*Environment. Technology. Resources. Rezekne, Latvia*
*Proceedings of the 15th International Scientific and Practical Conference. Volume I, 315-321*

# *Regulating the Electric Vehicle Market within the Framework of the European Green Course*

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***Abstract.*** **Transportation is a strategic sector of the EU's economy and directly impacts the daily lives of all EU citizens. This industry is responsible for around 11 million jobs. It is vital for the integration of Europe, as interconnected and sustainable transport networks are necessary to complete and adequately function the European Single Market. Over the last few decades, passenger and freight transport volumes have grown, and they are expected to continue to do so, although at a slower pace. Most passenger and freight transport is through road transport, and this article focuses on regulating road transport and its compatibility with the objectives of the European Green Deal. The European Commission has put forth a set of propositions to align the EU's climate, energy, transport, and taxation policies to achieve a minimum reduction of 55% in net greenhouse gas emissions by 2030 compared to the levels recorded in 1990. One proposition is to reduce road transport pollution by increasing the percentage of electric vehicles operating in the road transport sector. This paper aims to introduce the concept of the electric road vehicle, analyse the objectives of the European Green Deal, and discuss Lithuanian policy actions regarding electric road vehicles and related infrastructure.**

***Keywords: electric road vehicle, European Green Deal, infrastructure for electric vehicles.***

## I. Introduction

Transportation plays a vital role in the economy of the EU, and it significantly impacts the daily lives of all EU citizens. This industry is responsible for around 11 million jobs. It is vital for the integration of Europe, as interconnected and sustainable transport networks are necessary to complete and adequately function the European Single Market. While passenger and freight transport volumes have been steadily increasing in recent decades and will continue to grow, particularly in the road transport sector, there is a growing emphasis on aligning regulations with the goals of the European Green Deal.

The European Commission has put forth a set of propositions to align the EU's climate, energy, transport, and taxation policies to achieve a minimum reduction of 55% in net greenhouse gas emissions by 2030 compared to the levels recorded in 1990 [1].

One proposition is to reduce road transport pollution by increasing the percentage of electric vehicles operating in the road transport sector. This paper aims to introduce the concept of the electric road vehicle, analyse the objectives of the European Green Deal, and discuss Lithuanian policy actions regarding electric road vehicles and related infrastructure.

## II. Materials and Methods

In the study, the methods of analysis, comparison, and generalisation were applied. It analysed scientific and technical literature, statistical data, and technical data about electric vehicles, EU policy and law, Lithuanian policy and law, and Lithuanian municipalities' policy, law, and practice regulating the electric vehicle market within the Framework of the European Green Course. The comparison method was used to compare data from different periods and types of vehicles and determine the direction of the electric vehicle market regulation. By applying the generalisation method, the work summarises and highlights the policy gaps in Lithuanian policy and legal regulation regarding electric vehicles, indicating insufficient and unsuitable infrastructure and failure to ensure social justice. This method is also applied to present the conclusions of the study.

*Print ISSN 1691-5402*
*Online ISSN 2256-070X*
*https://doi.org/10.17770/etr2024vol1.7949*

## III. Results and Discussion

### A. The role of the electric vehicle in the context of climate change, market trends and developments

Electric vehicles have been around since the late 19th century. "During the early 1900s, around 40% of cars were electric, 38% on steam and a mere 22% on gasoline" [2]. The scientific literature uses different names to refer to electric vehicles, including electric cars [3], electric vehicles [4], pure electric vehicles [5] or battery/battery electric vehicles [6]-[7].

An electric vehicle is a mode of transportation powered by an electric motor that receives its energy from a stored electrical source, typically a battery [8]. This vehicle runs exclusively on electric power and has a battery that should be periodically recharged with an external power source. As it is powered by electricity, it emits zero pollutants and operates silently. The vehicle's electric range varies between 80 and 400 kilometres, depending on the specific model [9]. Presently, hybrid-electric vehicles constitute a substantial segment of the automotive market. These vehicles integrate a conventional internal combustion engine fuelled by petrol or diesel with an electric motor that derives power from electricity stored within a battery [8].

