

OPPORTUNITIES AND BARRIERS TO THE DEVELOPMENT OF ELECTROMOBILITY: THE PERSPECTIVE OF POLAND AND AZERBAIJAN

Tomasz Bober^{1*}, Paweł Wójcik¹, Tural Gojayev²

¹Cracow University of Economics, Cracow, Poland

²Azerbaijan University, Baku, Azerbaijan

Abstract. Year by year, there is an increasing interest in electromobility products on global transport markets. Governments of many countries support its development through legal conditions and financial incentives, companies are introducing new car models with various forms of electric drives with significant progress in their performance and range, and consumer awareness in these areas is growing. This last aspect is the main subject of the research conducted for this article. The aim of the paper is to present the issue of electromobility and analyze the market in terms of opportunities and barriers, as well as examining the perception of electric vehicles in terms of their usefulness, convenience and potential benefits of their use from the perspective of Poland and Azerbaijan.

Keywords: *Electromobility, electric vehicles, passenger cars, automotive market, development trends in the automotive industry.*

***Corresponding Author:** *Tomasz Bober, Cracow University of Economics, Cracow, Poland, e-mail: tomasz.bober@uek.krakow.pl*

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1. Introduction

The development of the automotive industry is one of the most interesting research areas. Not only is it an interdisciplinary issue, and the development of the automotive industry itself was conditioned by scientific achievements in many other fields, but it can also be said that progress in the field of transport has also significantly influenced socio-cultural changes over the last 100 years. Electromobility is not a new concept and appeared already in the first prototypes of cars, but when their serial production began, combustion engines won as the technological standard and maintained their advantage for decades. At the end of the 20th century, new technological solutions appeared and the ecological awareness of governments, management boards of automotive companies and consumers increased. It is the mix of these three entities that determines the further development of the automotive industry. Governments of many countries support electromobility through legal conditions and financial incentives, companies are introducing new car models with various forms of electric drives with significant progress in their performance and range, and consumer awareness in these areas is growing. This last aspect is the main subject of the research conducted for this article.

The aim of the paper is to present the issue of electromobility and analyze the market in terms of opportunities and barriers, as well as examining the perception of electric vehicles in terms of their usefulness, convenience and potential benefits of their use.

Electromobility is defined as all issues related to the operation of vehicles with electric drive. They cover both aspects related to the use of vehicles, charging infrastructure, as well as any technical or social and legal issues (Zaniewska-Zielińska, 2018). Electromobility is not limited to the mere implementation of electric vehicles. Its development requires deep reorganization and introduction of improvements in several sectors, including: technological innovations, legal regulations, network infrastructure, social environment, mobility management models.

When analyzing the market of cars using electric drive, several types can be distinguished, each of which has a slightly different specificity and structure:

1) BEV (Battery Electric Vehicle)

This category includes vehicles with only battery drive. The only engine is electric, energy stored in batteries (charged from external power sources). Vehicles in this category do not emit harmful substances directly into the environment, and their range in most cases is between 120 and 400 km.

2) HEV (Hybrid Electric Vehicle)

This is the most classic type of hybrid vehicle. They are equipped with two engines – combustion and electric, the latter of which is used to support the gasoline engine.

It serves mainly for starting and moving at speeds up to 50 km/h. Vehicles equipped in this type of drive do not allow the user to charge via external sources current.

The batteries in classic "hybrids" are charged with energy from work of regenerative braking systems and energy from the engine itself.

3) PHEV (Plug-in Hybrid Electric Vehicle)

In PHEV electric vehicles, the driving unit is an electric motor battery-powered as well as an internal combustion engine. What distinguishes them from their classic version is the possibility of charging from a socket and greater range when using electric drive. In PHEVs it is possible to use both an electric and a combustion engine, which can be used in parallel or completely separately, thereby maintaining appropriate charging frequency, they can only function as electric cars.

