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ANALYSIS OF THE DEVELOPMENT PROBLEMS OF THE WORLD MARKET OF ELECTRIC VEHICLES IN THE CONTEXT OF THE CONCEPT OF SUSTAINABLE DEVELOPMENT

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Key words:
electric car, world market, sustainable development, SWOT analysis, factors.

The article examines the problems of the development of the global market of electric vehicles using a SWOT analysis, reveals the main strengths and weaknesses of the development of the electric vehicle industry, and opportunities and threats faced by manufacturers, consumers and states.
The work analyzes the main factors affecting the development of the global market of electric vehicles taking into account the concept of sustainable development, considers the main trends in the electric vehicle industry, including technological, economic and environmental aspects. Special attention is paid to such challenges as the infrastructure of charging stations, the cost and availability of electric vehicles, and the issue of liquidity of this type of transport, as the main factors delaying their spread in the markets.
The issue of the distribution of electric vehicles and their role in the modern automotive industry is the subject of extensive discussion and research. In the context of a rapidly changing economic, technological and ecological environment, it is important to understand the current situation and prospects for the development of this market segment. The problem is that despite significant interest in electric vehicles from industry, governments and consumers, there are a number of unresolved issues and challenges that could affect their future development.

АНАЛІЗ ПРОБЛЕМ РОЗВИТКУ СВІТОВОГО РИНКУ ЕЛЕКТРОМОБІЛІВ В КОНТЕКСТІ КОНЦЕПЦІЇ СТАЛОГО РОЗВИТКУ

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Ключові слова:
електромобіль, світовий ринок, сталий розвиток, SWOT-аналіз, фактори.

У статті проведено дослідження проблем розвитку світового ринку електромобілів із застосуванням SWOT-аналізу, виявлено основні сильні та слабкі сторони розвитку індустрії електромобілів, а також можливості та загрози, з якими стикаються виробники, споживачі та держави.
У роботі аналізуються основні фактори, що впливають розвиток світового ринку електромобілів з урахуванням концепції сталого розвитку, розглядаються основні тенденції в електромобільній індустрії, включаючи технологічні, економічні та екологічні аспекти. Особлива увага приділяється таким викликам, як інфраструктура зарядних станцій, вартість та доступність електромобілів, а також питання ліквідності даного виду транспорту, як основних чинників, що затримують їх поширення на ринках.
Питання розповсюдження електромобілів та їх роль у сучасній автомобільній промисловості є предметом широкого обговорення та досліджень. У контексті економічного, технологічного та екологічного середовища, що швидко змінюється, важливо зрозуміти поточне положення та перспективи розвитку цього сегменту ринку. Проблема полягає в тому, що незважаючи на значний інтерес до електромобілів з боку індустрії, урядів та споживачів, існує низка невирішених питань та викликів, які можуть вплинути на їх майбутній розвиток.

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Statement of the problem

Every year, electric cars are becoming more and more popular, the increased interest of consumers and the desire of car manufacturers to develop new models of electric cars leads to the growth of the market. According to EV volumes [1], in 2022, cars with electric motors accounted for 13% of passenger car sales worldwide. In fig. 1 shows the global dynamics of sales of electric cars from 2013 to 2022. In the graph, the EV Market Share line shows the share of electric cars in the total volume of cars sold, the bars of the histogram show the sales of electric cars in thousands of units.

In the conditions of growing awareness of environmental problems and the desire for sustainable development, many countries around the world set ambitious goals for increasing the share of electric vehicles on the roads. However, despite significant efforts, the problems and challenges of introducing electric vehicles to global markets remain significant and diverse.

Therefore, there is an urgent need to analyze the factors affecting the development of the global market of electric vehicles in the context of the concept of sustainable development. The study of the global electric vehicle industry is important and relevant for the following reasons:

– the need to identify the strengths of the electric vehicle industry, such as advanced technology, environmental friendliness and the demand for environmentally friendly transport.