Electric cars can be classified into five primary categories based on scientific and technical discourse:

- Non-rechargeable Hybrid Electric Vehicles (HEVs)
- Plug-in Hybrid Electric Vehicles (PHEVs)
- Range-extended Electric Vehicles (REEVs)
- Fuel Cell Electric Vehicles (FCEVs)
- Battery Electric Vehicles (BEVs) [10].

In non-rechargeable hybrid vehicles, the internal combustion engine charges the battery during braking or coasting, while the electric motor is an auxiliary function. This hybridisation increases fuel efficiency, thereby lowering greenhouse gas emissions. Depending on the model, the range is 0-10 km [11].

Rechargeable hybrid vehicles' batteries can be charged the same way as non-rechargeable hybrid vehicles but can also utilise an external power source during charging. The battery in rechargeable hybrid vehicles is larger, allowing short distances to be travelled using only electricity. The internal combustion and electric motors can operate together or separately [12].

In these vehicles, the internal combustion engine starts operating when the battery is depleted; energy is needed for rapid acceleration, intensive air conditioning, or heating. Depending on the model, the electric range of hybrid vehicles varies from 20 to 85 km. The internal combustion engine in heavy-duty rechargeable hybrid vehicles requires more frequent engagement; thus, their operation is more similar to that of non-rechargeable hybrid vehicles [13].

Extended-range electric vehicles are powered by an electric motor and a backup internal combustion engine that acts as a generator. This generator supplies electricity to the electric motor or recharges the battery. Since the vehicle is powered solely by electricity, the internal combustion engine is smaller, which reduces the overall weight of the car. Additionally, these vehicles can be charged using an external power source. The electric range can vary from 70 to 145 km, depending on the model. [9].

Electric vehicles powered by hydrogen fuel cells generate electricity from hydrogen, which provides a longer driving range and faster refuelling compared to traditional electric vehicles. The range of these vehicles varies from 160 to 500 km. However, it's worth noting that the technology is currently in the developmental stage [14].

Entirely electric vehicles rely on charging infrastructure, while hybrid vehicles do not require it as much. Three main ways to charge an electric vehicle are grid charging, battery swapping, and wireless charging. In Europe, most electric vehicle owners use grid charging, which involves connecting the vehicle to a charging point with a cable and plug. Charging stations are classified as slow, fast, or ultra-fast by power capacity. Slow charging is the most common and readily available, taking 4 to 14 hours to charge. Fast charging takes 1- 2 hours, while ultra-fast charging can charge a vehicle in 30 minutes [15].

Electric vehicles are often praised for their numerous advantages. Compared to fossil fuel-powered cars, they have a simpler operating principle and construction. The electric car engine is more efficient, as it transfers 90% of energy to the wheels, while a conventional engine only transfers 40%. Electric vehicles have fewer moving parts and don't require exhaust systems, filters, or oil. They also have a much simpler cooling system, which makes maintenance much simpler throughout their lifespan. Additionally, these cars operate quietly thanks to the electric motor and produce zero CO2 emissions during driving (if solely powered by electricity).

The fundamental difference between electric and fossil fuel-powered vehicles is how they transform potential (stored) energy into kinetic (motion) energy. In electric vehicles, energy is stored in chemical form in batteries and released during chemical reactions in the motor. Due to this, no fuels are burned in electric vehicles, resulting in zero emissions of CO2 and other pollutants [16].

The transportation industry is one of the EU's leading sources of greenhouse gas emissions. This requires immediate action to reduce emissions to align with the EU's objectives for climate neutrality. Starting in 2025, Regulation (EU) 2019/631 [17] mandates stricter EU-wide CO2 fleet targets. This includes a 15% reduction for cars and vans by 2025, a 50% reduction for vans, and a 55% reduction for cars by 2030, compared to 2021. Furthermore, this regulation sets a zero-CO2 emission objective for new cars and vans starting in 2035. Achieving these ambitious targets requires a significant increase in the adoption of electric vehicles.

Electric vehicles, such as battery electric vehicles and plug-in hybrid electric vehicles, have steadily increased their presence in the EU market. The number of new electric cars registered has surged from 600 in 2010 to approximately 1.74 million in 2021, accounting for 18% of all new car registrations. This trend continued in 2022 when electric vehicles represented almost 22% of newly registered passenger cars. Battery electric vehicles comprised 12.2% of total new car registrations, while plug-in hybrid electric vehicles accounted for 9.4% [18].

