

Electromobility and the Environment in the Czech Republic

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Abstract: Background: Reducing the carbon footprint in transport through the introduction of electromobility is stipulated by the European legal framework. The shift to electric vehicles requires identifying the types of emissions from combustion engines that will be eliminated through electromobility. In addition to environmental benefits, another advantage of electromobility will be the reduction of noise pollution. Methods: From a technical point of view, it is necessary to assess the characteristics of these vehicles by focusing on the tire design, which significantly influences their performance, and to examine the impact of policy proposals and technical advancements on the number of electric vehicles registrations and their development over a given period. Results: The paper confirms that legislative developments and improvements in the technical characteristics of electric cars are driving an upward trend in the number of registered clean vehicles, which reduces their environmental impact. Conclusion: The authors of the article conclude that, despite higher investment and operating costs, the operation of electric cars, when supported by appropriate forms of support, represents an opportunity to reduce the carbon footprint in transport.

Keywords: Electromobility, environment, carbon neutrality

1. Introduction

Transport is a major source of atmospheric pollution. The European legal framework for climate requires the European Union to reduce greenhouse gas emissions across the entire economy by at least 55% by 2030 compared to 1990 levels, and to achieve climate neutrality by 2050 [1]. The European Green Deal underscores the need to reduce greenhouse gas emissions from transport by

90% by 2050 to reach climate neutrality. Additionally, the Zero Pollution Action Plan supports the transition to cleaner transport to mitigate atmospheric pollution and noise pollution [2].

It is expected that BEV (Battery Electric Vehicle) adoption will play a central role in meeting CO₂ regulations for passenger cars, with the transition to zero emission vehicles (mainly BEVs) anticipated to significantly reduce net GHG emissions by reducing life cycle emissions across the EU [3].

According to data from the European Environment Agency (EEA), over 100 million EU citizens are exposed to high levels of noise and air pollution, both of which negatively affect human health. One of the widely recognized solutions for reducing environmental burden in urban areas, both in terms of noise and air quality, is the promotion of electromobility [4].

Within this framework, the European Commission launched the EAFO (European Alternative Fuels Observatory) portal. Initial results indicate a growing trend in the market for Battery Electric Vehicles (BEV) and Plug-in Hybrid Electric Vehicles (PHEV) [5].

2. Data and Methods

The European legal framework stipulates that introducing electric vehicles will be the primary mechanism for achieving CO₂ regulation in the transport sector [1]. The aim of switching to electric vehicles is to reduce both air pollution and noise pollution. In addressing electric vehicles, it is necessary to define all types of propulsion systems and identify the emissions from combustion engines that electric vehicles will eliminate. When evaluating electric cars and their carbon footprint, it is appropriate to characterize their technical properties in more detail, as these significantly influence the design of tires, whose production has notable environmental impacts, which can offset the environmental benefits of electric vehicle operation.

2.1 Prerequisites for the Solutions

To address the problem of vehicles with electric drives, it is first necessary to define all types of electric drive systems. Given the requirement to mitigate the environmental impact of transport, it is important to identify all types of emissions from combustion engines that will be eliminated by electric vehicles.

Currently, the following types of vehicles are used based on their drive system:

- Battery Electric Vehicle (BEV) – a vehicle with a powertrain that uses exclusively electric motor as propulsion energy converters and relies solely on a rechargeable electrical system storing the obtained energy.
- Fuel Cell Vehicle (FCV) – a vehicle equipped with a propulsion system that consists of- solely one or more fuel cells and one or more electric motor serving as propulsion energy converters.

- Fuel Cell Hybrid Vehicle (FCHV) – a vehicle equipped with a powertrain that includes at least one fuel storage system and at least two different categories of propulsion energy transducers and at least two types of system storing the obtained energy.
- Hybrid Vehicle (HV) – a vehicle equipped with a propulsion system consisting of at least two different categories of propulsion energy converter and at least two different categories of propulsion energy storage system.
- Hybrid Electric Vehicle (BHEV) – a hybrid vehicle with at least one propulsion system that converts energy to an electric power.
- Off-Vehicle Charging Hybrid Electric Vehicle (OVC-HEV) – a hybrid electric vehicle that can be charged from an external source.
- Not Off-Vehicle Charging Hybrid Electric Vehicle (NOVC-HEV) – a hybrid vehicle with at least two different types of propulsion energy transducers and at least two various categories of energy storage system that cannot be external charged.

