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An Assessment of the Energy Efficiency of Diesel and Electric Cars for Sustainable Urban Logistics

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Abstract

Transport decarbonization and electrification are the current concepts of sustainable logistics. The European Green Deal aims to remove internal combustion engine vehicles from the roads and make the continent climate neutral by 2050. However, there is much debate about the means to achieve this goal and the rivalry between diesel and electric vehicles. This article aims to analyze the impact of the energy efficiency of diesel and electric vehicles on the sustainability of urban logistics and the benefits for the average transport user—the driver. The study uses scientific literature, statistical, comparative, SWOT analysis methods, and experimental research methods. In addition, a qualitative study was conducted with the help of experts, and the problematic relationships between diesel and electric vehicles were analyzed. The results of the study showed that even an old diesel vehicle is not inferior to a new electric vehicle in terms of energy efficiency and operation for the average user but does not meet the theoretical sustainability standards for urban logistics. Therefore, broader apolitical discussion and practical experiments are needed to ensure that the results of future research are unbiased.

Keywords: sustainability; transport; urban logistics; diesel cars; electric cars

1. Introduction

Traditionally, the transport sector contributes significantly to global greenhouse gas (GHG) emissions. Transitioning from gasoline-powered to electric vehicles is the most practical way to decarbonize the sector [1]. Replacing fossil fuels is a fundamental step to reducing emissions in the transportation sector; this approach, favored by policymakers in developed countries, is to simultaneously shift towards greener sources of electricity generation while promoting adoption of electric vehicles in an attempt to reduce their cost [2]. The European Green Deal and the Paris Agreement have established a strict plan for the automotive industry that will significantly affect transport companies and car owners. Under these agreements, EU countries have committed to ensuring climate neutrality by 2050 [3,4]. Although the initial aim was to ban the sale of new vehicles with internal combustion engines (ICE) by 2035, at the end of 2025, the European Parliament replaced this strict requirement with a more flexible 90% emission reduction target [5]. This technology-neutral compromise was designed to protect the competitiveness of European manufacturers while considering the slower-than-expected uptake of electric vehicles (EVs) and the current lack of charging infrastructure. However, this shift must also be understood within the broader global policy landscape. Governments worldwide, representing both

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developing and developed economies, are promoting vehicle electrification not only to address environmental concerns but to secure or expand their strategic position in the global automotive value chain. The transition to net-zero transport is as much about industrial dominance and control over battery technologies as it is about climate targets. Therefore, emerging developments and the puzzles they present create a complex environment where industrial competition may overshadow local operational practicalities [6]. This shift aligns with recent arguments that a rigid focus on a single technology may sideline decades of engineering excellence and weaken industrial resilience; instead, a multi-technology framework—including advanced internal combustion engines and e-fuels—is increasingly seen as a more "achievable path to net zero" [7]. Despite these policy shifts, the transportation sector has proven to be particularly difficult territory for the advancement of sustainable development. While the European Union accelerates toward an electric future, its roads remain a petrol and diesel fortress where internal combustion engines still account for over 91% of the total vehicle fleet. Scholars have noted that this persistence is often a result of "path dependency", where established fossil-fuel infrastructures and existing business models create high institutional barriers that slow the integration of alternative powertrains [8]. Most academic and policy discussions focus on the binary rivalry between diesel and electric vehicles, often relying on theoretical manufacturer data for EVs. However, there is a lack of empirical research comparing the long-term operational status and actual efficiency of high-mileage traditional vehicles against modern electric alternatives under real-world conditions.

While most academic and policy discussions rely on theoretical manufacturer data and standardized laboratory tests to promote EV adoption, there is a significant research gap regarding the empirical, real-world comparison between the long-term operational efficiency of high-mileage traditional vehicles and modern electric alternatives. Current Life Cycle Assessment (LCA) literature warns that the transition to EVs often involves a "delocalization of impacts", shifting environmental burdens from the vehicle's use phase to the raw material extraction and manufacturing stages [9]. There is a lack of data-driven insights that account for the extreme longevity of older diesel engines versus the "front-loaded" carbon debt and market-sensitive charging costs of new EVs under actual urban driving conditions. As empirical evidence on real-world logistics remains limited, there is an urgent need to investigate the "systemic conditions" and economic viability that shape adoption beyond just tailpipe emissions [10].

This study aims to fill this gap by conducting a year-long physical experiment that analyzes the impact of energy efficiency on the sustainability of urban logistics and the tangible benefits for the average transport user. By using a high-mileage diesel vehicle as an empirical baseline, the research evaluates whether electrification offers a genuine step-change in urban sustainability or merely shifts the environmental and economic burden elsewhere. To achieve these objectives, the study provides a multi-methodological approach, integrating a scientific literature review, a SWOT analysis, and qualitative research based on transport experts' opinions. By conducting a year-long physical experiment comparing an old diesel vehicle with the stated data of a modern EV, this research provides an empirical basis for assessing the critical dilemma of vehicle longevity versus immediate emissions. Ultimately, this study contributes data-driven insights to help balance decarbonization goals with the practical requirements of vehicle reliability and operational reality in urban logistics.