In 2022, approximately 56,500 electric vans were sold in the EU-27, comprising 5.5% of the market share and representing an increase of approximately 2.0 percentage points from 2020. The majority of electric vans sold were battery electric vehicles [18].

In 2022, there was a significant increase in the adoption of electric cars and vans in the EU. This was evidenced by the registration of electric vehicles, which accounted for 21.6% of new car registrations, totalling almost two million electric car registrations within a year. This marked an increase from 1.74 million in 2021. Additionally, the number of electric vans on European roads increased, comprising 5.5% of new registrations in 2022. Notably, the number of newly registered battery electric vehicles increased by 25% during the same period, while the count of plug-in hybrid cars remained stable. Moreover, battery electric vehicles made up the majority of electric van registrations in 2022 [9].

Although electric vehicles have grown substantially in recent years, they only make up 1.2% of the European car fleet. Expanding Europe's electric vehicle fleet is inevitable to meet emissions reduction goals and climate neutrality targets by 2050 [18].

### *B. The European Green Deal: main issues in the transport sector*

The world is currently threatened by climate change and environmental degradation, and in response to this alarming situation, the EU has initiated a Green Deal [19]. Climate change is largely caused by human activity. The primary factor contributing to this negative trend is greenhouse gases, including carbon dioxide (CO2).

Greenhouse gases occur naturally, but human activities such as burning fossil fuels, agriculture, livestock farming and deforestation have significantly increased their levels. The main problem caused by additional greenhouse gasses is that they increase the greenhouse effect of the planet's atmosphere, increasing the Earth's air temperature. This is leading to significant climate change.

To combat transportation-related urban air pollution, reduce greenhouse gas emissions, and reduce dependency on fossil fuels, policymakers worldwide are advocating for the electrification of transportation [10]. Research indicates that a transition towards electric vehicles holds the promise for significant reductions on a global scale in climate change, air pollution, dependence on fossil fuels, and improved human health [20]. Many countries worldwide, including Britain, France, Norway, and India, plan to replace fossil fuel-powered vehicles with electric vehicles soon. Furthermore, China, Germany, Japan, the Netherlands, Spain, Denmark, Ireland, Portugal, South Korea, and Austria have announced national plans to phase out internal combustion vehicles [10].

The European Green Deal, published in 2019, is the largest initiative taken by the EU to achieve climate neutrality. EU institutions showed ambitions for greenhouse gas reduction. In the September 2020 proposal, the European Commission proposed reducing emissions by 55% by 2030 compared to 1990, whereas the European Parliament proposed a 60% reduction [21].

The European Green Deal is a comprehensive framework and strategic blueprint that outlines the EU's course of action towards achieving climate neutrality. It emphasises the crucial role of all EU actions and policies in reaching this overarching goal. It provides directives for legislative and non-legislative measures that will help facilitate its attainment. These initiatives cover various sectors, including industry, energy, finance, mobility, and transport.

Climate change and environmental degradation pose significant threats to Europe and the global community. In response to these challenges, the European Green Deal endeavours to metamorphose the European Union into a contemporary, resource-savvy, and competitive economy [1]. This initiative aims to achieve:

1. Zero greenhouse gas emissions by the year 2050.
2. Decoupling economic growth from resource consumption.
3. No marginalised or neglected individual or geographical area in pursuing environmental sustainability and economic advancement.

As per the updated CO2 standards, all newly registered cars and vans in the European region will transition to zero-emission vehicles by 2035. The emissions of new cars should be reduced by 55% and new van emissions by 50% by 2030. This strategic initiative is designed to firmly establish road transport on a trajectory towards zero emission by the year 2050 [22].

It is notable that the amount of pollutants emitted by the transportation sector is increasing, with fossil fuels remaining the primary source of energy [23]. Transportation is responsible for over one-fourth of Europe's total greenhouse gas emissions, with road transportation alone contributing more than half. Transportation also consumes one-third of the EU's final energy, most of which is derived from oil. As a result, the transportation sector contributes significantly to the EU's greenhouse gas emissions, worsening the effects of climate change.

