ANALYSIS OF INFRASTRUCTURE DEVELOPMENT IN THE EUROPEAN UNION IN THE FIELD OF ELECTROMOBILITY

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Abstract. The article focuses on electromobility issues and the necessary infrastructure development in the European Union. As the transport system has been described in the past as unsustainable and in many respects moving away from sustainability, the current trend is electromobility, which develops annually. In this context, the key knowledge is that, according to expert studies, in 2050 only a very small proportion of cars will be powered in the way we know it today, by means of a petrol or diesel engine. This statement also follows from the national strategies for the development of electric cars in individual states, which estimate the number of electric cars in the future. It is also very important to estimate and assess the state of the infrastructure for electric cars, which form charging stations designed for recharging the storage of electric energy, electric vehicle. Therefore, it is necessary to develop a comprehensive approach and analyse the gradual development of infrastructure in the individual Member States of the European Union, which is one of the most important tools necessary for growth of electromobility. The authors of the article assess the current state of infrastructure for electric cars, based on the total number of charging stations in each Member State of the European Union and the average annual percentage change. These indicators, based on the European Union average, divide the Member States into categories which indicate the rate of infrastructure development, taking into account the number of electric vehicles in the Member State concerned. Efficiency is identified and the sequence of implementation into the road infrastructure.

Keywords: electromobility, European Union, infrastructure, analysis.

Introduction

Alternative fuels have the potential to increase energy efficiency and improve the environmental performance of the transport sector. The main alternative fuels with the potential for long-term oil replacement are considered to be: electricity, hydrogen, biofuels, synthetic and paraffinic fuels, natural gas and liquefied petroleum gas (LPG), also with regard to their possible simultaneous and combined use through, e.g., dual fuel technology systems. Electricity is currently a very attractive source of energy. It contributes to improving the air quality and reducing noise in urban agglomerations and other densely populated areas. The environmental benefits vary. However, electromobility has its requirements, and the most important thing is to provide publicly accessible charging stations. Without infrastructure, there will be no need to develop.

Use of Alternative Fuels in the European Union

The transport sector, which includes both domestic and international transport, accounts for almost 30% of annual carbon emissions in the European Union. The EU's goal is to gradually reduce these emissions through legislation and to achieve climate neutrality by 2050. One of the goals and initiatives is to break the link between the transport sector and its dependence from fossil fuels. In this respect, alternative fuels at least partially serve as a substitute for fossil resources, in particular oil in the supply of energy for transport, they contribute to the elimination of carbon emissions in the sector and improve the environmental performance of the transport sector. On the other hand, there is electricity, which also has the potential to reduce CO2 emissions from transport. Electromobility is a fast-growing area. It increases the energy efficiency of road vehicles. In electromobility, there is an important and fundamental requirement creating publicly accessible charging stations. Currently, the coverage of charging stations and the traffic of electric vehicles is concentrated in urban and suburban areas and other densely populated areas [1-5].

Measures and national targets are generally set for the development of the market for alternative fuels, which take into account the nature of the various transport sectors in the individual Member States of the European Union. They focus on supporting the industry and infrastructure. However, the individual Member States of the European Union differ greatly in their national targets for the use of alternative fuels. This follows from the AFI Directive, where stated that 10 of the 28 countries focus on electromobility as a matter of priority, while 12 Member States prefer either natural gas or ambitions

for alternative fuels are low. These 12 states are likely to experience delays in electrification [1]. In Table 1, Member States are divided according to development priorities in alternative fuels.

Table 1

Development priorities of the Member States of the European Union in the field of alternative fuels [1]

Country/ priority	AT	HU	DK	FR	DE	IE	NL	LU	VB	FI	CZ	BG	BE	HR	CY	EE	LV	LT	ES	PL	PT	SK
Electricity																						
Natural gas																						
Mixed																						
Low ambition																						

Promoting the use of alternative energy sources in transport, is related to the drive to become the first climate-neutral continent, through a set of measures set out in the Europe Green Agreement. The Green Agreement estimates that by 2025, there will be 13 million zero- and low-emission vehicles in the European Union. In line with the Green Agreement, the European Commission has set a milestone of at least 30 million zero-emission vehicles by 2030 and a predominantly zero-emission vehicle fleet by 2050. This is an ambitious goal [2; 5-7].

