TRANSFORMATION OF AUTOMOTIVE INDUSTRY INDUCED BY SUSTAINABILITY ISSUES AT THE DAWN OF TWENTY-FIRST CENTURY

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Abstract

Transportation on roads is understood as one of the sources of toxic emissions harming climate and air. Initiatives with aim of the carbon dioxide emissions reduction are arising as a consequence of environmental sustainability. For instance, it is a commitment to achieve energy neutrality by 2050 in EU countries. One of the tools for reaching the goal of energy neutrality is the hydrogen strategy. The hydrogen strategy is based on the transformation of industry and technology changes apart from others also in transportation where there is an assumption of usage till 2030. According to the Ministry of Industry and Trade in the Czech Republic, it is mainly the automobile market that is technically advanced and has greater potential in the use of hydrogen. Emissions from hydrogen fuel cells are low and therefore hydrogen deserves attention as a future fuel option. For example, European Automobile Manufacturers' Association suggested hydrogen refuelling infrastructure to be upgraded. European Investment Bank already has a funding scheme "Clean Hydrogen Europe". This gives impetus to examine economic aspects related to hydrogen as the new substance in the transportation industry.

Key words: energy, hydrogen, automotive industry

JEL Code: L94, Q41

Introduction

New fuels are being introduced for individual transportation, among them is Hydrogen (H2). The exploration, and excavation of sources start with technological advancement. In Albania (concretely: Eastern Mediterranean supra-subduction-zone ophiolite belt that the Balquize chromite mine is a part of) there are three scenarios (Truche et al., 2024) on how to prepare and safely operate the reservoir to use H2 in industry. Another example of Hydrogen investigation is placed in America (Idaho cobalt belt rocks (Johnson et al., 2012)). Critical Raw Materials Act (European Critical Raw Materials Act - European Commission, 2023) emphasises the diversification of suppliers of materials, however, cooperation on preventing climate change is

based on overall contributors, not on people who supply and who consume. Thus, there is a time to think complexly not separately about raw materials and separately on climate change.

For example, the European Automobile Manufacturers' Association (EAMA) suggested hydrogen refuelling infrastructure be upgraded ('Fuel Cell Vehicles', 2019). European Investment Bank already has a funding scheme "Clean Hydrogen Europe" (Ibid.) that shall help innovations to bring solutions to practice.

The paper examines economic aspects related to hydrogen as new substance in transportation industry. Examination is done by using secondary data from the Czech Automotive Association and the Ministry of Transport and previous surveys in selected European countries with emphasis on the Czechia. The paper applies only descriptive statistics using Excel and R software (R Core, 2021) and a literature overview.

1 Review of literature

The use of hydrogen in the automotive industry is being focused on by empirical literature, considering existing initiatives (for example, the Hydrogen strategy of the Ministry of Industry and Trade in Czechia) and future possibilities of using alternative forms of fuel. Wilberforce et al. (2017) focused on the issues limiting the expansion of fuel cell technology in the automotive industry. Their findings show a high price, low lifespan, problematic infrastructure for hydrogen refuelling, and hydrogen storage in vehicles with fuel cells. Wilberforce et al. (2017) consider the price as the main problem, which could be reduced by a lower platinum content without reducing the performance of the fuel cell and by finding platinum-free catalysts. Jain (2009) also points out the cost factor of hydrogen. Jain (2009) emphasises the need to create infrastructure for hydrogen refuelling in cars and to consider the safety aspects of its application.

The potential of hydrogen in the automotive industry is shown by Jain (2009) also by Candelaresi et al. (2021). Candelaresi et al. (2021) state that hydrogen is the solution to decarbonization, however, they also see some good opportunities in vehicles using hydrogen mixed with natural gas or gasoline. However, they see this combination as only a short-term boost to hydrogen use and emissions reduction. On the other hand, for example, Albatayneh et al. (2023) suggest that hydrogen vehicles will not replace electric cars and trucks (at least before 2050). Albatayneh et al. (2023) emphasize the high cost of hydrogen and the need to provide a supporting infrastructure. At the same time, they argue that hydrogen research in automotive transport is associated with high sunk costs and therefore consider further hydrogen research and development to be an important policy issue.

