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DEVELOPMENT OF THE PUBLIC INFRASTRUCTURE OF EV CHARGING STATIONS IN POLAND

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Purpose: The purpose of this article is to evaluate the development of the public EV charging station infrastructure in Poland, at the same time attempting to identify any dysfunctional areas of the process.
Design/methodology/approach: A critical analysis of the domestic and foreign research outputs regarding the importance and development of public charging station infrastructures. An analysis of secondary data derived from statistics reports which show the level of development of the public charging station infrastructure in Poland in the 2019-2022 period.
Findings: Based on the completed research it was found that the development of the public charging station infrastructure in Poland was quite dynamic. Nevertheless, an in-depth analysis of this direction of development makes it possible to identify potential problems and imperfections of that process. The most significant and accentuated problems include: (1) the disproportionately lower growth rate of the number of public charging stations in relation to the vehicle fleet electrification rate; (2) the dominating share of AC charging stations in the public charging station infrastructure, which offer a lower power level translating into longer vehicle charging times; (3) the uneven spatial distribution of the public charging station infrastructure.
Practical implications: Being aware of the direction of development of the public charging station infrastructure is extremely important when it comes to formulating and implementing subsequent investment projects and business models on the market.
Originality/value: Public charging station infrastructures – due to the relatively short history of operation – constitute a relatively new object of studies in economic sciences.

Keywords: electromobility, electric vehicles (EV), EV charging stations, zero-emission transport, sustainability.

Category of the paper: Research paper.

1. Introduction

Alternative fuels infrastructure development in road transport is an area of interest shared by a wide range of socio-economic life participants – EU institutions, national regulatory bodies, self-governments, and also individual users. The significance of the issue derives from one of the most important technological transformations of the 21st century – the gradual dethronement of the IC engine as the main drive of the broadly defined mobility (Jesień, Kurtyka, 2016). The global trend of substituting (mainly in the road transport) internal combustion drives with alternative fuels ensues from the sustainability concept which is based on a concern for the natural environment and for the excessive exploitation of energy carriers in the global economy (Ślusarczyk, 2020).

Undoubtedly, the economy sector that is the most dependent on fossil fuels is transport. From the beginning of this decade, the energy consumption in the transport sector has been increasing by 2% per year, and more than 90% of the energy comes from oil resources (Figure 1).

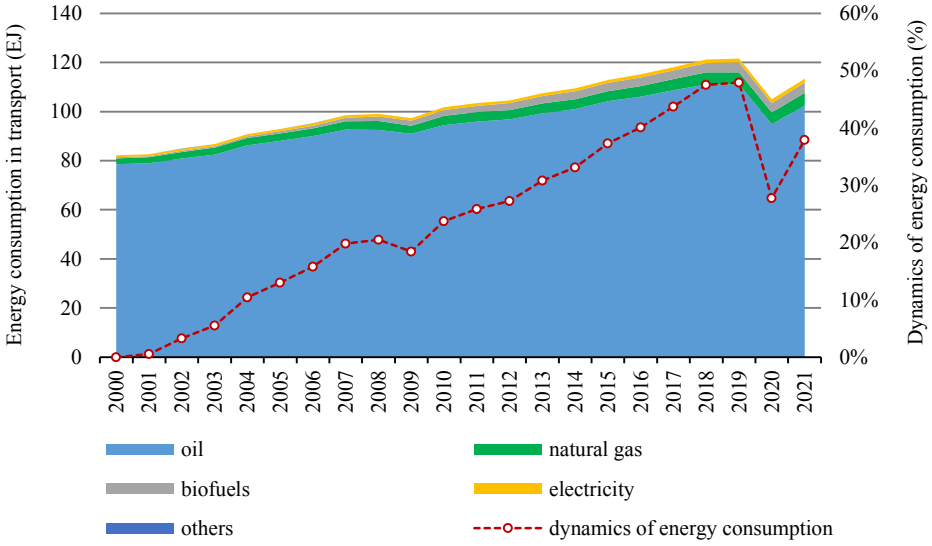

Figure 1. Energy consumption in transport by fuel (based on exajoule – EJ; the left axis) and the dynamics of energy consumption (year to base year – 2000; the right axis).