4) EREV (Extended Range Electric Vehicles)

EREV vehicles are characterized by an extended range. In terms of design they resemble plug-in hybrids - they also have both an electric engine and an electric motor and combustion engine, but in the case of this category of vehicles, the electric is the main unit drive. The combustion engine performs a supporting function and is only activated when necessary the need to generate energy to charge the batteries. This solution allows for a greater range of the car - up to 300-500 km.

5) FCEV (Fuel Cell Electric Vehicles)

FCEVs are partly a type of electric vehicle. In vehicles from this category, the battery function is performed by powered fuel cells due to the reaction of oxygen and hydrogen.

The only by-product of this reaction is water. It makes this type of drive an interesting prospect, but with the current technology and conditions, the development of hydrogen drive in passenger cars is rather a matter of the future (Gajewski et al., 2019).

Although the topic of electric passenger cars generates the most interest, it is worth remembering about other means of transport powered by electricity. The popularization of electromobility can be observed mainly in public transport. Van delivery vehicles with electric motors are also gaining popularity, as are alternative means of transport such as electric scooters and bicycles with electric assistance.

2. Development of electromobility

Electromobility, i.e. the use of electric vehicles, is still gaining popularity around the world. Due to the increasing ecological awareness of society, there is also a growing interest in alternative power sources to reduce air pollution emissions. Driven by the challenge of reducing CO₂ emissions, which most leading countries now prioritize, global sales of electric vehicles continue to accelerate in 2023 (Global EV Outlook 2023). In the first quarter of this year alone, 2.3 million electric vehicles were sold worldwide. This is 25% more than at the same time in 2022. Sales are expected to reach 14 million by the end of 2023. By then, electric cars could account for 18% of total car sales.

Although electromobility activities are a high priority on a global scale, development in this area varies depending on the region of the world. Many countries are adopting regulations that aim to limit the use of conventional combustion vehicles and promote electric vehicles. According to data available in the Global EV Outlook 2023, in 2022 the electric car market recorded another record. Sales of electric vehicles - including all-electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) - exceeded 10 million last year, up 55% from 2021. In just five years, from 2017 to 2022, electric vehicle sales increased from around 1 million to over 10 million. The share of electric cars in total car sales increased from 9% in 2021 to 14% in 2022 - an increase of over 10 times compared to 2017. In 2022, there were over 26 million electric cars on the road.

Poland and Azerbaijan are not among the world leaders in electromobility (such as China, the USA or Western European countries), but sales data show that electric cars are also gaining popularity in these markets. In January-June 2023, 8,497 electric cars were registered in Poland. This number constitutes 3.6% of all new cars sold in the country (samar.pl). In the first half of 2023, Azerbaijan imported 1,124 electric vehicles, which constitutes 2.3% of the total number of cars imported during this period (www.azerbaycan24.com).

In terms of the operation of electric vehicles, the key factors to be discussed are costs, ecology, comfort and safety of use. The advantages and disadvantages of the electromobility market are largely based on these four extremely complex aspects:

- *Costs*

The high efficiency of energy conversion in the electric drive significantly affects the operating costs of such vehicles. This efficiency is approximately 70-80%, which, compared to 15-20% in traditional combustion vehicles, puts electric vehicles above conventional means of transport in the context of operating costs (Rudnicki, 2012).

When focusing on the topic of operating costs, it is worth remembering that this factor depends on many aspects, so it cannot be unanimously stated that high processing efficiency proves the profitability of purchasing an electric vehicle, especially since the efficiency of the most modern combustion engines reaches 50% and in case of electric cars losses related to the production and transmission of electricity influence energy costs.

In addition to fuel costs, an important element is the general operating costs of the vehicle, which include, among others: replacement of parts, operating fluids, and repairs. Due to the much greater complexity of combustion engines, these factors favor electric drives until the batteries, which are one of the most expensive elements of an electric vehicle, wear out. The cost of purchasing an electric car is approximately half as high as a similar model with a combustion engine, however, operating costs favor electric cars.

- *Ecology*

The main sources of air pollution are combustion processes in industry, households and transport (Pavlinec, 2022). Emissions and pollution from the road transport sector result from, among others, from fuel combustion, oil and other operating fluid leaks, from abrasion of tires and brake system surfaces, and from dust raised by vehicle movement.