Exhaust emissions from internal combustion engines include several types of pollutants.

Monitored emission components include:

- carbon dioxide (CO₂) from the exhaust of a motor vehicle or engine; colorless gas, tasteless and odorless; it is not poisonous, but increases the effects of CO and contributes to the greenhouse effect,
- carbon monoxide (CO) emitted from the exhaust; colorless gas, tasteless and odorless, lighter than air, non-irritating, explosive. Highly poisonous,
- nitrogen oxides (NO_x) – a group of nitrogen oxides compounds emitted from exhaust that can irritate the lungs and mucous membranes,
- methane (CH₄) – a hydrocarbon gas emitted from exhaust,
- non-methane hydrocarbons (NMHC) – hydrocarbons emitted from exhaust, excluding methane,
- non-methane organic gases (NMOG) – non-oxygenated and oxygenated hydrocarbons emitted from exhaust,
- ammonia (NH₃) – a pungent compound emitted from exhaust,
- formaldehyde (HCHO) – a volatile organic compound emitted from exhaust.

Road vehicles emit particles not only from exhaust gases, but also particles from other sources, including brake and tire wear, road surface wear, and the resuspension of dust from the road surface.

These sources include:

- PM particles – the mass of material generated by tire abrasion or brake wear. For instance, PM₁₀ particles are particles with a diameter of less than 10 μm;

- PN particles – solid particles emitted from exhaust or brakes. PN10 are solid particles with a diameter of 10 nm or larger;
- dust resuspension – emission of dust particles that settle on the road surface and are re-blown into the air due to the turbulent flow caused by passing vehicles.

2.2 Carbon Footprint of Electric Cars and their Tires

The carbon footprint is an indicator of environmental impact, represented as the total of emitted greenhouse gases expressed in CO₂ equivalents. In this context, the long-standing serious problem in air quality is the environmental burden caused by automobile traffic.

Electric cars are very quiet and emit zero emissions while driving, significantly enhancing the quality of the local air [6]. According to the primary energy source used, electric cars can be manufactured with minimal CO₂ emissions [7], as supported by the literature [8,9]. Compared to vehicles with conventional combustion engines, electric cars have several distinct driving characteristics that place unique demands on tires.

Tires developed specifically for electric cars align with their driving characteristics, improving control, safety, range, and reducing noise emissions. However, tire production also has environmental consequences, particularly contributing to marine and freshwater ecotoxicity, as well as land use and depletion. [10,11].

Approximately 1.6 billion tires were manufactured worldwide in 2019, which is a 36 % increase compared to a decade earlier [12]. Several physical factors affect vehicle energy usage, including rolling resistance, aerodynamic drag, inertia, and internal friction. Tires are solely responsible for rolling resistance and also contribute to the vehicle's inertia [13], as noted in studies [14-16].

Construction of tires for electric automobile is significantly influenced by the technical characteristics of electric cars, namely weight, high torque, rolling resistance and noise:

- Weight – compared to cars with a combustion engine, electric cars are typically over 200 kg (depending on the type of vehicle) due to the weight of their large-capacity batteries. This additional weight has a major impact on driving characteristics, handling and tire wear. To prevent deformation and overheating, electric vehicle tires have specially reinforced sidewalls to accommodate the vehicle's higher weight.
- High torque – electric motors deliver higher torque than internal combustion engines and reach maximum power instantly when the pedal is pressed. The load on the tires of electric cars is more intense than that of cars with internal combustion engines, where the performance increases gradually. To handle this, electric vehicle tires feature stiff, wide center ribs to reduce the risk of slipping. Additionally, the treads have interlocking grooves in the pattern, which prevents aquaplaning.

- Rolling resistance – the higher weight of electric cars requires tires with lower rolling resistance (lower energy consumption and thus extended range). However, lower rolling resistance can conflict with cornering grip, effective braking and acceleration. Electric vehicle tires are therefore made from a harder compound, but this does not significantly affect the negative phenomena associated with it. The design focused on minimizing rolling resistance while ensuring braking distances and safety on both dry and wet roads.
- Noise – In internal combustion engine, the engine vehicles is the primary source of noise (approx. 50%). The electric motor is quiet, the interior of the vehicle is low noise even with regard to the aerodynamics of the bodywork. Since rolling tires generate the most noise, the solution is to choose a different tread design and insert a damping layer inside the tire.

