Impacts of electromobility on the environment and society

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https://doi.org/10.33542/VSS2025-1-3

Abstract

The paper deals with electromobility and analyses its impacts on the environment, evaluates the emissions of electric cars in comparison with conventional combustion engine vehicles. It points out current trends and current developments in the electric car market, with the aim of analysing and predicting future developments. The aim of the paper is to clarify the impacts of the extraction of strategic raw materials used in lithium-ion batteries, and to highlight their constantly growing production. The result of the paper is increased awareness of electromobility and its impact on society, where the geographical location of the city or municipality proves to be an important factor. The paper also offers a quality basis for forming an objective and constructive opinion on all the problems and advantages associated with electromobility.

Keywords: *electromobility, emission, emission-free use of vehicles.*

Introduction

In today's fast-paced and hectic times, full of electronic devices without which we can hardly imagine our daily lives, it is important to also think about issues related to the production, sustainability and recycling of these technologies. Electric cars, which have become increasingly popular in recent years and are rapidly breaking into the market, are no exception. In the case of electric cars, people are mostly divided into two camps (Tao and Qin, 2022). The first camp is made up of those who are advocates and supporters of the production and use of electric cars for environmental protection and reducing the carbon footprint. The second camp is made up of people who do not support this "current trend" and are not convinced that electric cars are ecological and environmentally friendly. The first camp focuses exclusively on the "landless" use of electric cars and often neglect the factors associated with the production, processing and recycling of individual components. On the other hand, the second camp focuses mainly on the negative aspects of electric vehicles, such as mining, processing and recycling, and neglects the benefits of electric vehicles in terms of reducing emissions.

The article deals with electric mobility and analyzes its impacts on the environment, evaluates the emissions of electric vehicles compared to conventional combustion engine vehicles, and points out current trends and developments in the electric car market, aiming to analyze and predict future developments. The main method of obtaining results was quantifying the share of hybrid and electric vehicles in global markets and the method of comparing emissions of the studied types of vehicles. We will therefore address these current issues related to electric vehicles through an analysis of international trade in hybrid and electric vehicles, which will provide an up-to-date overview of trends and trade relations in this area. At the end of the paper, we will focus on a comparison of emissions produced during the life cycle of an electric vehicle and a vehicle with an internal combustion engine. The outcome of the work is increased awareness of electric mobility, which provides a basis for forming an objective and constructive opinion on all issues as well as the advantages associated with electric mobility.

1. Theoretical foundations

From a technological perspective, electromobility is advantageous primarily in terms of the efficiency of the electric motor, which reaches up to 90% efficiency, which is significantly higher than the efficiency of the combustion engine. Electric propulsion also allows flexibility in vehicle design, such as the possibility of all-wheel drive without a cardan shaft and the location of the batteries in the floor, which lowers the centre of gravity and improves the stability of the vehicle. Recuperation, the process of recovering energy from braking and deceleration, is another key factor contributing to the efficiency and energy savings during the operation of electric vehicles (Sanguesa et al., 2021).

There are currently several types of electrified vehicles, such as hybrid (HEV), plug-in hybrid (PHEV), pure electric vehicles (BEV) and range-extending electric vehicles (REEV). Each type offers different advantages depending on the required range, charging infrastructure and efficiency of the energy systems. However, the development of pure electric vehicles (BEV) seems to be the most promising, as they have the greatest potential to reduce CO_2 emissions, especially when combined with the decarbonisation of the energy sector, where renewable and nuclear energy sources play a key role (Husain, 2021).

However, the production and operation of electric vehicles also comes at an environmental cost (Hawkins et al., 2012). The largest share of emissions during the life cycle of battery electric vehicles comes from the production of batteries, which require the extraction of raw materials such as lithium, cobalt and nickel, an energy-intensive process with negative environmental impacts. Although battery production causes approximately 40% higher emissions compared to hybrid and internal combustion vehicles, these emissions are significantly reduced during the operation of electric vehicles, especially if the electricity is generated from renewable sources. Decarbonisation of the energy sector, which includes the wider use of renewable and nuclear energy sources, is therefore essential to further reduce emissions and improve the environmental benefits of electric vehicles.

An important aspect that affects the environmental impact of electric vehicles is the treatment of batteries at the end of their life. Remanufacturing, reuse and recycling of batteries are key processes that can help reduce the need for new raw materials and reduce the environmental impact of producing new batteries. Although recycling technologies still face various challenges, such as battery variability and the energy intensity of recycling processes, improving these processes is essential for the sustainable development of electric vehicles. Remanufacturing batteries extends their life and can reduce the cost of battery replacement, which also reduces the environmental cost of producing new batteries (Koech et al., 2024). Reusing batteries in less demanding applications, such as energy storage in renewable sources, can reduce their environmental impact.