Source: own study based on: https://www.iea.org/.

As a result of the dependency on oil-derived fuels, in 2021 the transport sector was responsible for 37% of the global CO_2 emissions. At the same time, over the past two decades, the level of pollution produced by the transport sector increased by 33% (in relation to 2000), and the mode of transport responsible for the greatest part of the emissions is the road transport (Figure 2).

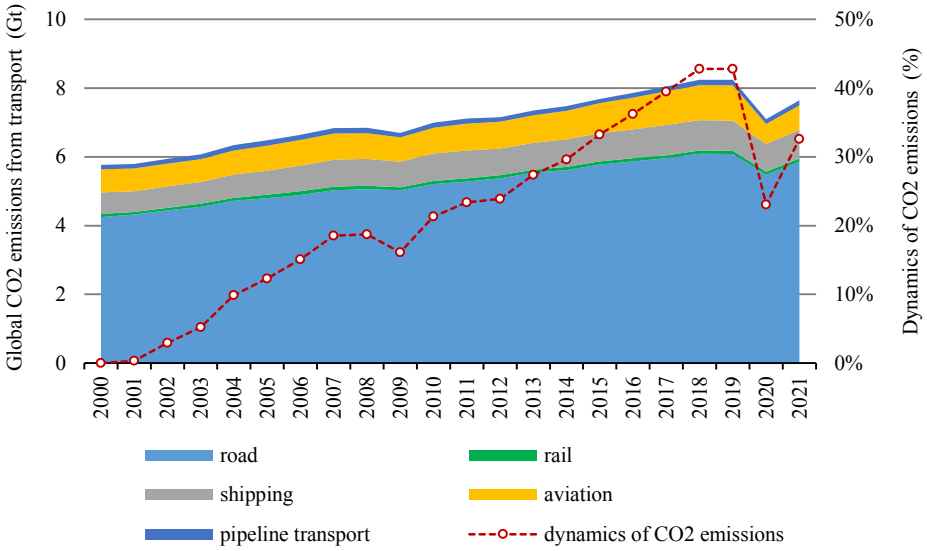

Figure 2. Global CO2 emissions from transport by transport mode (in Gt) (the left axis) and the dynamics of CO2 emissions (year to base year – 2000) (the right axis).

Source: own study based on: https://www.iea.org/.

In the context of these findings, transformation of the current economic models towards sustainability and low-carbon economy oriented systems is not merely a need, but an imperative and challenge for the contemporary world. The transport decarbonisation policy in the EU countries has its sources in numerous legal acts – these take the form of community-level regulations as well as internal legislation of the EU member states – and one of its pillars is transport electrification, more broadly referred to as electromobility (Chinoracky et al., 2022). It is electromobility that is considered to be the tool to mitigate the negative impact of road transport on the air-pollution levels.

The purpose of this article is to evaluate the development of the public EV charging station infrastructure in Poland, at the same time attempting to identify any dysfunctional areas of the process.

2. Socio-economic importance of the public EV charging station infrastructure

Electromobility is a concept that is intrinsically connected with any deliberations on the future of sustainable and low-emission transport. Being a relatively new and still developing term, electromobility has not yet been unambiguously defined. Still, it may be assumed that the electromobility concept covers individual and collective transport performed by means of road vehicles with electric drives, powered with electric energy stored in a battery (Mataczyński, 2018). The analysed concept should also include a public charging station infrastructure as its immanent element, because it provides a potential user of a BEV (battery electric vehicle) or

a PHEV (plug-in hybrid electric vehicle) with an unlimited (equal) access to a charging point, i.e. a device that enables charging a single vehicle (Ustawa, 2018).