Opposite findings compared to Albatayneha et al. (2023) were detected by Mazloomi & Gomes (2012). Mazloomi & Gomes (2012) show that hydrogen has a promising future as an energy carrier and energy source. As some of the advantages of hydrogen, Mazloomi & Gomes (2012) mention, for example, a higher content of gravimetric energy, the possibility of localizing fuel production and the possibility of production from renewable energy sources. On the other hand, it also finds many disadvantages, such as low volumetric energy content, infrastructure development, hydrogen storage costs and risk of handling hydrogen.

Based on the above-mentioned conclusions of empirical studies, in Tab. 1 find a summary of the basic advantages and disadvantages of hydrogen as a fuel.

Tab. 1: Advantages and disadvantages of hydrogen as a fuel

Factor	Advantage/disadvantage	Author/s
Fuel production localization	Advantage	Mazloomi & Gomes (2012)
High costs	Disadvantage	Wilberforce et al. (2017), Mazloomi & Gomes (2012)
Impact on health and environment	Advantage	Candelaresi et al. (2021), Jain (2009)
Infrastructure	Disadvantage	Wilberforce et al. (2017), Albatayneh (2023)
Low service life	Disadvantage	Wilberforce et al. (2017)
Low volumetric energy content	Disadvantage	Mazloomi & Gomes (2012)
The most abundant element in the universe	Advantage	Jain (2009)
Problems with storage	Disadvantage	Wilberforce et al. (2017)
Production from renewable energy sources	Advantage	Mazloomi & Gomes (2012)
A pure form of energy	Advantage	Jain (2009), Albatayneh (2023), Mazloomi & Gomes (2012)
Risk of handling hydrogen	Disadvantage	Mazloomi & Gomes (2012)
Storage of hydrogen in vehicles	Disadvantage	Wilberforce et al. (2017), Candelaresi et al. (2021)
The lightest fuel	Advantage	Jain (2009)
Theoretically unlimited resource	Advantage	Jain (2009)

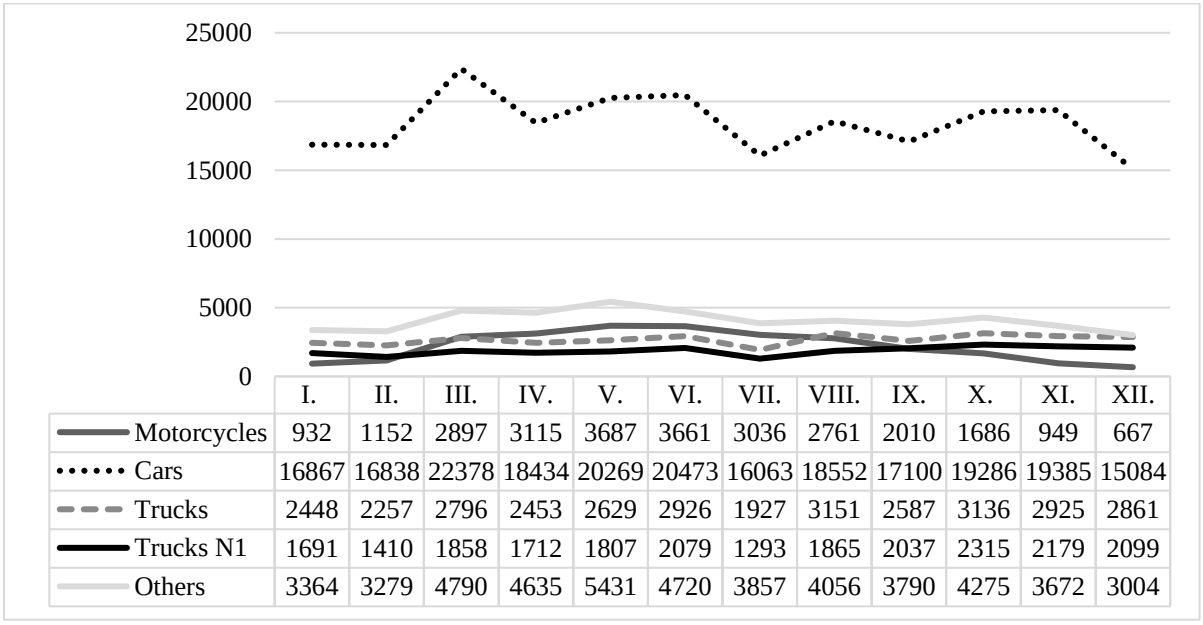
Source: Authors' representations.