The importance to study subject of the research is underlined by number of studies, such as Pietrzak and Pietrzak (2020), confirming importance of the electromobiilty increase in cities due to the pollution due to the public transport. This results from the different quality of the power in power system (Chudy and Mazurek, 2019). Later, Pietrzak and Pietrzak (2021) confirmed the problem is solved by increase of renewable energy sources share. Not every country in EU has electricity sources. This depends mainly on the type of energy mix and state support (Adamczyk et al., 2024). Popularization of green vehicles requires strategic management of the state (Kozlowska 2023). Solving of the presented problem could have significant impact also to the employment and economic indicators (Bravo et al., 2024).

2. Analysis of the international business with hybrid and electric vehicles

In this section, we analyse the import of hybrid and electric cars from countries outside the EU, reaching EUR 48 billion in 2023, an increase of 31% compared to 2022. The largest share was made up of electric vehicles (EUR 23 billion), followed by hybrids without connection to the electric grid (EUR 16 billion) and plug-in hybrids (EUR 9 billion).

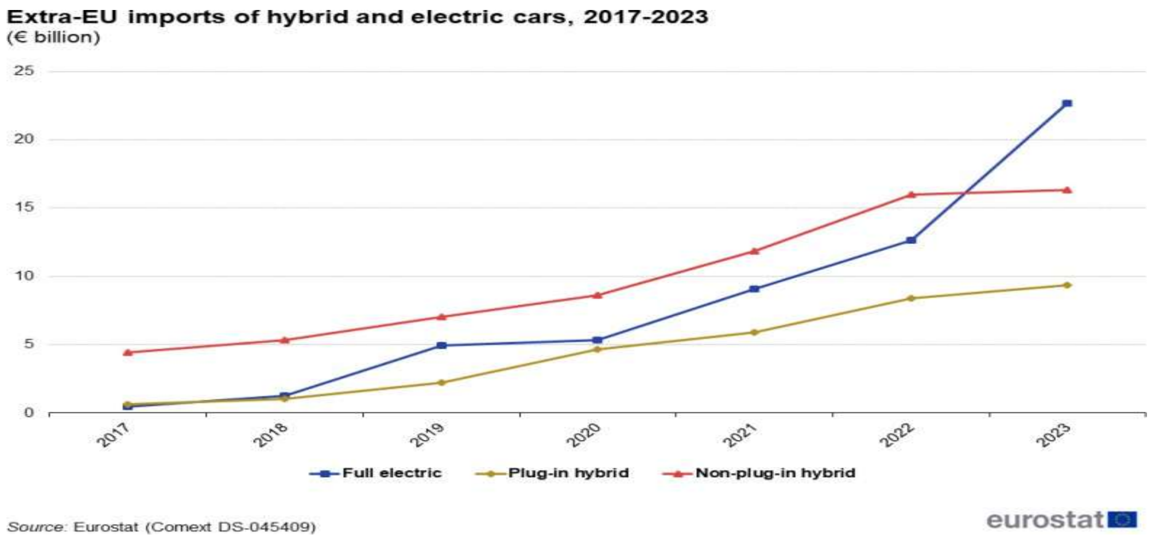

Figure 1: Import of electric and hybrid vehicles outside EU in billion EUR 2017 - 2023

Source: Eurostat, 2025

The graph shows a significant increase in imports of all three vehicle categories, with the most dynamic growth recorded by fully electric vehicles, which reached the highest import volume in 2023, exceeding 20 billion Euros. Fully electric vehicles (blue curve) recorded the most significant growth, especially after 2020. This trend is likely related to increased demand for electric vehicles, strengthening environmental regulations and growing investments in charging station infrastructure. Plug-in hybrid vehicles (yellow curve) grew at a smoother pace, with their imports gradually increasing every year. Although their share in total imports grew, they did not achieve the same dynamics as fully electric vehicles. Non-plug-in hybrid vehicles (red curve) (red line) had the highest import volume of all categories in the period 2017-2021. However, after 2022, their growth stagnated, while imports of fully electric vehicles surged, surpassing hybrids in 2023.

Exports of hybrid and electric vehicles to non-EU countries were even higher at €62 billion (+6% compared to 2022). Exports were also dominated by electric vehicles (€30 billion), non-plug-in hybrids (€23 billion) and plug-in hybrids (€10 billion). [6] Figure 2 shows exports of electric and hybrid vehicles from non-EU countries, in billions of euros, from 2017 to 2023.