– analysis and identification of industry weaknesses, identification of problems that are the main obstacles for consumers to give their choice in favor of an electric car.

– identifying opportunities for developing the electric vehicle market.

– the need to identify threats and risks for the effective existence and development of the global electric vehicle industry.

Research in this industry is important to many stakeholders such as:

– Car manufacturers. Research helps them understand current market trends, consumer needs, technological innovations, and the competitive landscape. It helps them to develop more competitive products and strategies.

– Consumers. It is important for consumers to understand the electric vehicles available on the market, their features, advantages and disadvantages, and industry trends to make informed purchasing decisions.

– Investors. Research helps investors assess the prospects and risks of investing in companies related to the production of electric vehicles, technological innovations, infrastructure, etc.

– Government. Understanding the state and trends in the electric vehicle industry helps government agencies develop policies and legislation that support the development of clean and energy-efficient vehicles and infrastructure for them.

Statement of the problem

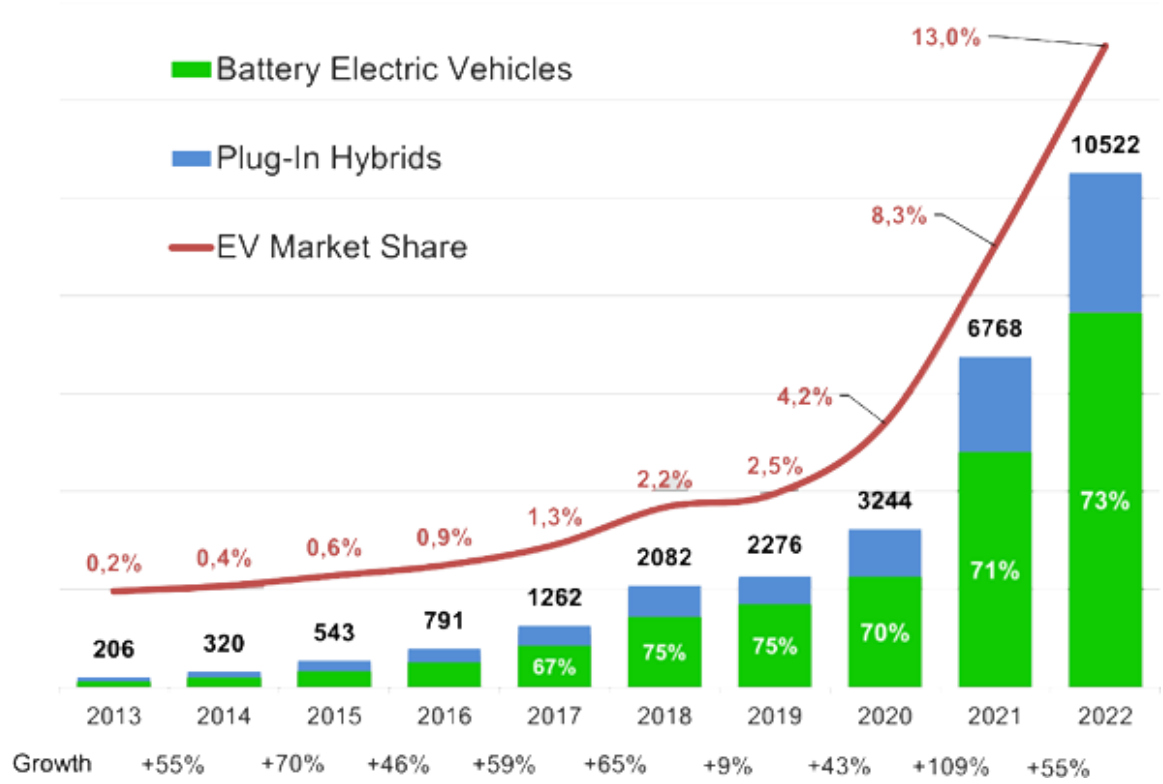

Figure 1 – Dynamics of sales of electric cars in the world for the period from 2013 to 2022 [1]

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– Environmental organizations. For environmental organizations, it is important to understand the impact of electric vehicles on air pollution and climate change.

