Impact of Electric Vehicles on the Environment: Pros and Cons

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Abstract. The article deals with the Sustainable Development Goals on the environmental sustainability of cities and the reduction of greenhouse gas emissions in relation to the use of electric vehicles. The dynamics of the global fleet of electric vehicles, demand and prices for lithium-ion batteries are analyzed. The research goal is to compare the positive and negative consequences of the production and use of electric vehicles for the environment. The research is based on the theory of stakeholders. The automakers, suppliers of raw materials for the production of electric vehicles, households, car carriers of passengers and cargo, the state, administrations of cities and settlements are the main stakeholders of the electric vehicles market. The article highlights the arguments «pros and cons» electric vehicles from the perspective of sustainable development and stakeholders. It has been established that it is premature to draw a conclusion about the complete environmental and climate neutrality of electric vehicles. The technological problem of safe storage, recycling and elimination of lithium-ion batteries needs to be solved. The improvement of batteries and the reduction of the carbon footprint in their production and disposal is the most important factor in the greening of electric vehicles.

1 Introduction

In the last few years, there has been an explosive growth in the production and sales of electric vehicles (Evs), which is associated with the implementation of the sustainable development goals and the reduction of greenhouse gas emissions into the atmosphere. During the operation of vehicles, there is a significant release of harmful substances. Not coincidentally, electric cars have become a key innovation, a green technology in the process of greening transport [1]. The greening of the car and the transition of humanity to clean energy, green technologies in all spheres of life are on the top agenda of international organizations, governments of most countries of the world as well as politicians and manufacturers of goods and services. Close attention to environmental issues has become a forced strategy for the survival of humanity and slowing global warming, which, according to a number of scientists, is caused by the greenhouse effect due to industrial activity.

The Paris Climate Agreement and national low-carbon development strategies set goals to reduce primarily direct carbon dioxide emissions without taking into account indirect

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effects [2, p. 246], which, in our opinion, does not allow you to fully assess the impact of green technologies on the environment. The development of electric urban transport, electric mobility of personal and commercial vehicles get the greatest attention in the scientific literature. At the same time, large megacities and the formation of a network of fast and slow charging stations in them gain the leading role. For example, Moscow has chosen an electrification strategy of public transport and is among the leaders of European cities in terms of the largest fleet of electric buses, which has a positive effect on the atmosphere. However, the global balance of harmful emissions remains the same, since power plants produce additional carbon dioxide emissions.

At the same time, many researchers note that the production of electric vehicles itself is resource- and energy-intensive at the current level of technology development. Forecast calculations show a significant increase in energy consumption and the number of charging stations, if the high rates of their sales in the EU continue [3, p. 72]. The researchers note the risks in achieving the sustainable development goals in the transition to electrified transport associated with the provision of resources, critical minerals and carbon neutrality scenarios. At the same time, not only the scarcity of resources for the production of electric batteries but also political factors cause the risk. In particular, "... more than 75% of lithium, cobalt, rare earth elements production capacities and more than half of copper and nickel production capacities are controlled by only three major countries" [4, p. 82].

Not all scientists consider the Kyoto Protocol to be scientifically sound, and the hypothesis of the impact of carbon dioxide emissions on global warming to be proven. In their opinion, the "greenhouse effect" is the same deception as the previous idea of ozone holes [5]. The presence of diametrically opposite points of view on the role of electric vehicles in achieving the sustainable development goals makes it relevant to compare the arguments of researchers for and against the process of transport electrification.

This article aims to compare the positive and negative environmental consequences of the production expansion and the use of electric vehicles from the perspective of the main stakeholders and to determine the conditions for achieving carbon neutrality, taking into account the balance of their interests.

2 Methods

The authors use the methods of descriptive statistics, content analysis of analytical reports on the dynamics of production costs, ecological footprint and life cycle assessment for electric vehicles characterizing their impact on the environment. To identify the positive and negative impact of electric vehicles on the ecology of cities and settlements, a comparative analysis of indicators is applied: the role of electric cars in reducing harmful emissions into the atmosphere and fuel/resource costs at all stages of the electric vehicles life cycle. The research is based on the theory of stakeholders. The authors identify the main stakeholders in the development of the world market and the purchase of electric vehicles, the arguments for and against the adoption of electric cars as a tool for achieving sustainable development goals and reducing the harmful impact on the environment, the interests of the main stakeholders in the production, use and disposal of electric vehicles.

3 Results

The main task of increasing the production and sales of electric vehicles was the desire of governments around the world to reduce greenhouse gas emissions, improve air quality in urban centers, and meet the needs of consumers interested in buying them. The electric car was invented more than 100 years ago, before the internal combustion engine (ICE), but its

production became economically feasible after the development of lithium-ion batteries (LIB), for which their inventor E. Akira received the Nobel Prize in Chemistry in 2019. High power, high voltage, and a long service life of up to 10 years are characteristics of lithium-ion batteries. The electric car is convenient for consumers due to its quietness, ease of driving, reliability, and relatively inexpensive maintenance.