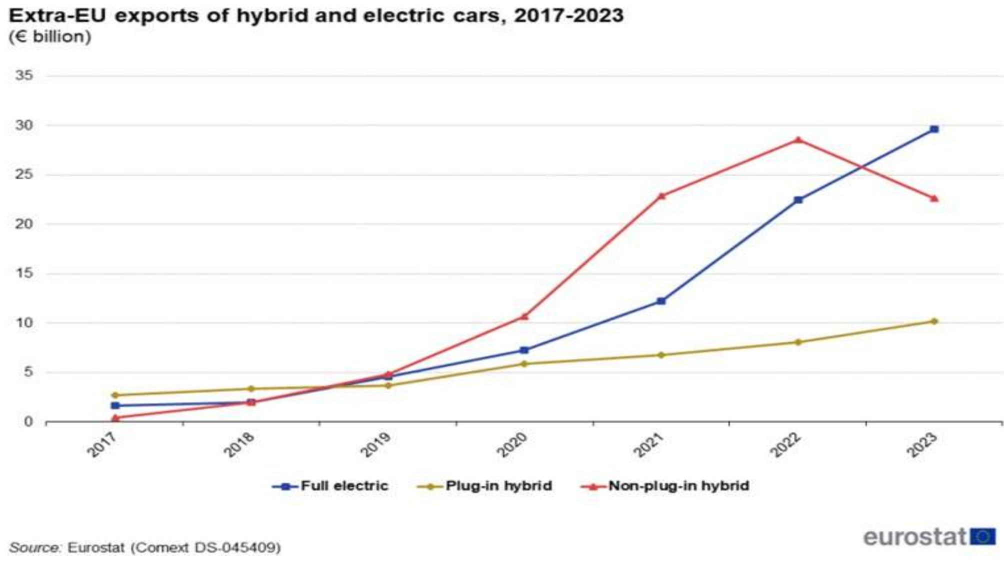

Figure 2: Export of electric and hybrid vehicles outside EU in billion EUR 2017 -2023

Source: Eurostat, 2025

3. Rate of hybrid and electric vehicles on import and export

In 2023, hybrid and electric cars accounted for 44% of total car imports into the EU, up 37 percentage points from 2017. Fully electric cars accounted for 21% of total imports (+20 pps compared to 2017), plug-in hybrids 18% (+12 pps), and non-plug-in hybrids 6% (+5 pps).

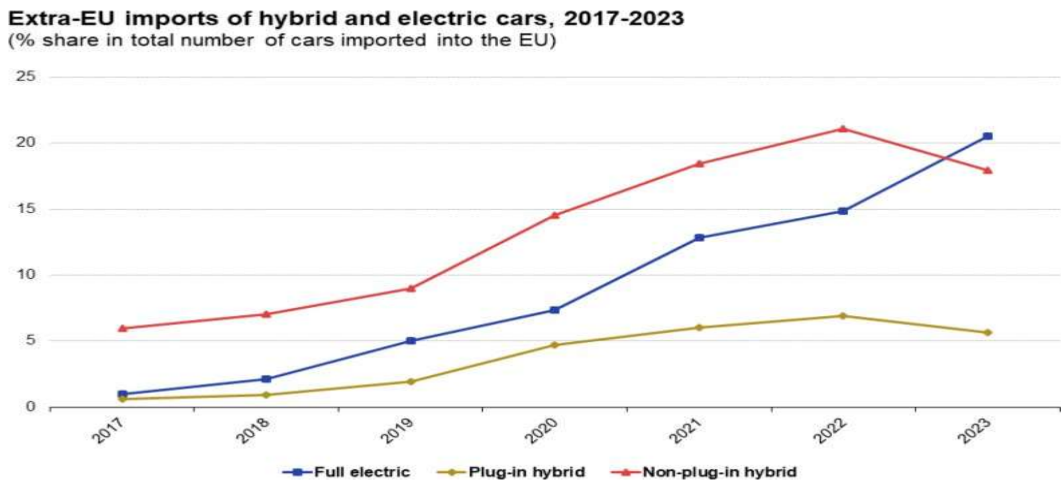

Figure 3: Import of hybrid and electric vehicles outside EU 2017 – 2023 (% rate on total number of imported vehicles to EU)

Source: Eurostat, 2025

Full electric vehicles (blue curve) – Their share of imports has grown significantly since 2017, with accelerated growth since 2020. In 2023, they reached a share of around