It is also worth considering the production and production-related processes of electric vehicles. The process of producing lithium-ion batteries necessary to power cars is unfortunately not as ecological as the operation of the vehicle itself, and therefore the production of an electric car means much more harmful gases than in the case of a conventional vehicle. Currently, electric car manufacturers pay attention to increasing the environmental friendliness of means of transport not only during the operation of the vehicle, but throughout its entire life cycle, i.e. from production to recycling or disposal.

- *Comfort of use and safety*

One of the advantages of using an electric vehicle is its low noise emission, incomparable to conventional vehicles, enabling acoustic comfort both inside and outside the car. The advantages also include dynamic acceleration and the ability to quickly maneuver due to the higher torque. Electric cars are also characterized by lowering the vehicle's center of gravity in order to increase its stability and thus reduce the risk of the car overturning. It is often believed that an electric vehicle poses a greater threat than conventional vehicles due to the fire risk and greater weight than combustion cars. Comfort of use also includes charging infrastructure and its availability.

There are several ways to charge electric vehicles. You can use a home or workplace socket, as well as public - slow and fast charging stations that allow you to replenish energy on longer routes. A related issue is the range of an electric car, which determines its usefulness in everyday transportation. Despite technical progress, limitations in the range of electric vehicles still raise concerns. When the availability of fast chargers in a given area is insufficient, drivers fear that they will not be able to charge their vehicle during a long route.

Barriers to the development of electromobility also include the relatively high prices of electric cars. The high purchase price of electric vehicles, including the cost of batteries, which can be up to half the price of electrically powered cars, largely discourages users from purchasing them. Lithium-ion batteries, which are the basic part of an electric car, are its most expensive component. However, in the future, thanks to the development of battery production technology, costs can be reduced and the ability to travel longer distances on a single charge can be expected.

Low awareness and concerns of users caused by the lack of appropriate education and information about the benefits, performance and availability of electric vehicles may lead to low interest, lack of trust among potential users and reluctance towards the topic of electromobility. One of the main concerns about electric vehicles is the risk of fire. Accidents involving electric vehicles as a source of fire often receive significant media attention, which may influence consumer concerns. However, it should be noted that fire cases in electric vehicles are relatively rare and the risk is comparable or even lower than in the case of combustion vehicles. Additionally, there are concerns about the safety of electric vehicles, especially regarding collisions and damage.

Due to differences in the design of electric vehicles compared to traditional combustion vehicles, there is a need for appropriate emergency procedures and training for emergency services to effectively respond to accidents involving electric vehicles. However, the automotive industry and emergency services are working together to

develop and continually improve standards and procedures that will ensure safety for both users and emergency services.

Battery recycling issues are another issue that may raise concerns. Batteries used in electric vehicles contain valuable raw materials such as lithium, cobalt and nickel that can be reused. However, effective and economical methods for recycling batteries are still being developed. In order to increase the sustainable development of electromobility, it is necessary to continue research on new recycling technologies to minimize the impact on the environment and use the potential of secondary raw materials (businessinsider.com.pl, 2021). Additionally, some people fear that electric vehicles may accelerate the destruction of local roads. Electromobility involves greater vehicle weight due to batteries, which can lead to greater wear and tear on roads (businessinsider.com.pl, 2023).

3. Perception of electric vehicles in Poland and in Azerbaijan

In order to deepen the perspective on the discussed issues of barriers and opportunities for the development of electromobility, pilot studies were carried out on the attitude of Poles and Azerbaijanis towards electromobility, focusing on passenger cars. Survey conducted on a group of 60 people in Poland and 30 in Azerbaijan, in various age groups, was used as a research method. Respondents were asked to assess issues related to the electromobility market, using closed single- and multiple-choice questions and five-point rating scale. The first set of questions assessed group awareness of the research topic discussed in the work. The next group of questions concerned the assessment of significance of potential benefits and limitations that, according to respondents, may apply to development of electric vehicles in each country. The survey allowed for partial determining the potential of both markets, possible development directions and prospects for implementation of electric vehicles, as well as examining how society perceives the concept of transforming the automotive industry towards electromobility.