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2. Literature Review: Theoretical Perspectives on Sustainable Urban Mobility

Urban logistics can be viewed in comparison to freight and passenger transport, which makes up the other main component of urban transport and is mainly comprising private vehicles, public transport, and shared mobility transport [11]. Zhang et al. [12] mentioned that public transport and sustainable development are closely linked as it effectively reduces urban traffic congestion, emissions, energy consumption, and environmental pollution. Public transport is more environmentally friendly than private vehicles due to several advantages, including higher energy efficiency, lower emissions, and reduced use of road resources. Martin [13] noted that the key trends in urban transport during the last few years have been an overall growth in transport demand and a growth in the modal share of private vehicles. Okeke et al. [14] reflected that the invention of the mass-produced automobile was a breakthrough in mobility and comfort; the modern consequences of its heavy use have led to a dramatic increase in accident death rates, the use of fossil fuels, social isolation, community disconnection, obesity, environmental pollution, urban sprawl and urban decay. Of course, walking, cycling and public transport travel are generally slower than driving; therefore, they provide less mobility. This suggests that the key to solving urban transportation problems is to improve accessibility in ways that do not increase motor vehicle travel [15].

Table 1 presents which solutions were proposed by the scientists for sustainable mobility.

Table 1. Proposed solutions.

Authors	Solutions for Sustainable Mobility
Alpine Convention Working Group Transport [16]	Public transport operated by local volunteers and non-profit organizations to serve residential needs.
Technology Foresight Center [17]	Solutions include the development of Level 4 and 5 autonomous vehicles, smarter multimodal public transportation, and personal micro-mobility devices.
UN-Habitat [18]	Avoiding unnecessary travel through compact land-use planning, shifting transport to more sustainable modes like public transit and cycling, and improving vehicle and fuel technology.
Freudendal-Pedersen et al. [19]	Sustainable mobility requires a systemic shift, like simply replacing gas cars with electric ones, toward a transformation of mobility cultures.
Transformative Urban Mobility [20]	Solutions include the development of Bus Rapid Transit (BRT) systems, improving minibus management, and implementing integrated corridor management to optimize existing transit routes.
Defranceschi, P. [21]	Sustainable Mobility Solutions focuses on using public procurement as a strategic tool to drive the transition toward a cleaner and more efficient urban mobility culture.
Gulc, A., Budna, K. [22]	There are three ways to move forward: Electro-mobility (switching to EVs), Collective Transport 2.0 (modernizing shared and public transit), and Low-mobility Societies (reorganizing cities to reduce the actual need for travel).
Majewski, J. [23]	Author advocates for a "15-min city" model and high-efficiency rail to reduce car dependency and travel demand. It emphasizes integrating zero-emission infrastructure with AI-driven smart systems and strategic spatial planning to achieve sustainable urban mobility.
Szpilko et al. [24]	"Mobility as a Service" (MaaS) approach, which integrates various transport modes into a single, demand-driven digital platform. Prioritizing pedestrians and cyclists over private vehicles.