Using an electric car is almost 3 times cheaper than a car with an internal combustion engine [6].

Table 1 presents statistical data on the global fleet of electric vehicles, demand and prices for LIB for the period from 2014 to 2022.

Table 1. Dynamics of the global fleet of electric cars and demand for LIB in 2014-2022

Indicator	2014	2015	2016	2017	2018	2019	2020	2021	2022
Fleet of electric cars of all types, thsnd. pcs	710	1260	2010	3100	5100	7200	10200	16200	25900
Demand for LIB, GW	12,6	26,7	43,2	59,2	100,0	116,0	95,3	134,2	163,9
LIB price, USD per kilowatt-hour	607	393	303	223	185	161	140	132	160

Compiled by: Electric Vehicles (world market) https://www.tadviser.ru/index.php/Статья:Electric vehicles of the world market, the Big lithium Race [Electronic resource]. Monthly printed information and analytical publication "Atomic Expert". – 2022. URL: https://atomicexpert.com/big_lithium_race

Currently, 36 times more electric vehicles drive on the roads of the world than in 2014 and about 3 times more than in 2020. The growth in the production of electric vehicles is associated with a complete ban of cars with an internal combustion engine in the future. State price regulation and preferential taxation influenced greatly the expansion of demand for personal and commercial electric vehicles [7]. The share of electric vehicles in global car sales has reached 10%. China accounts for 90% of the total fleet of electric vehicles [8, p. 16]. Leading automakers in Italy, Germany, Japan and Sweden will fully switch to the production of electric vehicles by 2030.

In proportion to the sales of electric vehicles, the demand for lithium-ion batteries (LIB) increased. In 2022, the growth was 13 times compared to 2014 and 1.7 times compared to 2020. The decrease in prices for LIB positively influenced the increase in sales of electric vehicles, which in 2022 amounted to 26% of the level in 2014. However, in 2022, battery prices increased compared to the previous year due to rising prices for raw materials, lithium and nickel, as well as a shortage of microchips, which are required for the production of an electric car twice as much. LIB accounts for half of the costs of producing an electric car, and the competitive price and performance characteristics of an electric car depend on these costs. China and the Republic of Korea, CARL and BYD companies are leaders in the production of lithium-ion batteries. "Japan, South Korea and China together account for about 95% of all the world's produced capacity for the production of battery cells" [8, p.43].

Rising electricity prices increase the operating costs of electric vehicles. A number of developed countries and China are removing tax benefits for the purchase of electric vehicles, refusing to subsidize manufacturers. The demand of electric vehicle owners for charging stations remains unsatisfied, and the EVs maintenance network needs to be expanded. As a result, the growth rate of electric vehicle sales may slow down.

The life cycle of electric vehicles differs from a car with an internal combustion engine, as the main consequences for the environment are not at the stage of operation, but at the stage of production and disposal of LIB, which experts attribute to the 2nd hazard class with a period of environmental restoration up to 30 years. At the same time, lithium cobaltite, from which cathodes for batteries are made, belongs to valuable rare-earth

materials. To extract valuable cells from batteries "requires almost ten times more energy than in their production," which increases the load on power plants, requires more energy costs [6]. Modern technologies are able to recycle only half of the materials.

The production of batteries for electric vehicles is toxic, accompanied by emissions of harmful substances into the atmosphere and requires significant energy resources. Acid rain falls around lithium-ion battery manufacturing plants, and the vital activity of the surrounding fauna deteriorates. According to the forecasts of the International Energy Agency, in order to achieve carbon neutrality by 2050 and provide electricity to the increased fleet of electric cars, six times more natural resources will be required than are currently consumed, and in thirty years mining will not only decrease, but also increase [6]. "The production of one electric car requires energy costs equal to the burning of 10 thousand liters of gasoline," which is comparable to the fuel consumption of a traditional car for the entire period of its operation [5, p. 11]. According to the results of the Volvo Cars study, emissions from the production of the C40 Recharge electric car are 70% higher than in the production of the XC40 with a gasoline engine. The main reason for this difference is the significant amount of carbon emissions while manufacturing batteries and steel, as well as a significant increase in the proportion of aluminum in the construction of electric vehicles in order to reduce the total weight.

The operation of electric vehicles has shown accelerated tire wear compared to cars with internal combustion engines, which is caused by the relatively large mass of EV. LIB "on average contains 8 kg of lithium, 35 kg of nickel, 20 kg of manganese and 14 kg of cobalt", weighs about 600 kilograms [9, p. 41]. With an increase in the mass of the car, emissions of small solid particles increase significantly during its operation.