In Poland, 50% of respondents were people aged between 18 and 25. The second largest group were people aged between 26 and 35 (28%). In Azerbaijan, the structure of the surveyed population was comparable: 47% of respondents aged 18-25 and 33% aged 26-35. In both research samples, the vast majority of respondents lived in cities, 82% in Poland and 90% in Azerbaijan, respectively. Due to the fact that electromobility is at a relatively early stage of development in both countries, both research groups are dominated by people who do not have an electric car (95% and 93%).

To the question "Are you interested in the topic of electric vehicles/electromobility?" the answers are divided. In Azerbaijan, almost 60% of respondents declared interest in this topic, and only slightly over 20% said they were not interested, while in Poland this relationship is the opposite, with less than 30% of respondents declaring such interest and almost 40% no interest.

When it comes to reasons why not to buy an electric vehicle, in Poland respondents indicate insufficiently developed charging infrastructure and limited range first, and the second reason is too high price of electric cars. In Azerbaijan, these two reasons were also included as the main indications, but in the reverse order.

When it comes to arguments for buying an electric vehicle in Poland, legal conditions (e.g. ban on entry to the city center by combustion vehicles) come first, followed by the willingness to follow the latest trends. In Azerbaijan, care about the

natural environment comes first, and the second argument for buying an electric car is lower maintenance costs.

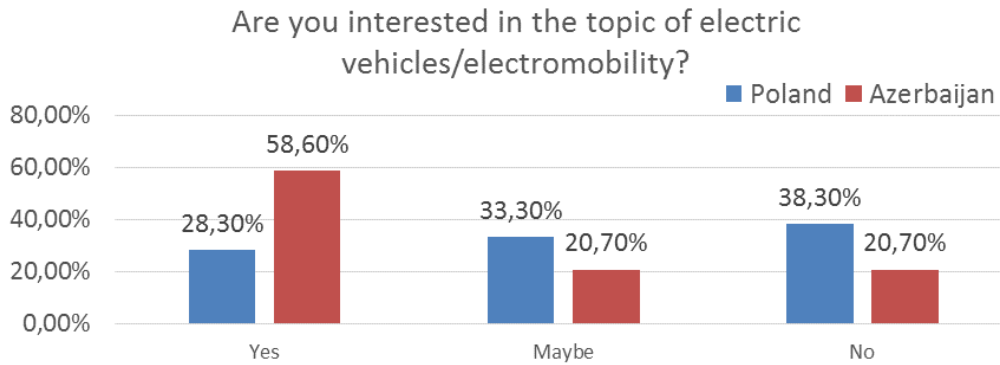


Figure 1. Interested in the topic of electric vehicles/electromobility in Poland and in Azerbaijan

Among people looking for information on this topic, the most popular source of information is the Internet (84.7% in Poland and 96.6% in Azerbaijan). This is probably due to the fact that both research groups are dominated by young people, but the greater diversity of responses in Poland may indicate that the topic of electromobility occupies more space in the media space.