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Urban transport systems are changing with population growth, sharing services replacing the need to own a private vehicle as a necessity to move to reach a certain destination [25]. Yet the transportation sector has proven to be particularly difficult territory for the advancement of sustainable development policy [26]. Despite efforts across Europe to increase the share of vehicles with low emissions, the share of passenger vehicles powered by alternative fuels remained low in 2024 in most EU countries [27]. This persistence is often linked to localized economic conditions; as scientists note, the acceptance of sustainable mobility lags in regions with lower economic levels because drivers are significantly more sensitive to income and operational risks when adopting new technologies [28]. While the European Union is accelerating toward an electric future, its current roads remain a petrol and diesel fortress where internal combustion engines still account for over 91% of the total vehicle fleet—with petrol leading at 50.6% and diesel at 40.8% [29]. Due to the emission of harmful compounds into the atmosphere, the authorities of the European Union are implementing projects aimed at reducing the number of passenger vehicles, especially those with internal combustion engines, in favor of public transport, electric vehicles or plug-ins. They are, to some extent, related to urban logistics [30]. Improving public transport is essential to get citizens to switch to lower emission transportation modes and provide an alternative form of mobility. The increasing uptake of shared mobility in urban areas will also play a significant role in the transformation of public transport [31]. Furthermore, road travel in urban areas often takes place on congested roadways at low average speeds, leading to greater fuel consumption and emissions per kilometer traveled, relative to optimal conditions [32]. Environmental protection goals will favor electric vehicles, which are crucial to break the dependence of the European transportation sector on fossil fuels and reduce greenhouse gas emissions [33]. Continuing to electrify passenger vehicles is thus a key pillar for achieving sustainability in the transport sector [34]. While the transition to electric mobility has been encouraged by increasing EV attractiveness, governments are imposing aggressive policies thus banning sales of passenger vehicles with internal combustion engines, pricing CO_2 emissions, and applying fuel taxes, although tax levels differ significantly between countries [35–38]. It is said that pricing private vehicles correctly and their use is paramount to building sustainable, safe, and equitable transportation systems [39]. However, fuel prices target driving itself, rather than the decision of whether to buy a vehicle [40]. Some cities have applied the European Union Urban Vehicle Access Regulations, implementing the Low-Emission Zones (LEZs) to reduce polluting vehicles in urban areas, hence creating a transition towards sustainable mobility [41]. This policy does not discourage driving itself and could even contribute to traffic congestion. However, it does represent a shift toward travel that is more environmentally friendly than travel by conventional fossil-fuel vehicles [42]. Public policies are increasingly promoting the use of public transport and soft modes. They impose restrictions on the public space dedicated to private vehicles to liberate space for more sustainable modes [43]. But the main question remains—is it a good strategy to aggressively ban vehicles with internal combustion engines in urban areas to achieve sustainability [44]? Recent research highlights that the success of such strategies depends on the 'willingness to participate' among driver groups, whose environmental awareness is frequently mediated by immediate economic survival and the 'front-loaded' costs of electric vehicle adoption [28]. Diesel engines have been framed as "undesirable" due to local air pollution but simultaneously as "desirable" and "effective" in combating global climate change when compared to gasoline engines [45]. Since sustainable urban development is envisioned without fossil fuels, especially diesel, it could be replaced in the future by renewable diesel which is a sustainable biofuel that could be used in the same combustion engines that operate with fossil diesel without modifications [46,47]. The internal combustion engine (ICE)—whether fitted alone or as a part of a hybrid system—will remain a significant component of transportation and power also globally relevant well into the 2030s [48,49].

3. Methodology

This study employs a sequential four-stage analytical framework. First, the systematic literature review identifies the conflict between high-level decarbonization mandates and the technical limitations of current infrastructure. This stage defines the parameters for the subsequent analysis. Utilizing the themes identified in the literature, the SWOT analysis organizes the operational strengths and systemic threats of both ICE and EV platforms. This step serves to translate theoretical gaps into specific strategic trade-offs. To ensure the SWOT factors reflect current industry realities, transport experts and engineers provide qualitative validation. Their input refines the focus of the study toward the most critical real-world variables, such as vehicle longevity and maintenance reliability. This helps to gather non-numerical data to produce insights [50]. Qualitative research helps gain a complex and rich understanding of a specific context or phenomenon [51]. The participation of experts is essential to ensure methodological rigor, credibility, and reflexivity [52]. An individual expert evaluation is performed by one expert without consulting the other members of the expert commission [53]. Furthermore, the physical experiment acts as the ultimate objective test. It provides the high-resolution empirical data needed to verify whether the strategic trade-offs identified in the previous steps hold true under rigorous, year-long operational conditions. It highlights records throughout the entire year, which provide the empirical data necessary to quantify CO_2 emissions and economic costs. Experimental research serves as a predictive and objective tool to assess hypotheses and determine cause-and-effect relationships [54]. Lastly, the prediction method was used for the diesel price forecast according to scenarios. Prediction is the practice of employing scientific methods and resources to logically infer the development trend of things based on historical data and the current state of objective things [55]. Collectively, this approach ensures that the study's conclusions are not merely theoretical but are calibrated by professional expertise and anchored in objective physical evidence.

4. Qualitative Study of Diesel and Electric Vehicles Based on Expert Opinions and SWOT Analysis

Before consulting a group of experts, it is necessary to examine the strengths, weaknesses, threats, and opportunities of diesel and electric vehicles by performing a SWOT analysis shown in Table 2. SWOT analysis is a technique that has gained widespread recognition in the area of strategic planning and decision-making due to its straightforward yet effective nature.

The SWOT analysis table compares the strategic positions of electric and diesel vehicles, indicating that although electric vehicles provide enhanced energy efficiency and reduced operating costs, they face challenges due to high acquisition costs and infrastructure limitations. On the other hand, diesel engines continue to be the norm for heavy towing and long-distance transportation because of their quick refueling and established dependability in harsh environments, but they encounter major challenges from increasing taxes, looming sales prohibitions, and decreasing resale prices in city regions. Electric vehicle prospects are linked to innovations such as solid-state batteries and regulatory zero-emission requirements, while diesel's future hinges on the potential of biodiesel and synthetic fuels to lower its carbon impact without needing engine alterations. In conclusion, the table shows a shift where diesel's conventional mechanical advantages are increasingly confronted by the efficiency and developing infrastructure of electric options.