Development of Electric Charging infrastructure in the European Union

The available charging infrastructure is a key prerequisite for accelerating the arrival of electric cars. From the European Union's point of view, the Member States' aspirations to promote alternative fuels vary considerably. This follows from a survey of individual government plans, within national policies. Each Member State analyses its current situation and, on that basis, sets its ambitious targets for the introduction of alternative fuels, including the deployment of infrastructure. From the point of view of electromobility, in the overall result, it can be argued that the current level of charging stations, available within the European Union is relatively sufficient with regard to the number of current vehicles on the road. It is important to note and emphasize that the European Commission has recommended one charging station for every ten electric vehicles. It is clear, that this ratio will vary considerably from one location to another in the European Union [3; 4; 8-10].

The share of electric vehicles varies across the Member States and ranges in percentage terms from 0.04% to 3% of the total passenger car fleet [2]. Take, for example, Germany, where the total number of passenger cars is 47.7 million. With a share of 0.8%, it is approx. 380,000 electric vehicles registered in Germany. The total estimate of registered electric vehicles in the European Union is approx. 2 million. However, it should be noted that the current state does not represent the desired state. The number of electric vehicles is growing, although different from the point of view of individual Member States. The differences in growth are mainly influenced by the already mentioned national strategies and goals of individual countries. Figure 1 shows the number of registered electric vehicles in EU Member States.

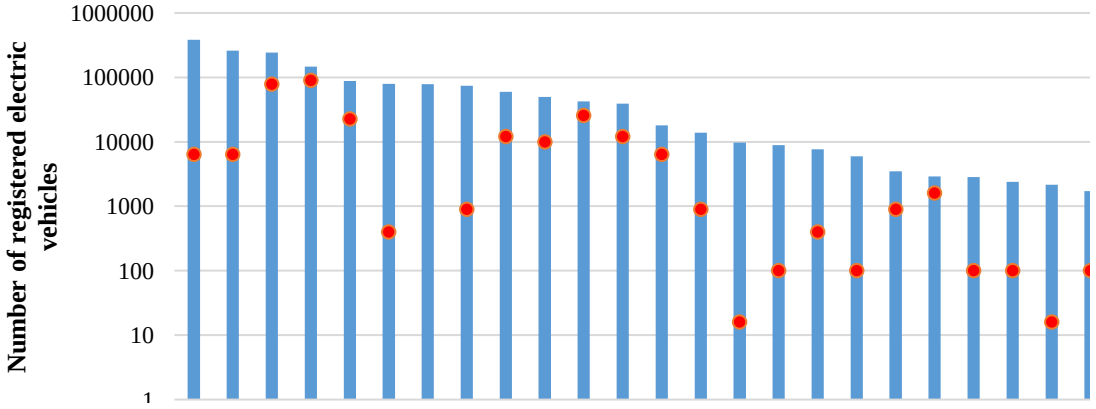

Fig. 1. **Number of registered electric vehicles in Member States and their percentage of the total number of registered vehicles [2; 4]**

The charging network for electric vehicles is growing in the European Union. The number of publicly accessible charging stations increased from approximately 34,000 in 2014 to 280,000 in 2021. The goal of the Green Agreement is to reach 1 million publicly charging stations by 2025 [2]. In this case, given the trend in 2014-2021, it is clear that there is a significant risk that the target will not be met. The difference between the goal and the current situation is quite high. At the same time, it should be emphasized that there are significant differences in the current state of publicly accessible charging stations between the Member States of the European Union. An overview of the current state of the charging infrastructure is shown in Figure 2.