20%, almost equalling non-plug-in hybrids. This development reflects the increased demand for electric vehicles, supported by environmental regulations and technological advances. Plug-in hybrid vehicles (yellow curve) – This category grew at a steady pace, but remained the least represented compared to full electric vehicles and non-plug-in hybrids. Growth slowed down since 2022 and even fell slightly in 2023. This may be related to the increased preference for pure electric vehicles over hybrid solutions. Non-plug-in hybrid vehicles (red curve) – Until 2022, they were the most important category within hybrid and electric vehicle imports, with their share reaching over 20% in 2022. However, they recorded a decline in 2023, probably due to a shift in demand towards fully electric vehicles. In exports in 2023, electric and hybrid cars accounted for 27% of the total volume, which is 24 p. p. more than in 2017.

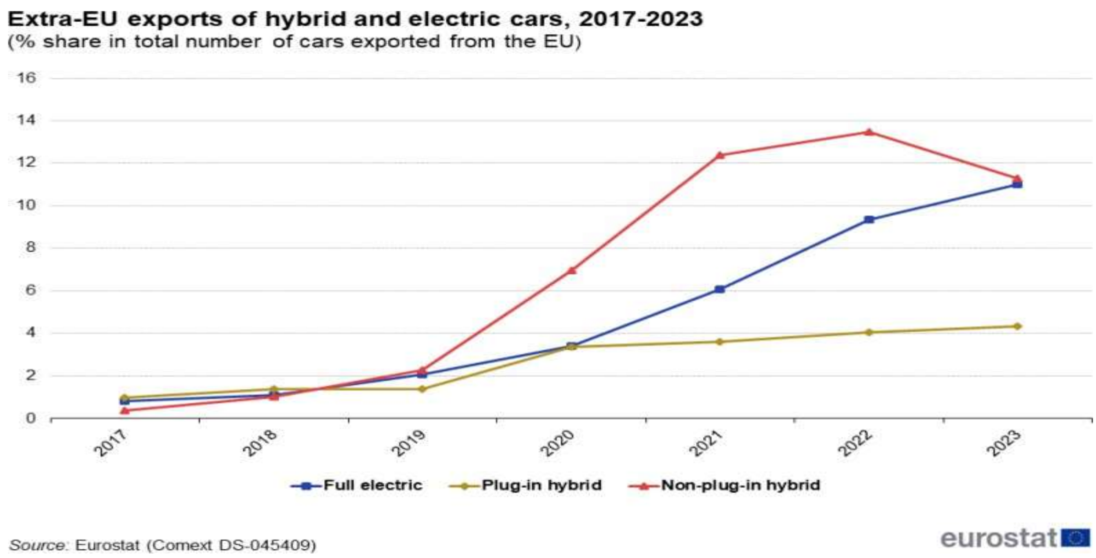

Figure 4: Export of hybrid and electric vehicles outside EU, 2017 – 2023 (% rate on total number of exported vehicles from EU)

Source: Eurostat, 2025

Fully electric vehicles (blue curve) - The share of these vehicles in total exports has increased every year. In 2017, it was only around 0.5%, but by 2023 it had grown to almost 11%. The most significant increase occurred between 2020 and 2023, indicating growing demand for electric vehicles outside the EU. Plug-in hybrid vehicles (yellow curve) - The development in this category has been more stable, without significant fluctuations. They started at around 0.5% in 2017 and reached around 4.5% in 2023. The increase has been smooth, especially since 2019, but has been relatively slow compared to the other two categories. Non-plug-in hybrid vehicles (red curve) - These vehicles have seen the steepest increase. In 2017, they accounted for around 1% of exports, but their share has been rising rapidly – especially between 2019 and 2021, when it rose to more than 12%. They peaked in

2022 (almost 14%), but in 2023 there was a slight decline to a level comparable to fully electric vehicles.

Of all three categories, non-plug-in hybrids have had the fastest and most significant growth. However, fully electric vehicles have shown significant and steady growth in recent years, catching up with the leading position. Plug-in hybrids maintain a less dynamic but steady growth. This development highlights the growing importance of low- and zero-emission technologies within European automotive exports.

4. Comparison of selected vehicles from the view of emissions

Life cycle emissions represent the total amount of greenhouse gases released into the atmosphere over the entire life of a product. This process includes emissions arising from the production, use and subsequent disposal of a given product. To objectively compare emissions, a standardized unit is used - metric tons of carbon dioxide equivalent (tCO_2e), which takes into account different types of greenhouse gases and their potential to contribute to global warming. The following table shows emissions in individual stages of the life cycle of medium-sized battery electric (BEV), hybrid electric (HEV) and internal combustion (ICEV) vehicles, assuming a 16-year period of use and a total distance travelled of 240,000 km.