Table 2. SWOT analysis.

Category	Electric Vehicle	Diesel Vehicle
Strenghts	• Energy efficiency (up to 85%) • Low running costs 2.50–8.75 Eur./km • High reliability (~20 moving parts)	• Superior for long-haul (1000+ km) and heavy towing • Fast 5 min refueling (40–50 L/min) • Proven reliability in extreme climates
Weaknesses	• Higher purchase price (20–40%) • Shorter range, longer recharge • Winter range loss (up to 30%)	• Fragile Euro 7 emission systems (DPF/AdBlue) • Inefficient in city traffic (30–50%) compared to highway • High maintenance costs as parts age
Opportunities	• Rapidly expanding LCV hubs • Solid-state battery programs • Zero-emission zone mandates	• Biodiesel can reduce CO_2 by 90% without engine changes • Life extension through synthetic fuels (e-fuels)
Threats	• Public charging bottlenecks • Rising electricity costs • Potential raw material shortages (Lithium/Cobalt)	• Rising diesel taxes and 2030/35 sale bans • Risk as resale values in cities plummet

With these results in mind, we are able to continue with a qualitative study by questioning the experts. Since we relied on an extensive experience-based method, we selected the four experts with the highest qualifications and the longest professional experience among all potential candidates. Two of these experts are professors at Vilnius Gediminas Technical University with extensive academic experience, while the other two are lecturers at Klaipeda University of Applied Sciences with more than 30 years of practical work experience. The expert selection approach assumes all contributors offer equally valuable insights, providing a neutral baseline. Conversely, the experience-based model prioritizes those with deeper expertise, acknowledging that seasoned perspectives often provide a more nuanced understanding of critical research issues [56]. Those experts were given ten statements to evaluate them by assigning “diesel” or “electric” to show superiority in the given situation. The statements and assignations are given in Table 3. It should be noted that although a group of four experts is small, it is not uncommon in the scientific literature. A small group of three to five experts is generally considered sufficient and good for an expert evaluation and also, a minimum of three experts is the standard to ensure a balanced perspective and to ensure a consensus or a clear majority in judgment [57–60]. This size is manageable for qualitative feedback while still providing enough variance to catch major errors [61]. It is also stated that a minimum of three experts is sufficient, but if you use five or fewer, there must be 100% agreement among them to consider an item valid [62]. Adding more evaluators beyond five provides diminishing returns [63].

The table presents a comparative analysis between diesel and electric vehicles across ten performance and lifestyle criteria, revealing a strong consensus favoring diesel for long-term utility and a split perspective on environmental and economic factors. While all four experts unanimously agree that diesel is superior for reliability, range, practicality, and secondhand market value, they are divided on modern concerns like sustainability and maintenance costs. Expert C emerges as the primary advocate for electric vehicles, particularly for urban and suburban living, whereas Expert B and Expert D maintain a heavy preference for diesel across nearly every metric. Ultimately, the data suggests that

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while electric is recognized for its efficiency and eco-friendliness by most, diesel is still viewed by these experts as the more dependable and "work-ready" technology.

Table 3. Experts' evaluation.

Statement	Expert A	Expert B	Expert C	Expert D
Much more reliable to work with	Diesel	Diesel	Diesel	Diesel
Eco friendly and sustainable	Electric	Diesel	Electric	Electric
Efficient and economic	Electric	Electric	Electric	Diesel
Easy and cheap to maintain	Electric	Diesel	Electric	Diesel
Owning living in the city	Diesel	Diesel	Electric	Diesel
Owning living in the suburbs	Electric	Diesel	Electric	Diesel
Range and practicality	Diesel	Diesel	Diesel	Diesel
Easy to recharge/refuel	Diesel	Diesel	Electric	Diesel
Secondhand market reliability	Diesel	Diesel	Diesel	Diesel
Longer lifespan	Diesel	Diesel	Electric	Diesel

5. Experimental Study of Diesel Vehicle Efficiency and Sustainability and Results

The following experiment was carried out to provide an empirical basis for comparing the long-term sustainability of traditional internal combustion vehicles against modern electric alternatives. A personal diesel vehicle and the latest electric vehicle were used for the experiment, which was conducted to monitor fuel consumption, refueling, and costs, but driving characteristics, vehicle load, and route types were not recorded, so their impact on fuel consumption and emissions was not investigated, which would be a good basis for future research. Since there were no conditions or means to conduct an actual experiment with an electric vehicle that would be analogous to the experiment conducted with a diesel vehicle, the official specifications of the electric vehicle manufacturer were relied upon, according to which calculations were performed and data was compared with the performance of a diesel vehicle. Both vehicles are equal not by their technical specifications but by their class, which is estate. During the experiment, the diesel vehicle operated for a year, monitoring its mileage and fuel consumption, while the data for the electric vehicle was obtained from the manufacturer. It should be noted that the difference in age between the vehicles is 28 years! These vehicles were specifically selected to evaluate extremes when comparing an old and supposedly polluting, uneconomical vehicle with the latest, environmentally friendly, and best-performing electric vehicle to find out whether the latest electric vehicle is more economical and cheaper than an old diesel vehicle. The technical data of the vehicles is presented in Table 4.