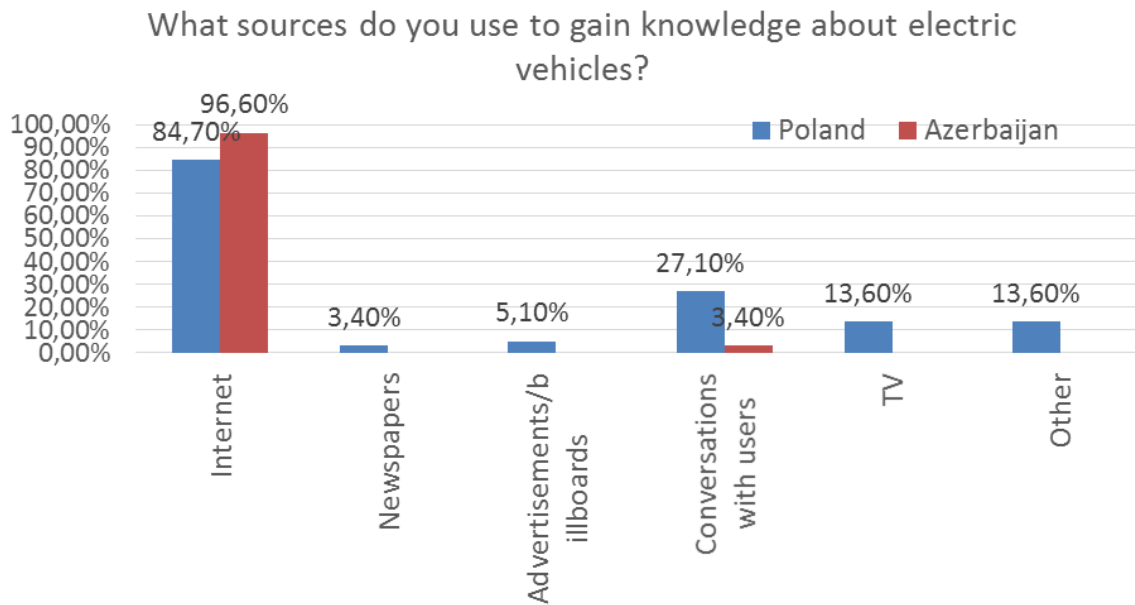


Figure 2. Sources of knowledge about electric vehicles in Poland and in Azerbaijan

Significant differences can also be seen in the approach to electric cars in matters such as their prices, environmental friendliness and the ocean of technical solutions. In Poland, over three-quarters of respondents believe that electric vehicles are much too expensive, while in Azerbaijan this is half of the answers.

The statement that electric vehicles are ecological in operation is completely different. In Poland, only 32% of respondents agree with it, while in Azerbaijan it is as much as 75%. This difference may result from the fact that in Azerbaijan mainly the

emission intensity of vehicles is taken into account, while in Poland there has been a long-standing discussion on the assessment of CO₂ emissions throughout the entire product life cycle (including its production and disposal).