Both issues mentioned above – electrically powered vehicles and a public charging station infrastructure – should be treated integrally as complementary elements that together form a definition of electromobility. What is more, both issues are interdependent in the context of electromobility development perspectives and road transport electrification. This is due to the fact that the research studies completed so far have demonstrated that lack of access to a charging station infrastructure constitutes a key barrier to a wider use of electrically driven vehicles (Alp et al., 2022; Berkeley et al., 2018; Sierzchula et al., 2014). In view of the limited travel range of electrically driven vehicles, an insufficiently developed (in terms of quantity and spatial distribution) public charging station infrastructure further reduces the flexibility and comfort of using such a means of transport. In comparison to vehicles with the traditional IC drive, BEVs are characterised by a shorter travel range on one charge, and the battery charging time is definitely longer than the refuelling time. These circumstances curb the functionality of electric vehicles and constitute a considerable hindrance in consumers' purchase decisions on the BEV market (Franke et al., 2012; Hoen, Koetse, 2014). Therefore, it is a legitimate claim that a well-developed public charging station infrastructure – both in terms of their quantity and their appropriate geographical distribution – will significantly mitigate the said hindrances (Schulz, Rode, 2022) and contribute to balancing the shares of the means of transport that are substitutive to one another (fossil-fuelled vs. electrically driven vehicles).

Another issue connected with the charging station infrastructure is the battery charging time, which depends on the kind of current that supplies the station and the charging technology. In practice, two EV charging models are the most commonly found[1]. The first of them is based on alternating current with the output power of up to 43 kW[2]. This kind of charging is offered by AC (alternating current) charging stations, and the characteristic feature of this model is the indirect way of charging the vehicle battery – the alternating current from the station goes to the vehicle's rectifier which transforms the alternating current to direct current that subsequently charges the vehicle's battery. The second solution is charging an electric vehicle with direct current with the output power of up to 350 kW (Schulz, Rode, 2022). This kind of charging is offered by DC (direct current) charging stations characterised by direct charging of the battery – straight from the charging station to the vehicle's battery.

The above indicated differences in EV charging models have a significant impact on the time necessary for battery charging (Table 1). The quick charge (DC) stations offer the possibility of charging a vehicle several times faster than the AC stations. Thus, the quick charge (DC) formula reduces the concerns related to the available travel range and enables

[1] In this study, the issue of plug standards and kinds of charging sockets for BEVs has been disregarded.
[2] In Poland, the maximum single-phase AC charging power is 7.36 kW, whereas in the case of 3-phase AC the max. charging power amounts to 22.08 kW (UDT, 2022).

relatively seamless driving for BEV users. Thus, being able to use DC charging stations translates into the possibility of driving long distances in electric vehicles, with short downtimes for battery charging (Lin et al., 2022).

Table 1.
Average time of EV battery charging depending on the kind of charging station – AC vs. DC

Charger type and speed	Power rating	Approximate time to charge*
AC – single-phase (slow)	3–7 kW	7–16 hours
AC – three-phase (normal)	11–22 kW	2–4 hours
DC (fast)	50–100 kW	30–40 minutes
DC (ultra-fast)	> 100 kW	< 20 minutes

*Also depends on the battery capacity and other variables.

Source: ECA, 2021.

It is also worth noting that along with the development of EV drive technologies – demonstrated i.a. by increased capacities of installed batteries – AC charging stations will be less and less useful in meeting BEV users' needs. A higher battery capacity means a longer charging time – undoubtedly, users will want to have fully charged batteries so as to be able to utilise the full functionality of the vehicle such as its travel range. Consequently, it may be supposed that the expected direction of future development of public charging station infrastructures will be based on direct current (DC) charging.

3. The public EV charging station infrastructure in Poland

The development of electromobility and the gradual electrification of the road transport constitute global phenomena. In 2021 the sales of electrically driven vehicles doubled in relation to the previous year and amounted to 6.6 million vehicles. Nearly 10% of the global car sales in 2021 were electrically driven vehicles, and this segment increased four times in relation to 2019. As a result of the above, at the end of 2021 there were 16.5 million electric vehciles on the roads all over the world, which was three times more than in 2018 (IEA, 2022).