Table 4. Technical data.

Manufacturer, Model	Volvo V70	Volkswagen ID.7 Tourer
Year	1998	2026
Powertrain	2.5 L Inline-5 Turbo Diesel	Single Electric Motor 86 kWh
Power output	140 hp (103 kW)	286 hp (210 kW)
Range	1200 km	685 km
CO_2 emissions	~168 g/km	0 g/km
Projected lifespan	1,000,000+ km	~500,000 km

While the Volkswagen is much more powerful, has no CO_2 emissions, and is therefore categorized as non-polluting and environmentally friendly, the diesel vehicle being tested already has 1,500,000 km on the odometer—a mileage that is currently unattainable for any modern electric vehicle. It is worth mentioning that the power output figures in Table 4

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have a performance limit reached only at maximum RPM and wide-open throttle; therefore, for the standard work of transportation, both engines function as functional equals. This comparison highlights a critical dilemma: while sustainability policies aim to integrate unobserved environmental aspects into decision-making, the 1,000,000+ km projected lifespan of Volvo challenges modern EVs that may have shorter operational lives. Based on the parameters established in the research, the primary objectives for the experiment were:

- To monitor the actual mileage and fuel consumption of a high-mileage diesel vehicle over a full year to establish a baseline for urban sustainability.
- To calculate and compare the total operating expenses, including fuel prices and electricity costs, to determine which propulsion type is truly cheaper to operate in the current market.
- To quantify the actual CO_2 emissions of the diesel vehicle per year against the zero-tailpipe claims of the electric vehicle.
- To use the cost and performance data to determine if electric vehicles provide a sufficient step-change in financial and environmental efficiency to justify the sustainable transition in urban mobility.

Details of the conducted experiment are shown in Table 5.

Table 5. Diesel vehicle experiment.

Date	Expenses, Eur.	Average Diesel Price, Eur./L	Diesel Amount, L/per Fill-Up					Total Diesel, L
June 2023	110	1.27	55.16	31.52				86.68
July 2023	180	1.32	61.35	30.21	30.21	29.54		151.31
August 2023	180	1.47	54.64	40.71	27.32			122.67
September 2023	240	1.51	54.09	27.23	25.82	25.99	25.99	159.12
October 2023	180	1.52	38.86	27.04	52.15			118.05
November 2023	120	1.47	55.02	27.14				82.16
December 2023	180	1.45	40.71	13.52	55.98	14.00		124.21
January 2024	150	1.48	33.58	55.40	13.34			102.32
February 2024	240	1.55	52.15	26.42	50.35	25.66		154.58
March 2024	280	1.53	25.82	25.33	51.65	39.76	41.12	183.68
April 2024	220	1.49	26.68	39.37	26.77	54.64		147.46
May 2024	240	1.38	56.98	43.99	14.04	59.52		174.53
June 2024	200	1.38	29.87	42.89	14.50	13.90	44.64	145.80
Sum:	2520	Average: 1.45					Sum:	1752.57

As shown in Table 5, the experiment was conducted from June 2023 to June 2024. During that time, we made 48 stops at fuel stations, consuming 1752.57 L of diesel fuel, with an average annual diesel price of €1.45/L and annual fuel costs of €2520. Monthly data is shown in Figure 1. The vehicle's fuel tank capacity is 70 L, which is sufficient for a range of 1200 km. It should be noted that we filled up with diesel only from Neste fuel stations. While the total number of fuel station visits was 48, the monthly frequency varied significantly depending on the time of year: March 2024 saw the highest activity with five fill-ups totaling 183.68 L. September 2023 and June 2024 also reached five fill-ups each. June 2023 and November 2023 had the fewest stops, with only two fill-ups per month. Individual refueling volumes ranged from as little as 13.34 L (January 2024) to as much as 61.35 L (July 2023). Given the 70 L tank capacity, the 61.35 L fill-up suggests the tank was nearly empty at that time. The cost of maintaining the vehicle fluctuated alongside shifting diesel prices: The average diesel price peaked in February 2024 at €1.55/L, which contributed to one of the higher monthly expense totals of €240. The experiment began with the lowest recorded price of €1.27/L in June 2023 (see Figure 1). The highest monthly expenditure occurred in March 2024, totaling €280.