The relationship between emissions from abrasion (brakes, tires and wear of the road surface) and the weight of the vehicle and the resuspension of road dust have been addressed by various experts. In the Czech Republic, the Ministry of the Environment initiated the creation of a Methodology for Calculating Particle Emissions Originating from Road Transport Resuspension. [17]

The above-mentioned characteristics have also been examined by Beddows and Harrison [18], who studies the relationship between PM10 and PM2.5 emissions from abrasion (brakes, tires and road surface wear) and vehicle weight and emission of dust particles. They compared these two types vehicles and found that the emissions depend largely on the extent of regenerative braking in electric vehicles relative to the use of friction brakes in BEVs. Ultimately, however, the total local particulate emissions from a personal vehicle, compliant with current Euro emission standards, show only minor differences [18]. This raises the question of whether the electrification of passenger cars will significantly reduce the total emissions of solid particles PM10. A graphical representation is shown in Figure 1.



Fig. 1 Reduction in emissions of solid particles after electrification of vehicles Source: [18]

In addition to the technical parameters of the vehicles, their mode of usage, specifically their driving mode, has a substantial influence on the environment. Driving mode can be controlled (almost) in real time using available information and communication technologies covered by V2X - Vehicle to Anything systems, with a significant improvement in the safety of their operation. [19]

2.3 Development of Electric Vehicle Registrations

An integral part of the development of electromobility supported by the specified measures is the introduction of electric vehicles into road traffic. Therefore it is important to conduct a comprehensive assessment of the growth in the registration of these vehicles over the past period, as well as the availability of public transport charging points.

2.3.1 Assessment of Clean Vehicle Registrations in the Czech Republic

The development of clean vehicle registrations in the Czech Republic from 2013 to 2023, as shown in Fig. 2, shows a gradual increase. During this period, the number of registrations grew by more than 10 thousand. Since 2013, a significant portion of the registrations has been related mainly to vehicles powered by LPG and CNG. Since 2019, a notable increase in registrations has also been observed for vehicles with BEV propulsion.

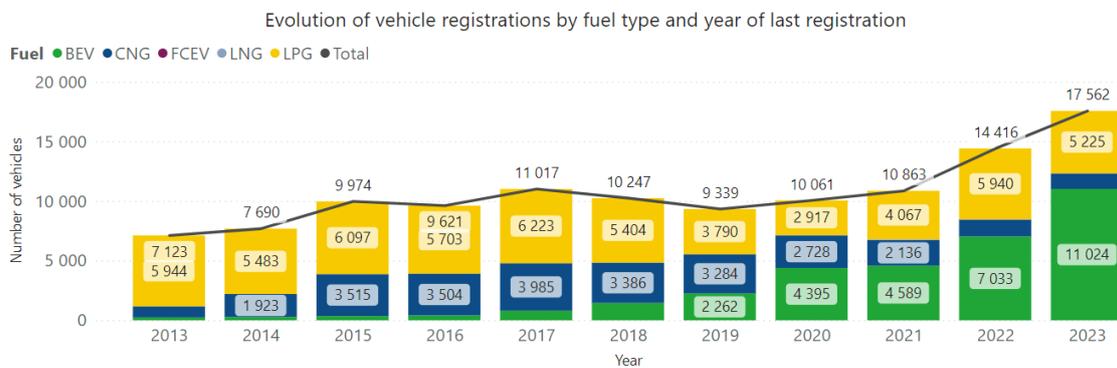


Fig. 2 Development of clean vehicle registrations. Source: authors according to [20]

From the development of the number of registered clean cars shown in the graph in Fig. 3, there is an evident increase in the number of new vehicles and a decrease in the number of used vehicles for the period 2013-2023. In the five-year period from 2013 to 2017, used vehicles were registered in greater numbers, while new vehicles saw a larger increase during the period from 2018 to 2023.