The growing interest in electrically driven vehicles is also seen in Poland (Figure 3). As at the end of 3Q2022 there were 57,256 electrically driven vehicles registered in Poland, out of which 54,795 were cars. Over the adopted period of study, the average quarterly growth rate of the number of electric vehicles fluctuated around 20%, as a result of which at the end of 3Q2022 the number of electrically driven vehicles was ten times higher compared to the beginning of 2019 and 73% higher than in the analogous period of 2021. Taking into account the hitherto growth trend in the analysed market, it is estimated that by the end of 2025 the total number of registered EVs will exceed 300,000 (PSPA, 2021).

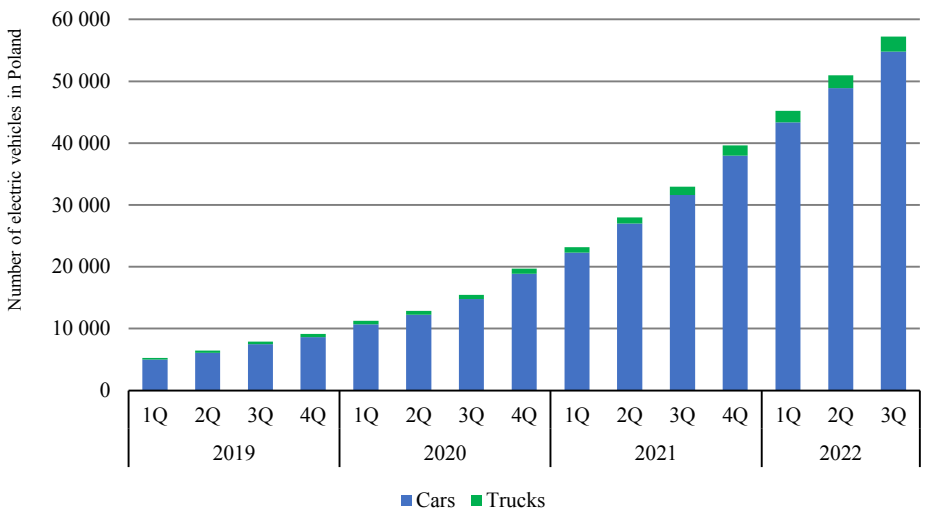

Figure 3. The number of electric vehicles (cars and trucks) in Poland in the 1Q2019-3Q2022 period (as at the end of the period).

Source: own study based on: https://www.pzpm.org.pl/.

Parallel to the EV market, the public charging station infrastructure has been developing in Poland (Figure 4). As at the end of 3Q2022, in Poland there were 2,460 public EV charging stations, offering the total of 4,736 EV charging points. Over the studied period, the average quarterly growth rate in the number of public EV charging stations amounted to around 10% (from quarter to quarter), and the dominating type of station was the alternating current (AC) charging station with a power capacity of max. 22 kW. Direct current (DC) charging stations accounted for only 28% of the total number of public EV charging stations functioning as at the end of 3Q2022.

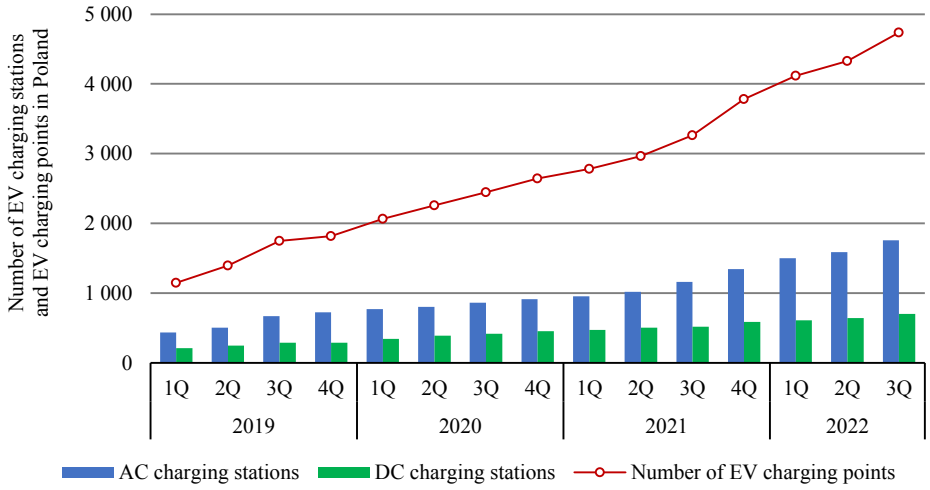

Figure 4. Number of EV charging stations and EV charging points in Poland in the 1Q2019–3Q2022 period (as at the end of the period).

