were not implemented. The Polish electric car had its first tests only in 2020, i.e. two years after the planned start. The subsidy program was initially one of the highest expenditures in Europe, but the government abandoned this idea and finally the amount of subsidy was reduced. Infrastructure development is ongoing, but requires the creation of programs encouraging private users to buy electric vehicles.

Low demand for electric vehicles in Poland is the result of high cost and the lack of clear benefits for the private user, such as tax breaks, lower charges or their complete elimination. The study proves that the number of charging stations in the capital is sufficient at the moment, but there are still not enough electric cars. The introduction of a price discount could be a wake-up call for a market frozen for more than 3 years with the unfulfilled promise of direct subsidies, which most of Europe has long used. The development of the current fleet of electric vehicles needs support, especially if Poland is to continue to pursue its goal of 1 million registered electric vehicles by the 2025, as forecasted in 2016.

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Katarzyna Kosakowska
katarzyna.p.kosakowska@gmail.com
Military University of Technology, 2 Gen. Sylwestra Kaliskiego Str.; 00-908 Warsaw