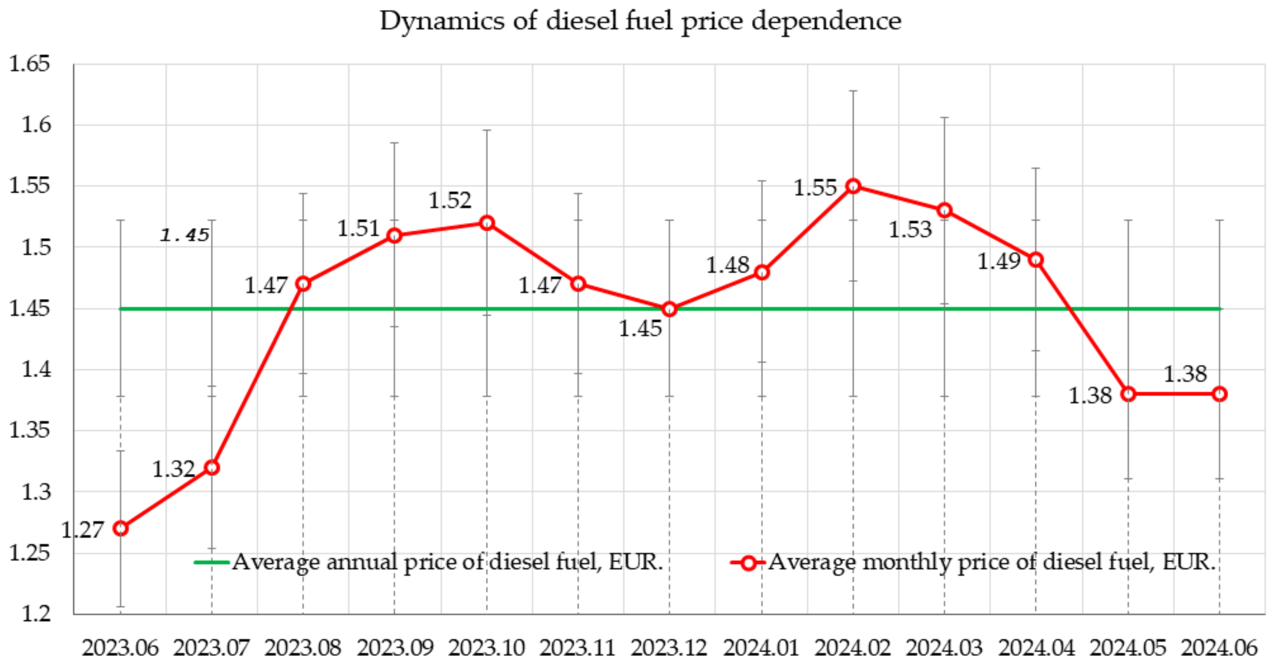

Figure 1. Dynamics of diesel fuel price dependence.

Beyond the provided sums, the data reveals that on average, the vehicle consumed approximately 134.81 L per month, resulting in a mean monthly cost of €193.85. The correlation between diesel consumption and costs is shown in Figure 2.

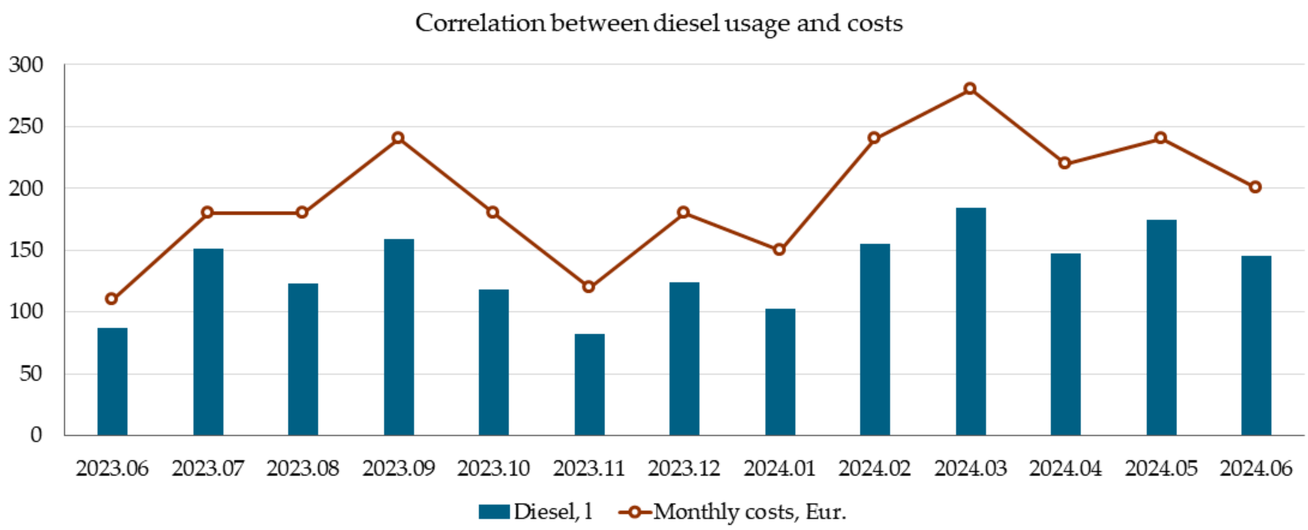

Figure 2. Correlation between diesel usage and costs.