Source: own study based on: https://www.pzpm.org.pl/.

One of the measures to assess the market saturation of the public charging station infrastructure is the ratio of the number of EVs to one charging point or station. The ratios estimated for the years 2019-2022 have shown a growing trend – from quarter to quarter the number of EVs per one charging station or charging point has been increasing (Figure 5). This phenomenon ensues from the disproportionate growth rates of the electric vehicle market and of the public charging station infrastructure development. As a result, at the end of 3Q2022 there were 13 electric vehicles per charging point in Poland, whereas in many countries of the European Union (i.a. Austria, Belgium, Spain, Holland, Finland, France, Sweden) the ratio was below 5.

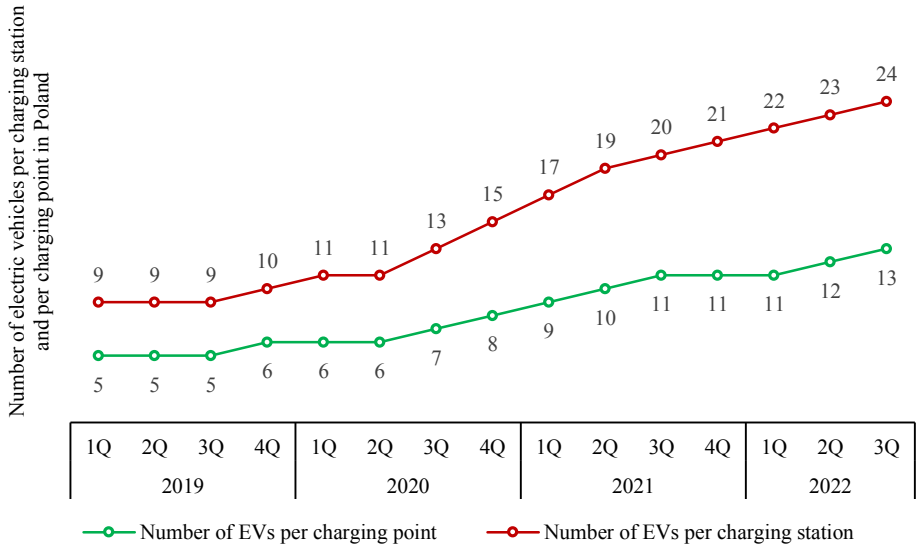

Figure 5. Number of electric vehicles per charging station and per charging point in Poland in the 1Q2019-3Q2022 period.

Source: own study based on: https://www.pzpm.org.pl/.

Another measure used in international rankings of public charging station infrastructure development is also the number of EV charging stations per 100 km of road. According to estimates, six EU countries do not have even one charging station per 100 km of road, whereas 17 countries have fewer than 5 charging points per 100 km, and only five countries have more than 10 chargers per 100 km of streets (www.acea.auto, 2022).