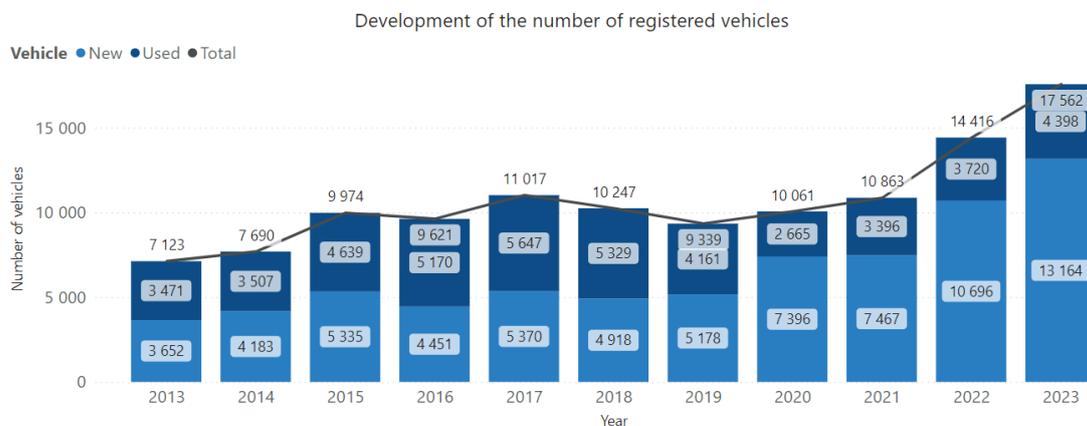


Fig. 3 Development of the number of registered clean vehicles. Source: authors according to [20]

2.3.2 Assessment of the Share of Clean Vehicle Registrations in the Czech Republic

The development of the share of clean vehicle registrations for the period 2013-2023 is shown in the graph in Figure 4. The data in the graph indicate a gradual increase in the share of vehicles with BEH drive from 3.39% to 39.39%, representing a 36% increase. There is also a gradual decrease in the share of LPG-powered vehicles, from 83.24% to 18.67%, which is a reduction of about 65%, and fluctuation in the share of CNG-powered vehicles from 13.12% in 2013 to 4.6% in 2023. FCEV vehicles were not registered until 2020, after which their share remained between 0.02% and 0.09%. The reduction in the number of LPG and CNG vehicles is apparently caused by the limited production of new cars with these types of propulsion, rising prices of these drives, and the growing support for alternative propulsion technologies.

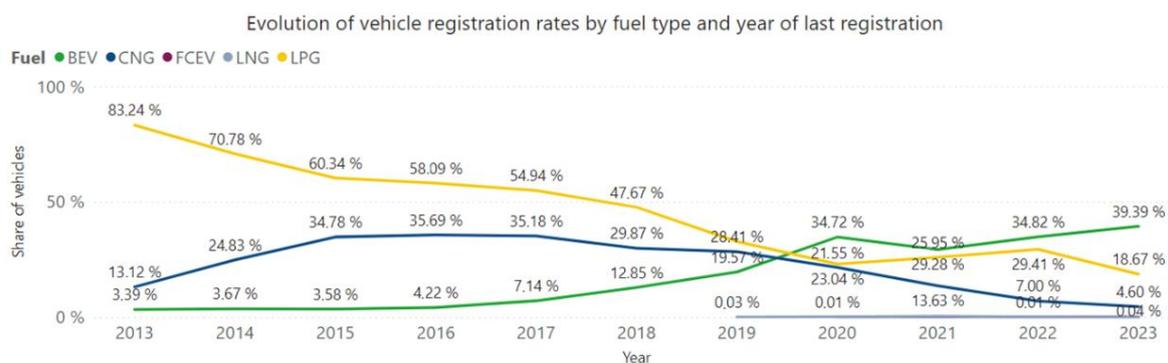


Fig. 4 Development of the share of registrations of clean vehicles. Source: authors according to [20]

From the share of registered clean vehicles in individual regions of the Czech Republic shown in the graph in Fig. 5, it is evident that the highest share of registered vehicles with BEV drive is found in the Capital City of Prague at 45%, with the average at 22% in other regions and the lowest at 16% in the Moravian-Silesian Region among all registered clean vehicles.

The highest share of BEV-powered vehicles is registered in the capital city of Prague compared to other regions, especially the Moravian-Silesian Region, which is probably due to higher purchasing power and a higher number of charging stations. FCEV and LNG-powered vehicles are registered only in tenths of a percent, as shown in the previous graphs.