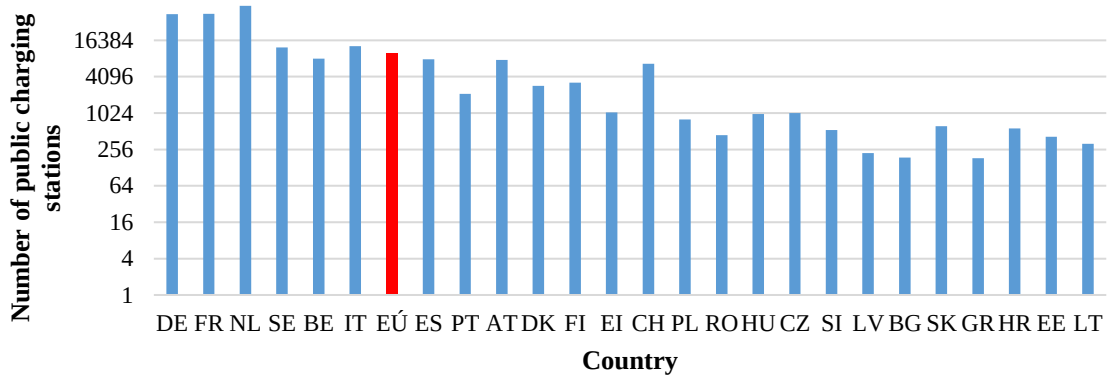

Fig. 2. **Overview of the current state of public charging points in the EU Member States [2; 4]**

It can be assumed that each country responds to the current market of electric vehicles by the number of charging stations. The more electric vehicles, the more charging stations. The issue in this case concerns cross-border drivers. In this case, it can be assumed that the situation will change very quickly over time and all countries will have to put in place a certain level of infrastructure.

Results and discussion

The development of the electric vehicle market itself and the construction of public charging stations in EU countries will take place in different waves. A report from the Platform for Electro Mobility pointed this out. Starting from Figures 1 and 2, the western Nordic countries show a high number of registered electric vehicles, but from the point of view of the total car fleet, this share is less than 2% in most cases. A very similar situation is repeated in the countries of the southern Mediterranean, Central and Eastern Europe, where the total share of electric vehicles in the total car fleet is about 1% or less. The number of public charging stations is derived from the number of electric vehicles in the country [1; 12].

Let us look at the situation based on the European Commission's recommendation - 10 electric vehicles for a public charging station [1]. Figure 3 assesses the total number of registered electric vehicles to the total number of public charging stations (European Commission recommendation). In the graph, the member countries are divided into two parts. Countries that are below the line – such as France, the Netherlands, Switzerland, the Slovak Republic, etc., have built more public charging stations than the number of registered electric vehicles. Countries that are above the line, such as, Poland, Romania, etc., on the other hand, have fewer public charging stations built than the number of registered vehicles. The overall assessment follows from the recommendation of the European Commission – 10 electric vehicles for a public charging station. At the same time, the graph shows that the individual countries of the European Union are not fundamentally deviated from the average that is in the Union [1; 12; 13].

Figure 4 shows the number of public charging stations per average annual percentage change. The European Union average of these two indicators divides the diagram into four quadrants, which divide the individual member states into categories that indicate the level of development of infrastructure for electric vehicles.