Considering the goals of the sustainable development of Ukraine [2], one of the identified directions is the Sustainable Development of Cities and Communities, in this section there is a task to reduce the negative impact of pollutants, including on the environment of cities, in particular through the use of innovative technologies. Motor transport produces 70-90% of pollution in cities. Carbon monoxide, nitrogen dioxide, lead, and toxic hydrocarbons predominate in the exhaust gases of automobiles. The spread of electric vehicles can greatly help solve this problem, because during operation, electric vehicles do not produce any harmful things, and the energy produced to charge them is usually produced at power plants located outside cities, which minimizes the negative impact on the environmental condition of cities and communities.

To solve these problems, it is natural to use SWOT analysis [3] as one of the analytical methods of conducting such research, which consists in dividing factors into four categories: strengths and weaknesses of the research object, opportunities and threats associated with its functioning. The results of the analysis will make it possible to determine the quantitative and qualitative factors affecting the object of the study, which will help, in particular, to build relevant models for predicting the behavior of the dynamics of the global electric car market in future studies.

Analysis of recent studies and publications

The study of the development of the market and the electric vehicle industry has received enough attention, but their rapid development requires constantly updating the results due to the fact that the electric transport industry is developing quite quickly, and the market is constantly exposed to external and internal factors.

Article [4] combines a systematic review of recent research with an emphasis on research focused on the social aspects of electric vehicles and their relationship with specific UN goals in the field of sustainable development.

The paper [5] examines the role of the electric car in the concept of sustainable development, and assesses the feasibility of the development of electric cars in general. This research expands the traditional definition of sustainable development by including and prioritizing the most important areas of technology, environment and policy effectiveness.

The paper [6] analyzed the prospects for the development of electric transport and its integration into the energy system of Ukraine. During the research in work [6], a qualitative methodology of strategic planning using SWOT analysis is used to take into account as much as possible various measures and initiatives related to the development of electric transport and its infrastructure at the same time as their integration into the energy system. In the reviewed work, the study identifies problems associated with the impact of the EV charging process on the power grid, namely the inability to accommodate increased energy demands and limiting the electrical load on the infrastructure from charging EVs. At the same time, a high percentage of renewable energy sources, increased social awareness about climate change and lower prices for electric vehicles can provide the necessary opportunities for the development of electric transport in Ukraine.

Electric vehicles are also considered in the context of political and technical aspects, taking into account, in particular, the peculiarities of the national economy of Lithuania in relation to global development and the development of the European Union in this field. The study [7] presents best practices for the deployment of electric vehicles, including potential market niches, as well as challenges and opportunities for supporting charging infrastructure systems. In this work, the authors pay sufficient attention to the assessment of strengths and weaknesses, opportunities and threats using SWOT analysis. This material provides insight into the challenges and opportunities of electric vehicles, particularly in the Baltic region.

Researching and demonstrating industry strengths and weaknesses is particularly important for countries whose markets are outsiders in the region. Thus, in [8], a portfolio of actions aimed at ensuring the sustainable development of transportation in the segment of passenger vehicles is formulated and the implementation of the Minimax strategy is proposed, which would minimize current shortcomings by maximizing potential market opportunities.

The authors of [9] identified relevant factors related to the introduction of electric vehicles in Thailand using a SWOT analysis. A strategy for the introduction of electric vehicles into the competitive environment of the country's car market with the involvement of local and international investors has also been developed in this research. It is proposed to implement a policy of introducing potential consumers and investors in order to spread information about the experience of countries that have introduced the use of electric vehicles into everyday life.

It is quite important to observe the markets of developing countries and how electric vehicles penetrate into their environment, because on their example you can follow how manufacturers and investors penetrate a new market and what strategies they use there.

For example, Bangladesh has a large market potential, but there are also some problems related to the implementation of new business models, [10] analyzed the potential market opportunities and business strategies for Bangladesh using SWOT-AHP analysis.