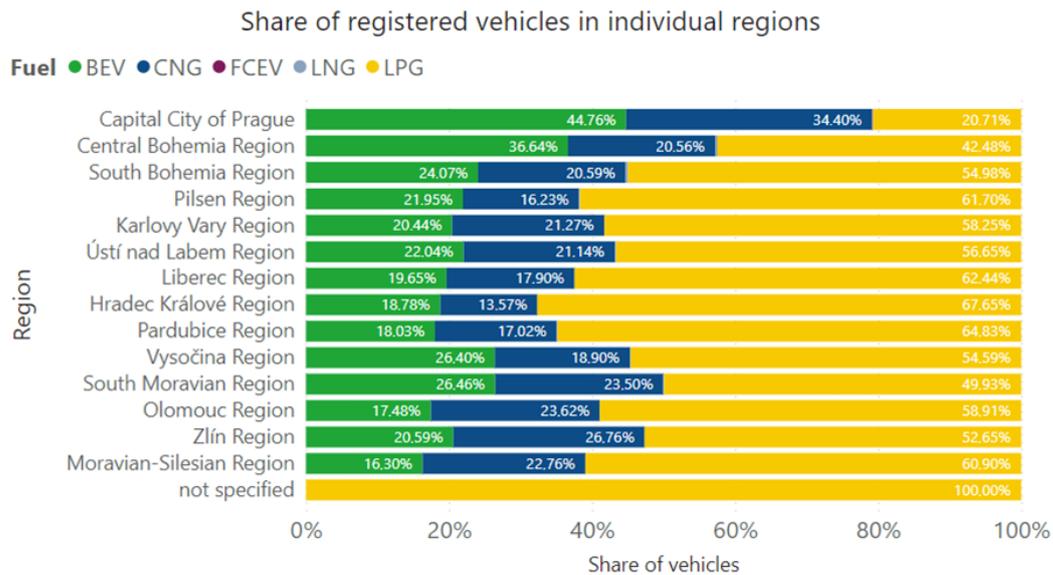


Fig. 5 Share of registered clean vehicles in individual regions. Source: authors according to [20]

2.3.3 Assessment of Public Charging Points and Stations in the Czech Republic

The development of the number of public charging points and charging stations commissioned in the period 2013-2023, as shown in the graph in Fig. 6, shows a significant increase in the number of connected points and stations from 2015 to 2022. According to the updated data, the increase in the number of charging points and stations continued into 2023.

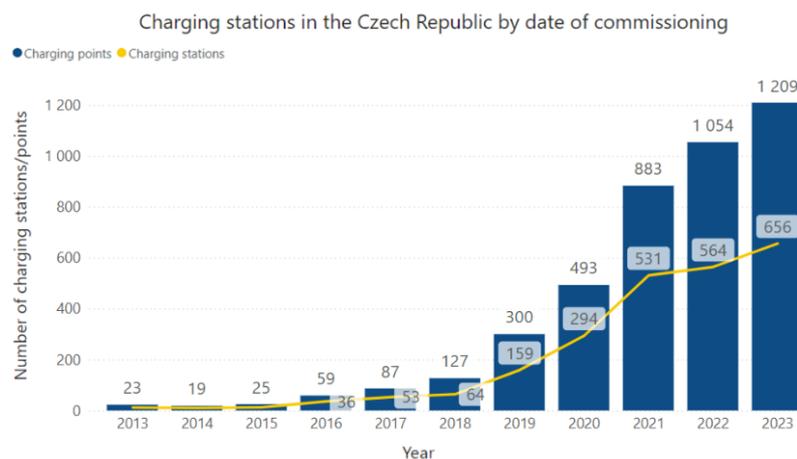


Fig. 6 Number of public charging points and charging stations. Source: authors using [20]

3. Results

Transport is one of the major sources of air pollution. Transport accounted for almost one third of the total consumption of fuels and energy by end users in the Czech Republic in 2022 (see Fig. 7).

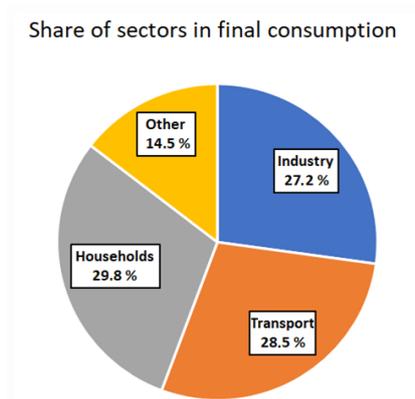


Fig. 7 Share of individual sectors of the national economy in the Czech Republic in electricity consumption. Source: [21]

From the perspective of individual types of transport, both in the Czech Republic and in other EU countries, road transport produces the highest emissions. In road transport, passenger cars are the largest contributors to air pollution. As the largest emitters of CO₂, they account for 60.6% of the total emissions from the transport sector in EU countries. It is therefore necessary to address the issue of electromobility to reduce average CO₂ emissions. An overview of emissions generated by individual modes of transport is shown in Fig. 8.