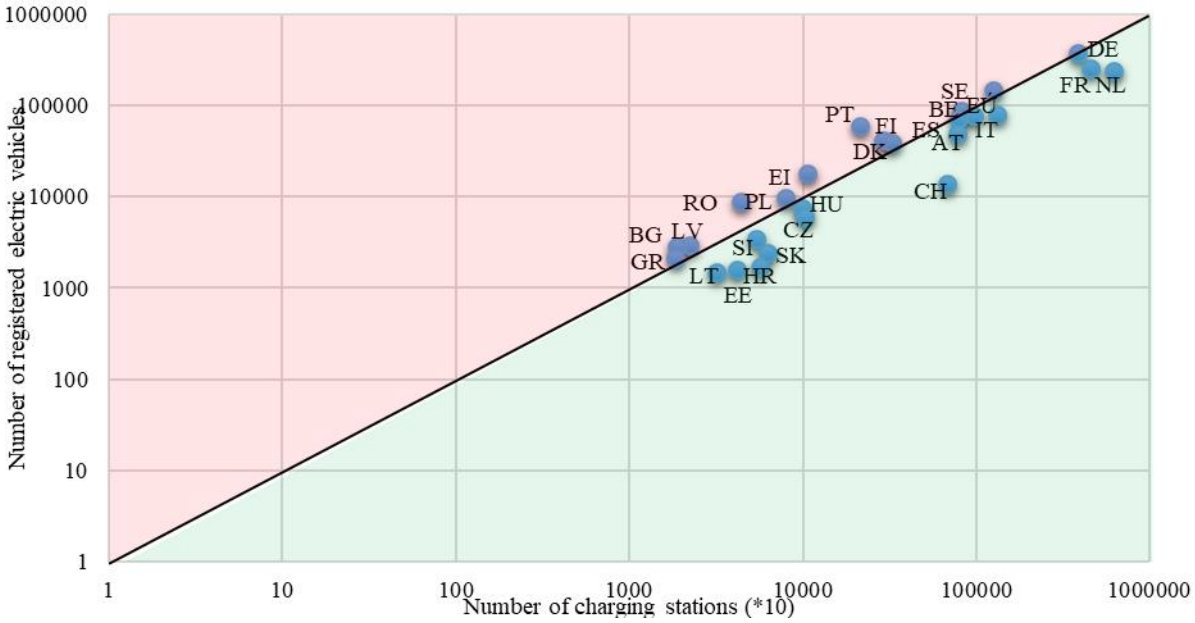

Fig. 3. **Total number of registered electric vehicles to the total number of public charging stations - recommendation of the European Commission**

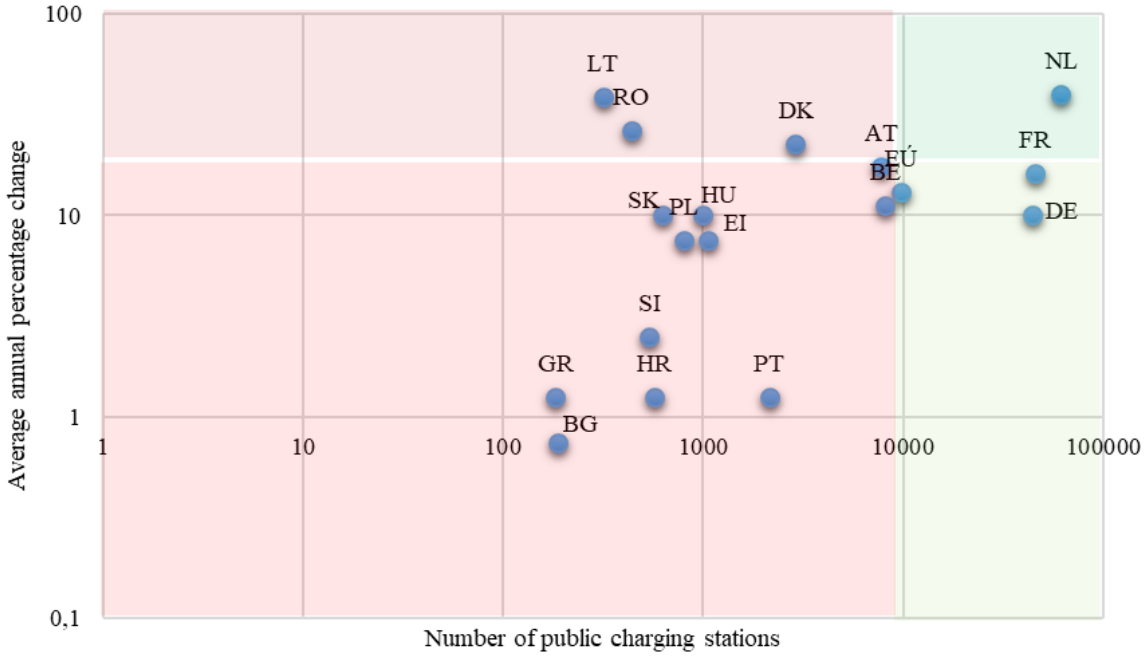

Fig. 4. **Number of public charging stations in relation to the average annual percentage change**

The highest pace of infrastructure development is recorded in the Netherlands and France, also taking into account the number of charging stations. In the case of Germany, a large number of charging stations are recorded, but the annual percentage change is 7.5%. Other countries have seen either a very high percentage change in infrastructure development in recent years, but the number of charging stations is low, or development and the number are relatively low.