Examining the example of Brazil in [11] shows the uncertainty regarding the transition to a new technological path, using electric transport. The competitiveness and main strategies related to the introduction of electric vehicles in Brazil are analyzed using a SWOT analysis, which contributes to the acquisition of relevant knowledge and helps decision-makers to make consistent and coherent choices within the various sectors affected by the characteristics of the Brazilian transportation matrices. The results of the work show that the use of hybrid technologies for powering motor vehicles fully corresponds to the Brazilian scenario, and purely electric vehicles can remain in limited parts of the market until the huge technological

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and market obstacles that exist in the way of popularizing the use of electric vehicles are overcome.

Objectives of the article

The purpose of the article is to identify and summarize the problems of development of the global electric vehicle market in the context of the concept of sustainable development by conducting a SWOT analysis. The identification of factors, namely environmental, social and economic sustainability factors, is aimed in particular at developing a basis for further modeling the development of the global electric vehicle market.

The main material of the research

SWOT analysis is a method of strategic analysis, the essence of which is to determine 4 blocks of factors (strengths, weaknesses, opportunities and threats) of the object being studied [3].

Having analyzed the factors influencing the expansion of electric vehicles on the global market, we present the results in the form of a matrix shown in Fig. 2. and consider its components in more detail.

Strengths:

Care for the environment. The biggest positive factors of this issue are the reduction of the level of emissions of harmful substances and the reduction of the level of noise pollution in cities, because cars are the biggest polluter of the environment in large or densely populated cities. Regarding the environmental indicator of the use of electric cars in general, according to various estimates, the carbon footprint of an electric car becomes smaller than a car with an internal combustion engine (ICE) after 33 thousand kilometers of mileage [12] or after four years of its operation [13]. Of course, the most important influence on this indicator is the method of energy production used.

Development of new technologies: The most important group of technologies affecting the operation of an electric car are technologies related to energy storage and accumulation. Growing demand for electric vehicles is driving research and development in lithium-ion and other types of batteries aimed at increasing capacity, reducing costs and improving durability.

Expanding the network of charging stations becomes a necessity to support the growing number of electric vehicles. This is driving the development of faster and more efficient charging technologies, including fast charging stations and innovative wireless charging methods.

Electric vehicles require high-tech electronics to manage energy consumption and efficiently control the engine. The proliferation of electric vehicles is driving the development of advanced engine management systems, regenerative braking, and battery monitoring and management systems.