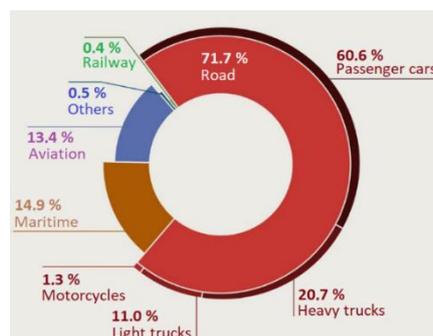


Fig. 8 Overview of emissions produced by individual modes of transport in the EU. Source: [22]

In context of this issue, it is important to assess CO₂ emissions produced by new vehicles in both the Czech Republic and the EU. When comparing the development of average CO₂ emissions from new passenger vehicles in the Czech Republic and the European Union for the period 2013-2023, as shown in the graph in Fig. 9, a decrease or slight increase in emissions occurred during the period 2013-2020 in the Czech Republic. However, a significant increase in emissions was observed between 2020 and 2021. In the European Union, there was a slight decrease in produced emissions over the entire period from 2013 to 2022. The common trend of decreasing average CO₂ emission values from 2013 to 2022 diverged considerably in the years 2020 to 2022, with the Czech Republic showing a negative deviation.

It can be assumed that the reduction in CO₂ emissions in recent years is due to the tightening of Euro emission standards for vehicles with internal combustion engines and the increased adoption of electric vehicles.

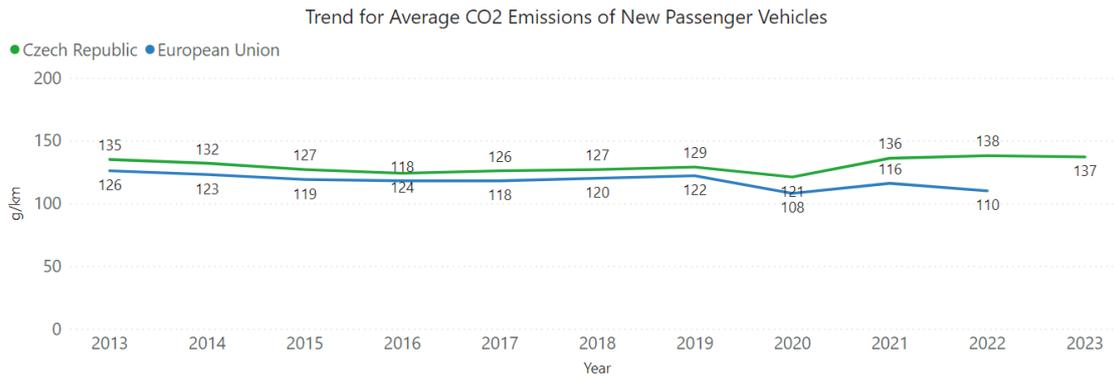


Fig. 9 Development of average CO₂ emissions of new vehicles in the Czech Republic and the EU.

Source: authors according to [20]

4. Discussion

The issue of electromobility is a current topic in today's society, particularly in relation to the environment. The registration of new alternative drive vehicles is growing, and in 2021, their share exceeded 10% of the registrations of new passenger cars.

The operation of electric cars is still more expensive per hundred kilometers compared to cars powered by gasoline or diesel. Currently, electricity remains cheap (or almost free for owners of photovoltaic system). However, when charging at public or fast chargers, the cost is higher than that of fossil fuels. For the state budget, the taxation of 60% of fossil fuels is a significant revenue source, which is not matched by the taxes that are included in the price of electricity for electric cars. For example, in Norway, where the share of electric cars is 20%, a new tax targeting electric vehicles is being discussed due to the loss of revenue from fossil fuels. While operating electric cars may not be cheap compared to fossil fuel cars, their environmental impact is decidedly positive.

5. Conclusion

When assessing electromobility, carbon neutrality, and their impact on the environment in the Czech Republic and the EU, the increasing trend in the number of electric vehicles whose operation reduces the impact on the environment and noise load was confirmed.

In future development, electric and hybrid electric cars will become an integral part of road traffic. Therefore, it is essential to improve the design of electric vehicles, financially supporting the purchase of new electric vehicles and continue the expansion of charging stations infrastructure.

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