While the initial study found an average diesel price of €1.45/L during the experimental period, the long-term economic outlook is heavily influenced by evolving legal and environmental frameworks. The following projections represent our prognosis for diesel prices through 2030, which we have developed based on current national and European institutional laws and regulations (see Figure 3). By analyzing these regulatory trends, we have established three distinct trajectories to forecast the potential financial burden on internal combustion engine users over the coming years.

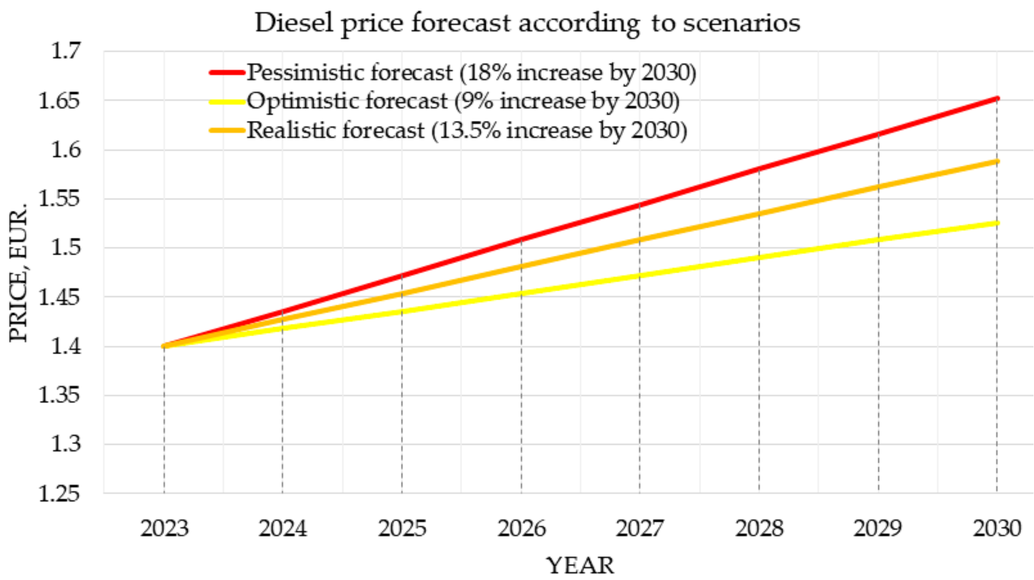

Figure 3. Diesel price forecast according to scenarios.

The diesel price forecast for 2023–2030 indicates a uniform upward trend in all scenarios examined, starting from a base value of €1.40. The study data show that fuel price dynamics are directly dependent on the economic model chosen: the pessimistic scenario predicts the highest increase of 18% (to €1.65), the realistic scenario predicts 13.5%, and the optimistic scenario predicts a more moderate increase of 9%. The gap between the extreme forecasts (9% and 18%) reaches a critical point in 2030, highlighting the risk of energy uncertainty and the need to diversify fuel sources in the transport sector in the long-term strategic perspective. Parallel to these economic pressures, the environmental impact of diesel consumption remains a critical metric for transport sustainability.

It is especially important to note that the year-long experiment conducted from June 2023 to June 2024 involved a diesel vehicle traveling a total distance of 28,100 km. Based on this data and on an emission factor of 168 g/km, it is possible to calculate the vehicle's annual CO_2 emissions:

$$28,100 \text{ km} \times 168 \text{ g/km} = 4,720,800 \text{ g}. \quad (1)$$

This equals 4.7 tons of CO_2. It takes approximately 225 mature trees a full year to absorb 4.7 tons of CO_2. The following graph illustrates the environmental footprint of the experiment by comparing the vehicle's usage to its chemical output. It visualizes the direct correlation between high-mileage utility and the cumulative volume of greenhouse gases released into the atmosphere (see Figure 4).