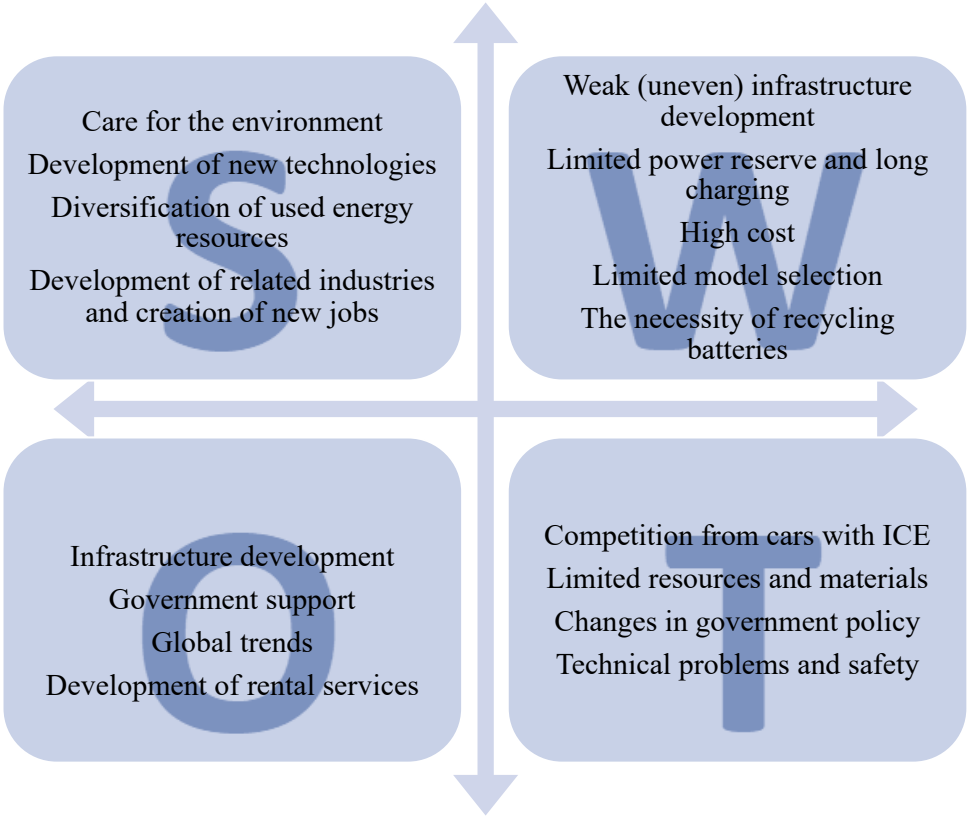

Figure 2 – Matrix of the results of the SWOT analysis of the market development of the global market of electric vehicles in the context of the concept of sustainable development

Source: constructed by the author

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No less important is the development in the field of technologies of autonomous (unmanned) movement. Because EVs are typically equipped with advanced motion sensor systems, and electric motors are much simpler to control than an internal combustion engine, they are an ideal platform for developing and testing autonomous features such as driver assistance systems and fully autonomous driving.

Diversification of used energy resources. Electric vehicles play an important role in reducing the dependence of the world economy on fossil fuels. Transportation based on traditional fuels is highly dependent on the volatility of oil prices and can be subject to geopolitical tensions. The introduction of electric vehicles helps to diversify energy sources and reduce dependence on limited natural resources [14].

Importantly, the process of charging electric vehicles can be carried out by using energy produced from renewable sources, such as solar, wind or hydropower. It helps to further diversify energy consumption, reducing dependence on traditional energy sources such as coal or natural gas.

Development of related industries and creation of new jobs. The demand for electric vehicles is driving the development of their production and related components, such as batteries, electronics, control systems and electric drive components. The appearance of electric cars also leads to an increase in demand for their maintenance and repair services and training of specialists in working with electric cars.

Along with electric cars, new business models and services are developing, such as rental services [15], delivery services and various services supporting a mobile lifestyle. So, electric vehicles are driving growth and innovation in many related industries, helping to create new jobs and driving economic growth.

Weaknesses:

Weak (uneven) infrastructure development. According to a recent study [16], the lack of public charging infrastructure is the main obstacle to the introduction of electric vehicles around the world, as the results of this study show, more than a third of respondents cited insufficient access to urban charging stations as the main reason for refusing to switch to an electric vehicle. This factor is ahead of concerns about the high price of an electric car, which used to be the main obstacle for potential buyers of this type of transport. People who do not have access to a charging station at a permanent car park have to rely on urban infrastructure, which is often unevenly distributed and can be expensive to use.

Limited power reserve and long charging. This factor is another weakness in the introduction of electric vehicles. According to [16], about a third of drivers around the world are concerned about long-distance trips on electric vehicles. An electric vehicle's range depends largely on its battery capacity and engine efficiency, but it can also be affected by factors such as weather, speed and whether the vehicle is driven on city roads or the open highway. Compared to the distance that ICE car can travel on a full tank, electric cars are closing the gap, because the range of electric cars is gradually increasing.

In addition, it turns out that charging an electric car is a more complicated process than users imagine. This is due to the fact that its duration can take from several hours at a fast charging station to more than a day from a 220-volt home power grid [17].

High cost. The purchase price of an electric car is usually higher than the average car with ICE. In addition to the car itself, the cost can include the installation of a charging station at home or additional accessories, making owning an electric car a more expensive endeavor.