Reducing the negative impact of transportation is a key objective of the European Green Deal. The primary way to achieve environmental sustainability in the transportation sector is through implementing more eco-friendly transportation technologies, fuels, and infrastructure, as well as the transition to the least polluting and most efficient modes of transport. It is widely believed that electrified transportation is low-emission and efficient. The EU aims to have over 30 million electric vehicles on the roads by 2030 - a significant increase compared to the 2 million electric vehicles currently navigating European streets and roads. [24].

The objectives of the European Green Deal for transportation are becoming more stringent and legally binding, as opposed to just being policies or strategies. These objectives are outlined in Regulation (EU) 2021/1119, which serves as a framework for achieving climate neutrality. [25]. To neutralise climate impacts in the transport sector:

1) Emissions must be reduced by 90% by 2050 [25];

2) Emissions of new passenger cars must be reduced by 55% and new light commercial vehicles by 50% by 2030 [26];

3) Zero average emissions of new passenger cars and new light commercial vehicles by 2035 [26];

4) Average CO2 emissions of trucks and other heavy-duty vehicles must be reduced by 15% by 2025 and 30% by 2030 [27].

To achieve the objectives set out in the European Green Deal, which prioritize sustainability and intelligence, member states need to improve several areas, such as implementing multimodal transportation, integrating automated and intelligent mobility solutions, reviewing tax policies, promoting the production and use of alternative fuels, and imposing stricter regulations on traditional transportation practices.

### C. *Situation in Lithuania regarding electric vehicles and policy measures*

The transport sector is currently a significant contributor to greenhouse gas (GHG) emissions in Lithuania. In fact, it accounts for 29.88% of total GHG emissions in the country in 2021. [28]. While vehicle efficiency has improved during the period from 1990 to 2019, GHG emissions from the transport sector have been steadily increasing due to the rising number of vehicles and the intensification of freight transport activities [29]. In 2020, the situation has stabilised and started to improve, albeit very slowly. In 2020, GHG emissions decreased by 2.37% compared to 2019 and 2021 by an additional 0.23% compared to 2020.

In the transport sector, which includes road, rail, air, and inland waterway transport, road transport accounted for 96.16% of emissions in 2021. At the end of 2022, there were about 1.98 million registered road vehicles in Lithuania, of which about 1.65 million (83.28%) were passenger cars [28]. Lithuania has one of the oldest and most polluting passenger car fleets in the EU, with an average age of 15 years, and about 70% of passenger cars are diesel-powered [29].

The transport sector is also the largest energy consumer, accounting for 40.42% of the energy consumed in Lithuania in 2022 [30]. Most of the energy consumed by the road transport sector was produced from fossil oil or gas resources (91.39%). The share of renewable energy sources (RES) in road transport consumption in 2022 was only 8.6% [31]. The share of electricity used in the transport sector is still very low, accounting for only around 0.69% of total electricity consumption in 2022 [32]. 63.29% of the electricity consumed in the transport sector is consumed by road transport. This represents only 2.5% of the total energy consumption of road transport [31].

Electric car purchases are being promoted through various regulatory and financial measures. Vilnius allows electric vehicles to drive in a specially marked public transport lane to increase electro-mobility. It should be noted that the number of these lanes has recently been reduced. There are also various parking incentives in major Lithuanian cities. Funding for the purchase of electric cars is also available starting in 2020. Each person can get a compensation of €5,000 for a new pure electric vehicle and €2,500 for a second-hand one [33]. Individuals using the vehicle for economic activities can get a €4,000 compensation for a new M1 or N1 pure electric car [33]. Statistical data shows that from July 2022 to February 22, 2024, legal entities purchased 1406 LCVs and, in total, got €5,624,000 compensations. [34].

Lithuania is developing its electric vehicle charging infrastructure. Initially, electric vehicle connectivity was ensured in five major cities and national roads at 50 km intervals.

Currently, the electric vehicle's charging infrastructure is being expanded. In January 2024, the Public Electric Vehicle Charging Stations Registration System (CSRS) indicated 45 registered charging operators and 1312 public and semi-public electric vehicle charging stations in Lithuania [35]. Although the number of charging stations is relatively high, it should be noted that only 33 of them are ultra-fast charging [36].

In the CSRS, any registered user can find the nearest EV charging station at any time and learn its characteristics, availability, and charge price [37].