Table 1: Comparison of BEV, HE, ICEV

Period of living cycle	Battery electric vehicle (BEV)	Hybrid electric vehicle (HEV)	Internal combustion vehicle (ICEV)
Production (tCO_2e)			
Battery production	5	1	0
Vehicle production	9	9	10
Utilization (tCO_2e)			
Fuel/electricity production	26	12	13
Direct exhaust emissions	0	24	32
Maintenance	1	2	2
Liquidation (tCO_2e)			
Processing at the end of living cycle			-1
TOTAL EMISSIONS (tCO_2e)	**41**	**48**	**55**

Source: own processing according to Visual Capitalist (2021)

While it is not surprising that battery electric vehicles have the lowest emissions over their entire life cycle, several other key lessons can be drawn from the data:

1. The production of battery electric vehicles is more emission-intensive compared to hybrid and internal combustion vehicles, with the difference reaching approximately 40%. This is due to the high energy intensity of the extraction and processing of

minerals such as lithium, cobalt and nickel, which are essential for the production of batteries. In addition, the assembly process of electric vehicles itself is quite energy-intensive.

2. The largest share of emissions in the life cycle of BEVs comes from the production of electricity needed to operate them. Therefore, decarbonisation (the process of reducing or completely eliminating emissions of carbon dioxide (CO_2) and other greenhouse gases) of the energy sector, in particular through the wider use of renewable and nuclear energy sources, can significantly contribute to reducing the overall emissions of these vehicles.
3. One of the most important emission reductions is the proper recycling of materials and components at the end of the vehicle's life cycle, which can help offset some of the emissions generated in the earlier stages of their life cycle. However, complete and energy-efficient recycling of batteries is not yet carried out worldwide, as, as we have already mentioned, the design of batteries is very diverse and therefore time- and economically demanding for complete professional recycling. [19]

5. Discussion

Based on the analysis, which points to growing production and increasing interest in fully electric vehicles, it can be assumed that the demand for electric cars will increase significantly in the coming years:

- In the context of current knowledge regarding the extraction of strategic raw materials, especially lithium, cobalt and nickel – essential for the production of lithium-ion batteries, which are a key component of electric vehicles – we consider the most strategically important element of the entire life cycle of an electric vehicle to be the effective and sustainable recycling of batteries. Recycling is the only long-term sustainable way to reduce the environmental burden caused by the primary extraction of these raw materials (Dunn et al., 2021). From an environmental point of view, the extraction and production of electricity are among the largest producers of emissions in the entire life cycle of an electric vehicle.
- From the perspective of reducing the carbon footprint, it is therefore crucial to ensure that electricity production comes mainly from renewable sources (such as solar, wind, hydropower and biomass) and from nuclear power plants. This would at least partially eliminate the need for electricity production from fossil fuels, especially from coal-fired power plants, which have high carbon dioxide emissions.
- Based on the analyzed data and available expert studies, the use of electric vehicles appears to be most effective especially in urban agglomerations with high population density. It is in these areas that the highest level of exhaust gas pollution, which can be

avoided by electric propulsion, can be expected (Zhang et al., 2021). In addition, in cities, there is a higher probability of availability of infrastructure for charging electric vehicles and at the same time there is less need for long ranges, which reduces the demands on battery capacity.

An important factor to consider is the geographical location of the city. Optimal conditions for battery operation are achieved in areas with a moderate and stable climate zone, where the risk of battery degradation due to extremely low or high temperatures is minimized. Temperature has a significant impact on the lifespan, performance and safety of batteries.

Conclusion

Electromobility, as a modern trend in the automotive industry, has undergone a long development from experimental vehicles in the early 20th century to today's practically usable models, which are gradually becoming increasingly popular and efficient. A significant moment in this transformation was the revival and development of electric vehicles in the second half of the 20th century, when these vehicles began to reappear on the market, supported by technological advances in batteries, electric motors and innovations in the field of propulsion and energy recovery. With the growing interest in sustainable mobility and ecological solutions, electromobility has come to the fore as a key alternative to traditional combustion engine vehicles.

Overall, electromobility brings significant environmental and economic benefits, especially in terms of reduced greenhouse gas emissions and operating costs. However, to ensure the sustainable development of electromobility, it is essential to improve battery production processes, implement effective recycling systems and ensure the decarbonization of the energy sector. Cooperation between industry, academic institutions and legislative bodies is key to creating effective and sustainable solutions that will support the further development of electromobility and minimize its environmental impact.

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