Unlike the market for cars with ICE, the choice of electric cars in the secondary market is still limited. This means that even as prices for new EVs drop, buyers may face limited choice and high prices for used models.

Limited model selection. Despite the fact that the number of electric vehicle models is gradually increasing, it is still significantly less than the number of models with ICE. Currently, most EVs are in the premium or mid-market segment, limiting the choices for those looking for affordable options. However, with the appearance of new models and the development of technologies, an expansion of the offer in various price categories is expected. Also, some EV models may only be available in certain regions or countries due to differences in government regulation or market demand.

The necessity of recycling batteries. The problem of disposal of electric vehicle batteries is one of the key aspects that must be considered in the context of the environmental responsibility of this technology. Batteries used in electric vehicles typically contain materials such as lithium, cobalt, nickel, and other metals. These materials are toxic or harmful to the environment, and batteries must be disposed of properly to prevent soil and water contamination. As the number of electric vehicles on the road increases, the volume of recycled batteries will increase. It is predicted that in the coming decades, the number of used batteries will increase significantly, which will require the development of efficient disposal and recycling systems [18].

At the same time, the presence of valuable materials in batteries opens up opportunities for their recycling and reuse. However, the extraction of these materials requires specialized technologies and processes, which can be expensive and costly in terms of economic efficiency of such processing [19].

Solving the problem of recycling electric vehicle batteries requires a comprehensive approach that includes the development of effective recycling technologies, the creation of infrastructure for recycling, the promotion of secondary use and recycling of materials, as well as the implementation of standards and regulations to ensure the safety and environmental sustainability of the process.

Opportunities (Opportunities):

Infrastructure development. The development of infrastructure with the spread of electric vehicles has a huge potential to change the urban environment and the transport system in general. With the increase in the number of electric cars, there is a need to expand the network of charging stations. This includes not only upgrading existing gas stations, but also creating new ones, especially in cities and on highways. Fast charging stations can be a key

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factor in removing barriers to the use of electric vehicles. The development of intelligent networks will allow to optimize the process of charging and energy management. This could include demand-side management systems that anticipate EV usage patterns and dynamically manage charging station capacity to reduce grid congestion.

The development of the infrastructure of electric buses and other forms of public electric transport is also becoming an important factor affecting the spread of electric mobility technologies, the integration of electric transport into public infrastructure can help reduce emissions and improve the accessibility of public transport.

Government support. The state has a number of tools and policies that can be used to support and stimulate the spread of electric vehicles. Government subsidies, tax breaks and grants can be provided to both private individuals and companies for the purchase, lease or production of electric vehicles. This could include subsidies to reduce the cost of electric cars, tax breaks or bonuses for scrapping old combustion engine cars.

Public investment in the development of infrastructure for charging electric vehicles can include financing the installation of charging stations and the development of smart networks for energy management.

Standardizing charging ports for electric vehicles can make their use much more convenient by ensuring compatibility between different charging stations.

Public awareness campaigns about electric vehicles, their benefits and available subsidies can help increase awareness and confidence among potential buyers.

Global trends. Growing public awareness of environmental issues and the desire for sustainable development may increase demand for electric vehicles from private, corporate and government consumers. International agreements and initiatives to reduce greenhouse gas emissions also contribute to the mutually beneficial use of electric vehicles [20].

Social popularization of electric cars plays a key role in their spread and acceptance by society. Conducting information campaigns about the environmental, health and fuel-saving benefits of electric vehicles can increase public awareness.

Bringing in famous personalities and star power figures to promote electric cars can make them more attractive and fashionable to the mass consumer.

The involvement of businesses such as car rental companies, taxis and courier services can help increase the visibility and accessibility of electric cars to a wider audience. A combination of these methods can help create a positive image of electric cars in society and increase their popularity among consumers.