From 2 August 2021, stricter requirements for the public procurement of vehicles or services provided by vehicles were applied. Currently, contracting authorities and contracting entities must ensure that, when procuring vehicles or the services they provide, a defined proportion of the vehicles procured are environmentally friendly or that a specified proportion of the services offered are provided by environmentally friendly vehicles. Non-polluting vehicles of categories M1, N1, and M2 (up to 50 g/km CO2) must account for 60% of procurement transactions, and non-road vehicles of category M3 (powered by alternative fuels) must account for 80% [38].

As of 1 January 2022, 50% of the costs of connecting public and semi-public charging stations for electric vehicles to the electricity grid can be reimbursed [39]. From 8 June 2023, operators of pure M2, M3, N1, N2, and N3 electric vehicles do not have to pay road taxes for using highways [40].

Starting from January 1st, 2023, an economic unit can recover the VAT paid on a category M1 electric vehicle whose value, including VAT, does not exceed €50,000. This tax allowance does not apply to cars with internal combustion engines. [41].

While efforts to promote the use of electric cars are ongoing, they represent a small share of passenger vehicles in Lithuania. In 2023, out of the 123,943 passenger cars registered for the first time in Lithuania, only 4,147 were electric vehicles (3.35%). It should be noted that only 53.34% of the newly registered electric vehicles were new cars (2,212 units). Notably, the proportion of newly registered electric vehicles is slowly increasing compared to previous years. 0.26% of newly registered passenger cars were electric vehicles in 2019, 0.73% in 2020, 1.72% in 2021 and 2.14% in 2022 [42]. According to the data of REGITRA (entity registering vehicles in Lithuania), of 1 February 2024, a total of 20112 M1 and N1 class electric vehicles were registered in Lithuania, including 12185 BEVs and 7927 PHEVs. There were also 68942 hybrid M1 and N1 vehicles [43].

The policy document *Lithuania's vision for the future, "Lithuania 2050",* states that Lithuania in 2050 will have a "sustainable economy that is climate-neutral, resilient to

adverse changes in climate change, is based on the restoration of natural ecosystems, balanced growth and moderation." [44]

Another policy document, the *National Agenda for Management of Climate Change*, shows the State's aims to reduce the emission of greenhouse gasses by at least 14 per cent compared with 2005 [45]. To achieve this, national policy documents foresee the following milestones:

- At least 20% of the light-duty vehicle fleet will be electric and clean vehicles, and all necessary charging and refuelling infrastructure will be established by 2030 [45] - [46]; the number of electric vehicles will be at least 118,000 [47];
- At least 10% of annual purchases of class M1 and 30% of annual purchases of class N1 will be electric vehicles by 2025; at least 50% of annual purchases of class M1 and 100% of annual purchases of class N1 will be electric vehicles by 2030 [45]; Budget for partial compensation of vehicle price for the period of 2022-2026 is 129 million Eur [48]
- Since 1 January 2030, vehicles of class N1 with internal combustion engines, except vehicles of class N1 powered by alternative fuels, shall not be registered [45];
- By 31 December 2030, 100% of M1, M2, M3, and N1 road vehicles and 16% of N2 and N3 road vehicles purchased through public procurement will be environmentally friendly [45];
- At least 60 000 charging stations for electric vehicles are established [45]; by 2030, 46 million Eur budget for partial compensation for the acquisition or installation of 54 000 private charging stations and 74 million Eur for the acquisition/installation of 6000 public and semi-public charging stations [48];
- From 2023, all petrol stations, bus and train stations, airports and seaports under construction or reconstruction must have at least one public charging station of fast or ultra-fast charging [45];
- 50% reduction of fossil fuels in road transport by 2035 (measures to increase energy efficiency, the use of renewable energy sources and alternative fuels) [45];
- 15% share of RES in the total final energy consumption of the transport sector by 2030 (measures for developing the charging network for electric vehicles and the refuelling infrastructure for alternative fuels) [49];
- By 2035, passenger transport and logistics services in cities will be provided only by environmentally friendly vehicles [45];
- Vehicle charging and refuelling infrastructure is consistently expanding in line with the increasing number of clean vehicles [45];
- No fossil fuels in road transport by 2045 [45];
- Prepared and adopted the plan for public and semi-public charging stations for electric vehicles on local roads by 2030 [45].