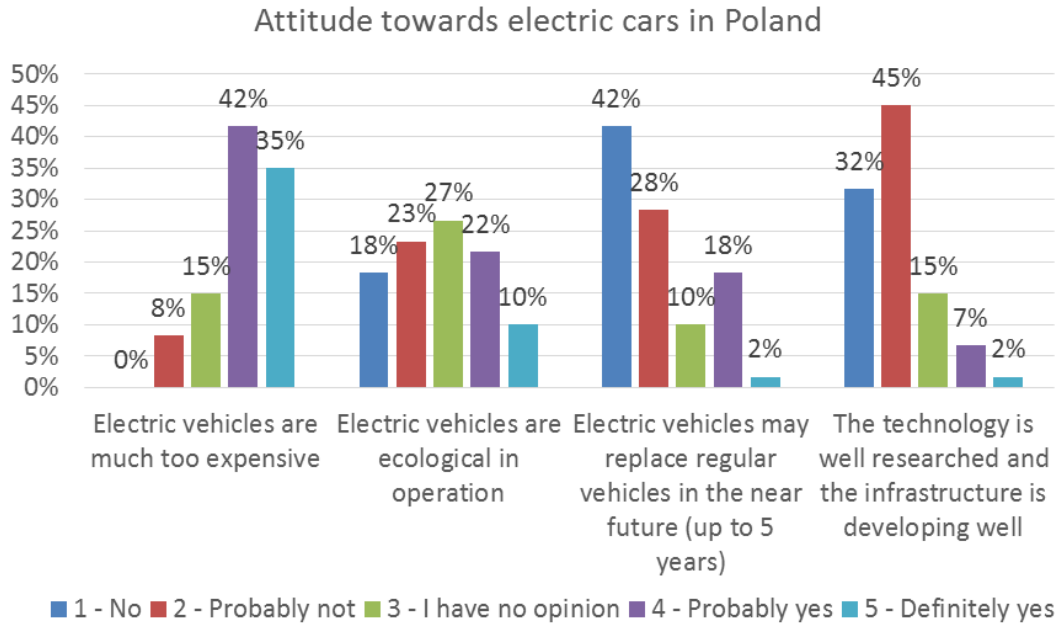


Figure 3. Attitude towards electric cars in Poland

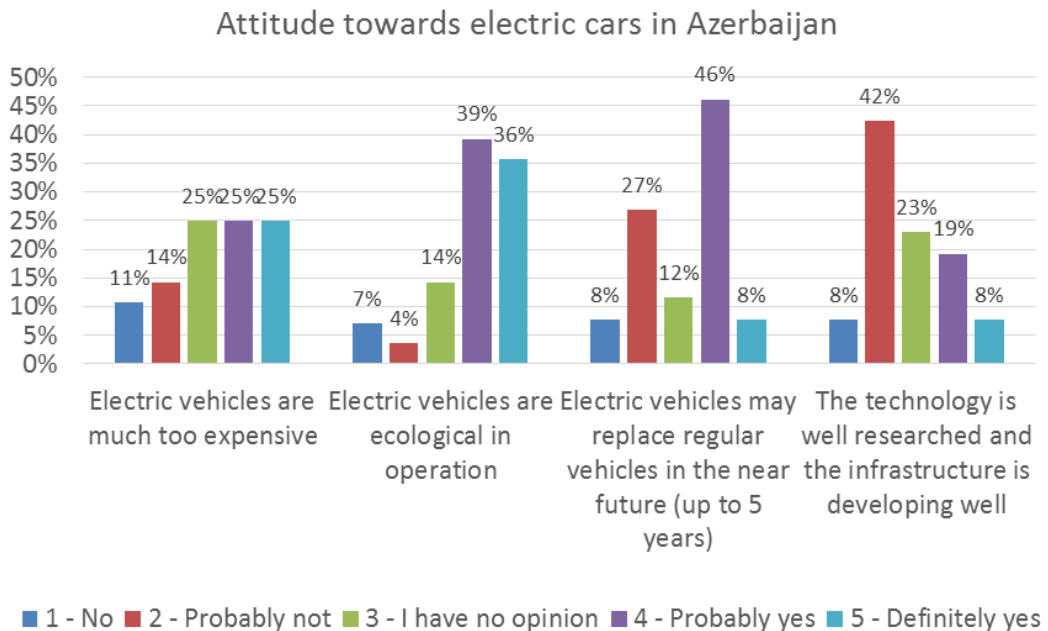


Figure 4. Attitude towards electric cars in Azerbaijan

In assessing the statement that electric vehicles may replace regular vehicles in the near future (up to 5 years), Poles are much more skeptical than Azerbaijanis. In Poland,

70% of respondents said that it is not possible, while in Azerbaijan over half of respondents see it as a possibility.

In the case of both countries, there is disagreement with the statement that the technology is well researched and the infrastructure is developing well (in Poland/Azerbaijan), while in Poland the percentage of respondents who disagree with this statement is higher, over three quarters of respondents, and in Azerbaijan half of them.

4. Conclusion

As noted by B. Jacob and J.B. Kovarik policies, technologies and behaviors must be continually adopted to new constraints, such as climate change, the diminishing supply of fossil fuels, the economic crisis, the increased demand for mobility (Andre & Samaras, 2016). Development trends in the automotive industry include an increasing share of electronics and the development of fully or partially electric cars. This is related not only to technological progress, but primarily to legal conditions aimed at reducing CO₂ emissions. Rapid changes in the automotive industry open up many new business opportunities, but they also encounter various types of barriers. Both categories were discussed in this article, and the conducted pilot research revealed significant differences in the perception of electromobility in Poland and Azerbaijan. The research samples were relatively small and the conclusions can only be limited, however the survey provided insights into the market potential, direction of development, and prospects for the implementation of electric vehicles, as well as an understanding of how society perceives the concept of electromobility in Poland and in Azerbaijan. The analyzes conducted indicate the validity of further research in this area, the expansion of the research sample and the deepening of the analysis in the areas of economic, legal and socio-cultural conditions.

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