Development of rental services. The development of electric car rental is a promising opportunity in the conditions of the spread of electric cars. The creation of a network of automated rental points where users can easily rent electric cars through a mobile application or self-service terminals can significantly increase the availability of electric cars to a wide audience.

The development of renting electric cars for tourists can be a promising direction. Offering tourist routes and packages that include electric car rental will help attract tourists and create an additional source of income.

Offering special rental programs for corporate customers can be an effective solution for companies that want to implement sustainable practices in their business processes. This may include renting on a long-term basis or providing special rates and conditions. Partnering with public transport operators to provide integrated services that include electric car rental for the last kilometer can make renting more convenient and attractive for public transport users.

Threats:

Competition from cars with internal combustion engines. Although electric cars have many advantages, cars with ICE are still in demand and have their strengths. Cars with internal combustion engines usually have a longer range and can be refueled in minutes, making them more convenient for long trips and long-distance trips.

The infrastructure of gas stations for internal combustion engines is more developed and widespread compared to charging stations for electric vehicles. This makes ICE cars more convenient for use outside the urban environment and in areas where access to charging stations is limited.

Currently, such cars usually have a lower initial cost compared to electric cars, making them more affordable for a wide range of consumers. The internal combustion engine market offers a wider selection of models, including different body types, engine capacities and other features, allowing buyers to choose the car that best suits their needs and preferences.

Many drivers are used to traditional cars and feel more confident driving such cars because they are familiar with their device and operational features.

Limited resources and materials. The limited resources and materials used in the production of electric vehicles can present challenges to scale up their mass production and distribution. Most electric cars use batteries, the main material of which is lithium. However, global lithium reserves are limited, and increased demand for it due to the growth of electric vehicle production could cause problems with its supply and price.

Some electric vehicle components, such as magnets in electric motors and other electronic components, require rare earth metals. Limited stocks of these materials can create supply risks and increase production costs.

Electric motors used in electric vehicles contain large amounts of copper, and many electric vehicles use aluminum and other lightweight materials to reduce weight. An increase in demand for these metals may cause their prices to rise and cause an imbalance in the global metal market.

Government Policy Changes. Changes in government policies regarding subsidies, taxes, and other support measures may adversely affect the EV market. Many states provide subsidies, tax breaks and other incentives for the purchase of electric vehicles [21]. Their abolition or reduction could make electric cars less affordable and attractive to consumers, especially if they have a higher initial cost compared to diesel cars.

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An increase in electricity tariffs or the introduction of additional fees for electric vehicle owners may increase the cost of operating electric vehicles and make them less attractive to consumers.

A change in tariffs or duties on the import of components for electric vehicles or electric vehicles themselves can increase their cost and make it difficult to be available in the market, especially for import-dependent countries.

Technical problems and safety. The use of electric vehicles is associated with a number of technical and safety issues that may affect their spread. Problems with batteries can lead to reduced range, longer charging times, and even fires or explosions. This can cause danger to both drivers and others.

Electrical systems of electric vehicles can experience various malfunctions and failures, which can lead to loss of control of the car, as well as to the occurrence of dangerous situations on the road. In the event of an electric vehicle accident, specific problems may arise, such as current leakage, or the battery catching fire when it is damaged, which can cause additional danger to rescuers and bystanders.

Thus, the conducted SWOT analysis allows you to systematize problems and identify key influencing factors that create an environment for the development of this market.

Conclusions

The analysis of the factors affecting the development of the global market of electric vehicles made it possible to identify the strengths and weaknesses of the industry, as well as the opportunities and threats faced by the market of electric vehicles. This allows to identify strategies for solving problems and taking advantage of opportunities for sustainable development.

Using the results of the analysis in the construction of a factor model in further research will allow to obtain more accurate forecasts of the development of this market, which, in turn, can help in making strategic decisions and planning actions for the sustainable development of the electric vehicle industry in the future.

Also, the results of the study can be used by all interested parties, including manufacturers, importers, consumers and government organizations in order to promote the development of the electric vehicle industry.

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