2 Using of motor vehicles in the Czechia

The future of hydrogen as a fuel can also be seen in Czechia due to the growing use of motor vehicles. In Czechia, there has been an apparent increase in the utilization of motor vehicles in 2023, despite the fluctuating trend. This is evidenced by Fig. 1. In Fig. 1, we observe the development of new motor vehicle registrations as of January 1, 2024, according to the Czech

Ministry of Transport. While the highest numbers of registrations are evident for cars, new registrations are also growing for other categories of motor vehicles, including motorcycles, buses, trucks, N1 trucks, and other types of motor vehicles. Among these other types of motor vehicles, we include tractors, trailers, buses, specialized transport vehicles, and other types such as towing vehicles. Across all types of motor vehicles, there are noticeable fluctuations in 2023, which could be attributed to several factors. For instance, it may have been influenced by an energy crisis, leading consumers to be more frugal. Another reason could be a logistical crisis, and supply and production issues, which resulted in increased costs for motor vehicles, subsequently affecting consumer demand.

Fig. 1: Development of registrations of new motor vehicles (as of 1/1/2024, in numbers)



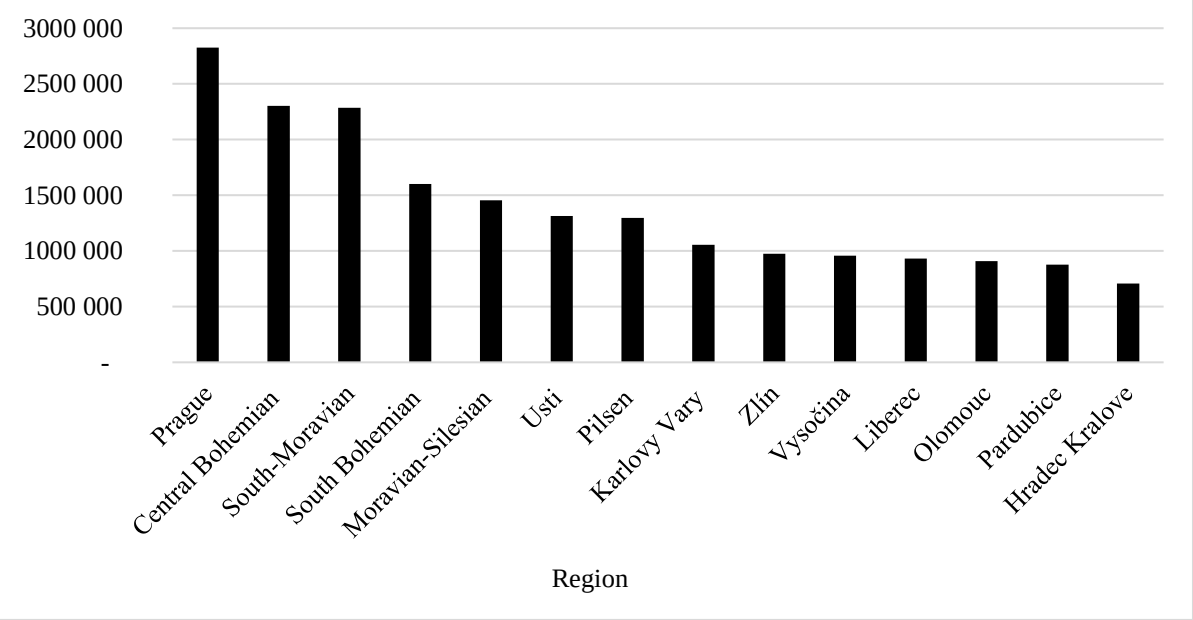
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
Motorcycles	932	1152	2897	3115	3687	3661	3036	2761	2010	1686	949	667
Cars	16867	16838	22378	18434	20269	20473	16063	18552	17100	19286	19385	15084
Trucks	2448	2257	2796	2453	2629	2926	1927	3151	2587	3136	2925	2861
Trucks N1	1691	1410	1858	1712	1807	2079	1293	1865	2037	2315	2179	2099
Others	3364	3279	4790	4635	5431	4720	3857	4056	3790	4275	3672	3004