It has been established that the storage, processing and disposal of LIB causes great harm to the environment. In this regard, the ecological footprint of electric vehicles is deteriorating due to the need for the secondary use of batteries, the development of technologies for the safe storage of obsolete batteries, the extraction of valuable elements and the prevention of environmental pollution. The scale of the global problem with battery recycling is increasing exponentially with the rapid growth in the production of electric vehicles. In particular, he high fire hazard of both new and used lithium-ion batteries is noted, when they are concentrated in warehouses. The materials of the electrodes in LIB are characterized by reactivity and high flammability. So far, there are no statistics confirming a higher frequency of ignition of electric vehicles compared to traditional ones. However, due to the tightness of the battery, more water is required to extinguish it, and there is a possibility of re-ignition. As a rule, an electric car that catches fire burns out completely [9]. At the same time, hydrogen, methane, carbon monoxide, hydrogen fluoride and hydrogen cyanide, which are toxic and poisoning gases, are released into the atmosphere. In order to improve the safety of lithium-ion batteries, standards have been developed to assess their safety, according to which batteries are tested during charging, temperature changes and mechanical stress.

The development of "clean" energy and green automotive industry depends in the future on R&D of safe technologies for the disposal and recycling of batteries, semiconductors and composites, increasing the production of electricity from renewable energy sources. Currently, thermal power plants prevail in the world.

The analysis of foreign studies by universities and international organizations that compared cars with internal combustion engines and LIB showed that "... the production of electric vehicles brings much more harm to the environment in terms of the total carbon footprint, which, however, is compensated during operation due to the absence of harmful emissions" [10, p. 79]. Studies show that the impact of electric vehicles on the environment depends on their size: the larger the electric motor, the more obvious is the reduction of

carbon dioxide emissions and harmful emissions and a positive impact on the environment [11].

Table 2 summarizes the interests of the main stakeholders from the standpoint of ecology and the motives for production and use of electric vehicles, highlighting the arguments for and against the development of the electric vehicle market.

Table 2. The impact of electric vehicles on the environment from the perspective of stakeholders

Stakeholders	Pros	Cons
Automakers	Increasing market share Implementation of the ESG agenda Reduction of working time for car assembly	Rising R&D costs Rising costs of raw materials and batteries for the production of electric vehicles
Suppliers of raw materials for the production of electric vehicles	Income and investment growth	The growth of anthropogenic pressure on the environment, Energy demand growth
Households	Operation is cheaper Environmentally responsible behavior Ease of management Low noise level	Weak network of chargers The high price of an electric car Possible increase in electricity prices Limited mileage Recycling problem
Car carriers of passengers and cargo	Reduction of the carbon footprint Implementation of the ESG agenda Green logistics	Possible increase in electricity prices High price of electric truck and electric bus Poor quality of maintenance Recycling problem
State	Growth of budget revenues for states suppliers of raw materials and manufacturers of electric vehicles Reduction of carbon dioxide emissions due to electrification of transport	State budget expenditures to stimulate the production and sales of cars Increasing load on the power grid and power plants Charging station costs Increased consumption of minerals and harmful emissions from the production and disposal of electric cars Reduction of budget revenues of petroleum exporting countries
Administration of cities and settlements	Improving the quality of life of the population by reducing harmful emissions into the atmosphere Achieving the Sustainable Development Goals	Increased costs for charging infrastructure and dismantling of petrol and diesel filling stations Increased demand for electricity and new power grids Possible increase in electricity prices

Compiled by the authors

Electric cars are one and a half times more expensive than cars with internal combustion engines, but the gap is gradually decreasing. The price of electricity depends on the type of fuel. In descending order, the price rating looks as follows: solar energy (five times more expensive than oil and gas generation), wind energy, oil and gas, coal, hydropower. The

production of batteries requires a lot of electricity consumption and is "dirty" for the environment. The issue of safe disposal of used batteries has not been resolved. Significant investments are required in the infrastructure of charging stations for electric vehicles. For consumers, when deciding to buy an electric car, the most important issue is the price, the availability of a charging station nearby and maintenance. Thanks to the development of electric transport, the administrations of cities and settlements improve the quality of the urban environment.

4 Conclusion

It is still difficult to say that an increase in the fleet of electric vehicles will significantly reduce the negative impact of human production activities on the environment. Assessments of individual scientists, companies and international organizations on harmful emissions at all life stages of the car give different results, which requires further research and consideration of all indirect effects on the environment taking into account production, operation and disposal of an electric vehicle. Researchers are unanimous in one thing, the quality of life of the population in the cities when switching to electric vehicles increases due to the purification of atmospheric air from greenhouse gas. Electrification of motor transport in many countries of the world is impossible without state support and tax incentives. The positive impact of electric vehicles on the environment depends on an increase in electricity generation using renewable energy sources and progress in the development of technologies for the recycling of used batteries.

The prospects for the development of the electric vehicle market will depend primarily on the buyers' demand. Electric cars will be able to completely replace cars with an internal combustion engine if the idea of their environmental friendliness, harmlessness to the environment, and low carbon footprint is introduced into the minds of consumers. The future of the global automotive industry depends on technological progress in the field of battery recycling.

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