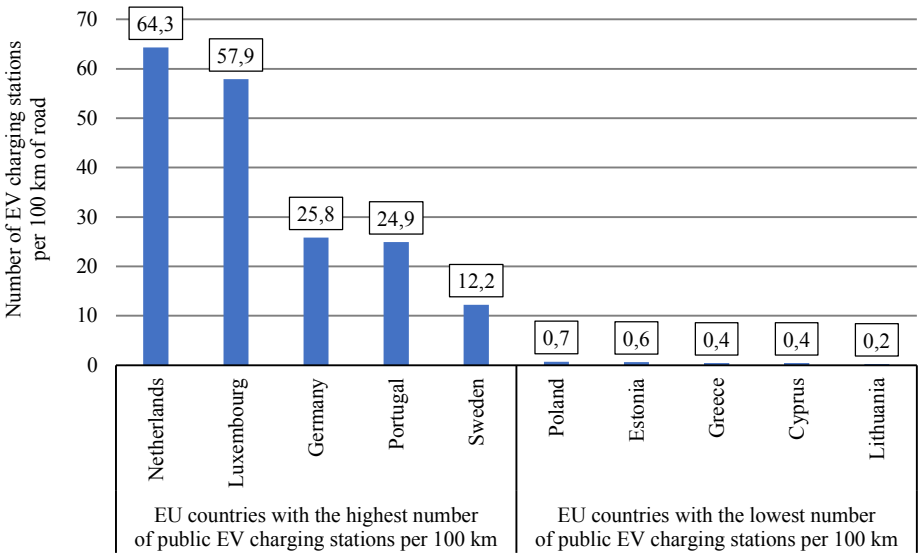

Figure 6. Number of EV charging stations per 100 km of road.

Source: https://www.acea.auto/.

What is more, it is possible to observe a considerable gap between the countries where there are the most chargers per 100 km and those where the number is the lowest. For example, in Holland there is one charger per each 1.5 km of road, whereas in Poland there is only one charger per 150 km. Consequently, in Holland over a stretch of 100 km on average there are 64 EV charging points, whereas in Poland – 0.7. Thus, the distribution of EV charging points in Poland is considered to be one of the worst in the European Union (Figure 6).

4. Conclusions

There is no doubt that electromobility redefines the contemporary transport model and sets the course for its future development. The gradual electrification of road transport has a significant impact on the level of air pollution[3], contributing to improved air quality and better living conditions as well as to protecting the health of local communities, especially those living in urban agglomerations. Nevertheless, full implementation of the electromobility concept requires ensuring appropriate conditions for correct and effective substitution of the IC engine with the electric one – ensuring a well-developed infrastructure of public charging stations, in terms of both their quantity and spatial distribution.

[3] It should be explicitly emphasised that in order to ensure zero-emission road transport (or just a reduction in the carbon footprint) it is necessary to provide electric power that is derived from sources other than fossil fuels (e.g. renewable sources of energy or nuclear power).

In the conditions of the Polish economy – despite its relatively short history of operation, the public charging station infrastructure has been developing quite dynamically. Nevertheless, an in-depth analysis of this direction of development makes it possible to identify potential problems and imperfections of that process.

First of all, it is possible to notice that the growth rate of the number of charging points has not been keeping up with the vehicle fleet electrification process that is definitively faster. Over the studied period, the number of electric vehicles per charging point almost tripled (from 5 to 13). If this trend continues – particularly in view of the planned prohibition on sales of fossil-fuelled vehicles – this may mean an insufficient number of charging stations to meet the needs of their users.

Another significant issue is the prevailing type of public charging station in terms of the kind of offered power. In Poland there is a tendency to install AC charging stations which consistently account for 70% of the total public charging station infrastructure. The prevailing share of slow charging stations combined with the above mentioned potential market shortage of EV charging stations can only exacerbate the problem of EV charging points availability in the future. In addition to that, continuing the infrastructure development while preserving the dominating share of AC charging stations may be deemed contrary to the direction of the technological progress. After all, the offer of electric vehicles on the market has been developing successively, and the main point of interest for the market participants is the ever increasing travel range of EVs. This is possible in principle only via increasing the battery capacity, which entails longer charging times.

Another problematic issue is the spatial distribution of the public charging stations in Poland. In international rankings, Poland is classified as a country with one of the least developed public charging station infrastructures in terms of spatial distribution. This not only hinders the fluidity of EV operation in everyday traffic, but also impedes travelling on longer distances, which makes Poland less attractive for tourists using EVs.

In conclusion, it must be emphasised that the problems addressed here certainly are not exhaustive. This article constitutes merely an attempt to diagnose the current state of the public charging station infrastructure development in Poland and points to hitherto most vital dysfunctional areas that entail potential barriers to further development. Changes in the transport sector take place at such a fast rate that the need for eliminating the said problems should be treated in terms of “a high necessity” rather than “a possibility”.

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