Conclusions

A coordinated approach is needed to meet the long-term needs of transport. The Member States of the European Union have created a national policy framework that focuses on growth and the subsequent setting of national targets, intentions and support measures for the development of the market for

alternative fuels. In this respect, we see a different approach to the development priorities of individual Member States. It should be emphasized that some Member States are more ambitious and prefer electromobility to gas. From the electromobility data analysed in the article, it is clear that each Member State does not deviate in any way from the European Union average. As a rule, the more electric vehicles in the country, the more public charging stations. The pace of infrastructure development varies, but first of all it can be argued that the pace of development is influenced by the development of the electric vehicle market and the fulfilment of established infrastructure plans. At the same time, it should be noted that with regard to charging stations for electric vehicles, which are not publicly available, distribution system operators play an important role in relation to charging stations. We emphasize the need to harmonize the development of infrastructure for alternative fuels, so as not to prevent the development of economies of scale on the supply side and mobility on the demand side.

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Author contributions

Conceptualization, M.B.; methodology, M.B., J.K. and K.Z.; software, M.B.; validation, M.B., J.K. and K.Z.; formal analysis, M.B., J.K. and K.Z.; investigation, M.B., J.K. and K.Z.; data curation, M.B. and J.K.; writing – original draft preparation, M.B. and J.K; writing – review and editing, M.B., J.K. and K.Z.; visualization, M.B.; project administration, M.B.; funding acquisition, K.Z. All authors have read and agreed to the published version of the manuscript.

References

[1] European Federation for Transport and Environment. 2020. How EU Member States roll-out electric-mobility: Electric Charging Infrastructure in 2020 and beyond. Website. [online] [17.03.2022]. Available at: https://www.transportenvironment.org/wp-content/uploads/2021/07/Emobility%20Platform%20AFID%20analysis.pdf

[2] European Court of Auditors. 2021. Infrastructure for charging electric vehicles: more charging stations but uneven deployment makes travel across the EU complicated. 2021. ISBN 978-92-847-5730-5

[3] VIRTA. 2021. Here's how EU legislation accelerates the EV revolution. Website. [online] [20.03.2022]. Available at: https://www.virta.global/blog/this-is-how-eu-regulation-accelerates-the-electric-vehicle-revolution

[4] Ballay M., Kubas J., Zabovska K. Development of Electromobility in The European Union with the Emphasis on The Safety. 37th IBIMA. Spain, 2021. ISBN: 978-0-9998551-6-4

[5] Ballay M., Monoši M. Electric vehicle technologies in relation to the implementation fire service rescue operations. In. Crisis Management Journal, 2016. ISSN:1336-0019

[6] Grant C. Personal Protective Equipment for Hybrid and Electric Vehicles", Fire Protection Research Foundation, Quincy MA, 2012. Online: www.nfpa.org/Foundation.

[7] International Energy Agency. 2010. Energy Technology Perspectives. Scenarios and Strategies to 2050. ISBN : 978-92-64-08597-8

[8] Sventekova. E., Leitner B., Dvorak Z., Transport critical infrastructure in Slovak republic. IMCIC 2017 - 8th International Multi-Conference on Complexity, Informatics and Cybernetics, Proceedings. Volume 2017-March, pp. 212-215. ISBN 978-194176355-1

[9] Leitner B., Luskova M., Dvorak Z., Sventekova E., Fatigue damage prediction as a part of technical systems reliability assessment. Key Engineering Materials. rans Tech Publications Ltd. ISSN:1013-9826

[10] Dvorak Z., Leitner B. Novák L. Software support for railway traffic simulation under restricted conditions of the rail section. In: Procedia Engineering [online]. - ISSN 1877-7058. - Vol. 134 (2016), online, pp. 245-255.
[11] European Comission. 2021. Statistical Pocketbook 2021 – EU Transport in figures. Luxembourg: Publications Office of the European Union. ISBN 978-92-76-40099-8
[12] Sventeková E. Urbancova, Z. Holla, K. 2021. Assessment of the vulnerability of selected key elements of rail transport: Slovak case study. In: Applied sciences - ISSN 2076-3417 (online). - Roč. 11, č. 13 (2021), pp. 1-22.
[13] Jánošíková M., Zábovská K., 2021. The Use of Simulation in Dealing with Crisis Events within Transport. In. Transportation Research Procedia, 2021, 55, pp. 1641-1648