Source: Czech Ministry of Transport. (2024, April 10). *Archiv statistik Registru silničních vozidel*. mdcr.cz. https://www.mdcr.cz/Statistiky/Silnicni-doprava/Centralni-registr-vozidel/Statistika-2-2016-(k-1-7-2016)/Statistika-II-pol-2022-(k-1-1-2023)?returl=/Statistiky/Silnicni-doprava/Centralni-registr-vozidel/Statistika-2-2016-(k-1-7-2016), Authors' calculations.

The growth in new registrations of motor vehicles belonging to the considered categories (motorcycles, cars, buses, trucks, N1 trucks, and other types of motor vehicles) has manifested in the number of registered motor vehicles in individual regions of the Czechia as of January 1, 2024. The largest number of motor vehicles is registered in Prague (2,825,776),

the Central Bohemian region (2,302,294), and the South-Moravian region (2,285,286) as Fig. 2 shows. These three regions are followed by the South Bohemian region (1,600,862), the Moravian-Silesian region (1,454,760), the Usti region (1,313,524), and the Pilsen region (1,295,904). Very similar numbers of registered motor vehicles are then recorded in other regions of the Czech Republic. Specifically, in the Karlovy Vary region (1,056,106), the Zlín region (974,202), the Vysočina region (958,522), the Liberec region (930,800), the Olomouc region (909,972), the Pardubice region (877,770), and the Hradec Kralove region (708,158). The prominent position of Prague and the Central Bohemian region could be related to the highest population numbers in these two regions. Differently, in individual regions, factors such as residents' financial situations, public transportation services, and availability of services and employment may also play a role.

Fig. 2: Number of motor vehicles by the original region (as of 1/1/2024, in numbers)



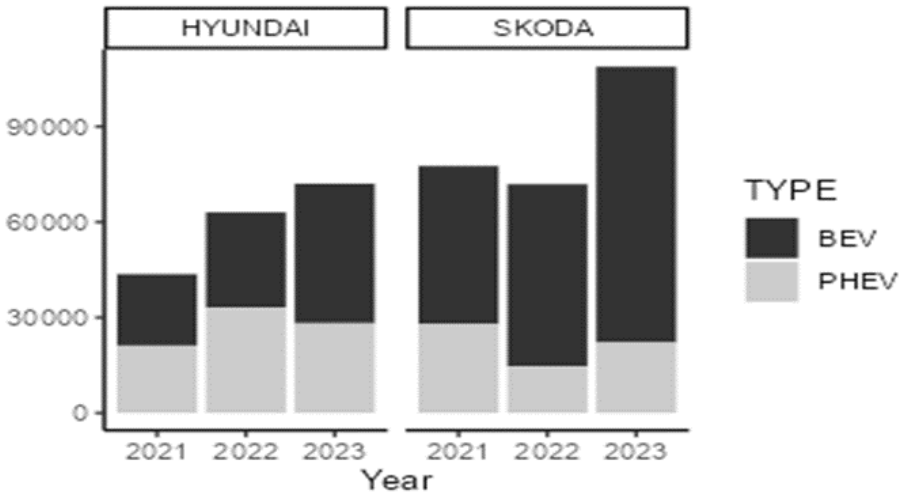
Source: Czech Ministry of Transport. (2024, April 10). *Archiv statistik Registru silničních vozidel*. mdcr.cz. https://www.mdcr.cz/Statistiky/Silnicni-doprava/Centralni-registr-vozidel/Statistika-2-2016-(k-1-7-2016)/Statistika-II-pol-2022-(k-1-1-2023)?returl=/Statistiky/Silnicni-doprava/Centralni-registr-vozidel/Statistika-2-2016-(k-1-7-2016), Authors' calculations.