The analysis of Lithuanian policy and legal regulation regarding electric vehicles indicates insufficient and unsuitable infrastructure and inadequate policies and laws that fail to ensure social justice.

Speaking about insufficient and unsuitable infrastructure, it can be noted that the charging station network hinders the entry of cheap electric cars into the Lithuanian market. Research shows that more affordable electric vehicles, after fully charging the battery, travel 230 kilometres in summer and up to 200 kilometres in winter. Such mileage is insufficient for the movement of people in Lithuania. The round-trip distances between major cities are 280-500 kilometres. It is evident that electric cars with such a range need to be charged on the way. Currently, there are only a few ultra-fast charging stations in Lithuania where you can charge an electric car in half an hour, while in other places, it takes 6-9 hours to charge the car fully.

Relatively cheap, low-mileage electric cars are too small for a family ride and do not fit tall people. Such electric vehicles are suitable for driving only within the limits of one city. As a result, a person must also purchase a non-electric vehicle to drive between cities. In Lithuania, people with average or lower incomes buy one car, usually used, suitable for driving both in the city and between cities.

The Lithuanian electricity network and the amount of electricity that can be produced limit the development of the network of charging stations for electric cars. If the environmental protection goals were implemented only by expanding the fleet of electric vehicles and, accordingly, their charging network, the capacity of the current electric network would not be sufficient.

To achieve the goals of the Green Deal, the increase in the number of electric cars is justified to the extent that it is possible to produce electricity from renewable sources. Otherwise, the benefits of using electric vehicles may be lost due to the environmentally unfriendly method of producing electricity.

Furthermore, there are problems with the social justice aspect of electric vehicles. In Lithuania, the existing charging station network, in essence, is only suitable for owners of more luxurious cars that travel longer distances. The base price of such vehicles in the market starts from 40 thousand euros. In Lithuania, the disposable income of one household in 2022 amounted to an average of 1,504 EUR per month, and the disposable income per household member was 751 EUR per month [50]. A person with an average income will not buy such a car. A new electric vehicle is a luxury item that only people with higher incomes can afford.

Some charging stations for electric vehicles are free, especially those built with project funds. These are usually part of urban or state infrastructure. It is clear that all taxpayers, including those with lower incomes, pay for the electricity used to charge the electric cars of the wealthier people.

Finally, the analysis of the situation shows that all benefits (car movement lanes for electric cars, free parking, compensation for the purchase of a vehicle, free charging) are, in essence, support the rich in society at the expense of all taxpayers.

## IV. CONCLUSIONS

Electric vehicles have been around since the late 19th century. An electric vehicle uses a motor powered by a stored electrical source, usually a battery. There are five main categories of electric cars: Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), Non-rechargeable Hybrid Electric Vehicles (HEVs), Range-extended Electric Vehicles (REEVs), and Fuel Cell Electric Vehicles (FCEVs). The key difference between electric and fossil fuel-powered vehicles is how potential (stored) energy is converted into kinetic (motion) energy. In electric vehicles, energy is stored chemically in batteries and then released through chemical reactions in the motor.

The European Green Deal, released at the end of 2019, is the EU's most significant effort to achieve climate neutrality. The European Commission proposal of September 2020 (55% emission reduction in 2030 compared to 1990) and the European Parliament proposal that followed soon after (−60%) have changed ambitions on greenhouse gas reduction. The European Green Deal serves as a comprehensive framework and strategic blueprint delineating the course of action for the EU in its pursuit of climate neutrality. It emphasises the indispensable contribution of all EU actions and policies towards this overarching objective while providing directives for both legislative and non-legislative measures to facilitate the attainment of this goal.

Speaking about Lithuanian policy in the field of electric vehicles, the national agenda for the management of climate change aims to reduce the emission of greenhouse gasses by at least 14 per cent compared with 2005. To reach these aims, the national policy documents foresee a number of measures regarding electric vehicles. The analysis of Lithuanian policy and legal regulation regarding electric cars shows insufficient and unsuitable infrastructure. The policy and law do not ensure social justice. The charging stations network hinders the entry of cheap electric cars into the Lithuanian market. The Lithuanian electricity network and the amount of electricity that can be produced limit the development of the network of charging stations for electric cars.

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