3 Discussion on the production of cars that use alternative fuel

Till 2015 in whole of Europe had about 100 hydrogen stations as claimed in the National Action Plan for Clean Mobility[1] (NAP, 2015). This is an obvious hindrance to the use of vehicles fuelled by hydrogen. The solution is to use gas stations, chemists already test how to mix gas and liquid hydrogen to provide flexible transportation and supply for trucks, buses and cars. Hyundai is known for Corean „new age" cars and the company literary follows trends in producing a car that uses hydrogen as fuel, i.e. ix35 Fuel Cell. Hydrogen-fuelled cars are tanked as fast as traditional cars and faster than charging electric cars.

To illustrate the situation in the Czechia the data of the Czech Automotive Association (SAP, 2024) was examined. Fig. 3 shows the growth of the production in either Plug-in Hybrid Electric Vehicles (PHEV) or Battery Electric Vehicles (BEV) that are produced by companies Hyundai or Škoda. The distinction between the two types is that BEV has zero emission and no gas engine parts, while PHEV is similar to a hybrid. It should be visible that Škoda is focused on production of BEV cars.

Fig. 3: Comparison of vehicles that are focused on the use of alternative fuels (in numbers)



Source: The Czech Automotive Industry Association. (2024).

The Average Annual growth rate in PHEV type was 0.98 % and 1.02 % in year changes 22/21 and 23/22 respectively. For type BEV the growth rates are 1.09% and 1.22 % in the same

[1] Národním akčním plánu čisté mobility (NAP CM)

period. This calculation was done on the total number of cars produced by Hyundai and Škoda. The production started with 49 093 cars of PHEV and 72 169 BEV in 2021 and reached 50 316 and 130 571 cars of PHEV and BEV respectively by the end of the year 2023. The number of cars using hydrogen as fuel is minimal in Czechia compared to the number of registered motor vehicles. Specifically, in 2023, there were 24 cars manufactured by Toyota and Hyundai. Of these, 20 cars were manufactured under the Toyota brand (20 cars, Mirai model) and the rest were manufactured under the Hyundai brand (4 cars, Nexo model), according to The Transport Research Center (2023).

Conclusion

The paper examined economic aspects related to hydrogen as a new substance in the transportation industry. The issue of using hydrogen as a fuel is still the subject of research and extensive debates. This paper provided a summary of some factors that are referred to as advantages and disadvantages connected to hydrogen as used as fuel. Some advantages of using hydrogen can be highlighted, such as the impact on health and the environment (Candelaresi et al., 2021; Jain, 2009), production from renewable energy sources (Mazloomi & Gomes, 2012) and the lightest fuel (Jain, 2009). The most important disadvantages include, for example, infrastructure (Wilberforce et al., 2017; Albatayneh, 2023), low service life (Wilberforce et al., 2017) and high costs (Wilberforce et al., 2017; Mazloomi & Gomes, 2012).

However, the extensive use of motor vehicles leads to the need to find new forms of fuel due to the sustainability of transport. For example, in Czechia, there is a relatively growing use of the Plug-in Hybrid Electric Vehicles and Battery Electric Vehicles. A certain shift is also visible in the use of hydrogen cars, but so far this is rather negligible.

This suggests that progress in the industry is being made with hurdles and doubts. After a brief analysis, it can be concluded that hydrogen could become the next generation of fuel and power. Foremost it is the cleanest energy possible as many have agreed already (Jain, 2009; Albatayneh, 2023; Mazloomi & Gomes, 2012).

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