If our selected electric vehicle can drive up to 685 km with one charge, then it is possible to calculate how many times it would need a recharge (0–100%) to reach the same mileage as a diesel vehicle:

$$\frac{28,100}{685} = 41. \quad (2)$$

Since it would need to recharge 41 times, we must calculate the price for all recharges. It should be noted that electricity prices on the market change daily, so we cannot estimate and calculate how much it will cost to charge an electric vehicle in a month or a year. Therefore, for the purposes of the experiment, the average realistic price of electricity on the market was used. One of the most popular electricity providers is "Ignitis ON", which has some fast charging (HPC 150 kW) stations with an average price of 0.39€/kWh in Vilnius city. First, we must calculate the price for one recharge of an 86 kWh battery:

$$86 \text{ kWh} \times 0.39€/\text{kWh} = 33.54€ \text{ per charge.}$$

Second, we can calculate the price for all recharges:

$$€33.54 \times 41 = €1375.14.$$

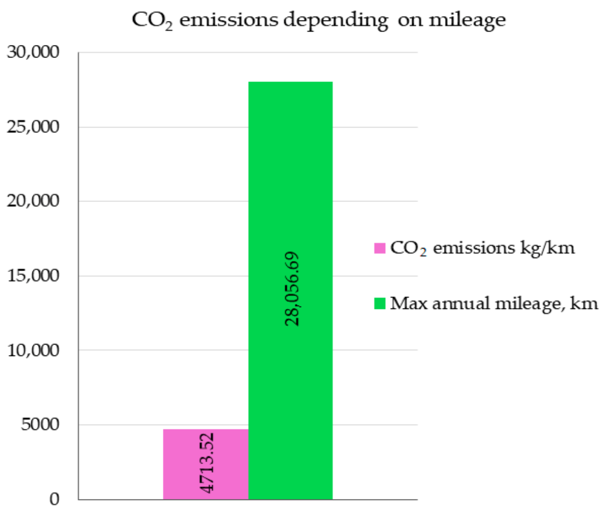

Figure 4. CO_2 emissions depending on mileage.

By these calculations, we can state that the electricity needed is €1144.86 cheaper than diesel to cover the distance. It is important to note that maintenance and battery wear are not included in the price of the operation, as this would be a variable cost in monetary terms. However, there are several significant force majeure factors. The diesel vehicle operated in a wide variety of conditions, including extreme ones, while the electric vehicle data was provided by the manufacturer based on tests conducted under ideal conditions. The price per kilowatt-hour was taken without considering changes in the electricity market and electricity supplier prices, where the price can reach €0.50/kWh, in which case a single vehicle charge would cost €70–80. The impact of weather conditions and battery fatigue, which would require more frequent charging of the electric vehicle, has not been considered. Furthermore, the weight being carried and the type of driving (urban or suburban), which would result in faster electricity consumption and more frequent charging of the electric vehicle, were not considered. The age of the vehicle does not affect the reliability of the findings, but the fact that we were unable to conduct the experiment with an electric vehicle under real conditions and had to rely on the manufacturer's technical data and specifications does affect the results regarding operational efficiency and sustainability.

The objectives of this experiment proved:

- The experiment proved that an older diesel engine can reliably cover high annual distances (28,100 km) while demonstrating mechanical longevity far exceeding current expectations for modern electric alternatives.
- The calculations showed that while the EV was theoretically €1144.86 cheaper over the year, this advantage remains vulnerable to extreme electricity price spikes and real-world efficiency losses not accounted for in manufacturer data.
- The experiment found the diesel vehicle produced 4.7 tons of CO_2—requiring roughly 225 trees to offset—while highlighting that the EV's true impact is often obscured by energy-heavy battery production and grid carbon intensity.

- The study concluded that while EVs offer clear green potential, the diesel vehicle's superior reliability and lower acquisition costs suggest a technology-neutral approach—incorporating renewable biofuels in existing engines—is a more practical path forward.

When evaluating operational emissions, the data shows a clear environmental advantage for the electric vehicle, which produces 0 g/km of CO_2 compared to the 4.7 tons of annual emissions from the diesel vehicle. However, when shifting the assessment to vehicle lifespan, the diesel vehicle exhibits a superior operational sustainability, with a projected life of 1,000,000+ km—double that of the modern electric alternative. Finally, the dimension of energy sourcing introduces a critical economic-operational trade-off; while the electric vehicle is theoretically €1144.86 cheaper to charge annually, this sustainability benefit is highly sensitive to energy market unpredictability, where electricity prices can increase charging costs by up to 50%. By analyzing these factors simultaneously yet distinctly, the research highlights that true urban sustainability requires balancing decarbonization and energy cost stability.

6. Discussion

The study addresses the scientific problem of the energy and economic efficiency gap between traditional high-mileage diesel vehicles and modern electric vehicles (EVs) within the context of sustainable urban logistics. Sustainability is a relevant and important topic that has a direct impact on the environment and society; therefore, its importance is widely recognized and is one of the major topics that are discussed all over the world. Sustainable urban mobility refers to the idea that cities should provide environmentally friendly transportation options to their citizens that do not harm the environment or cause poor social impacts, such as poor air quality [64]. Sustainability policies aim to integrate unobserved environmental and social aspects into decision-making, thereby transforming the cities [65]. Still, the transition towards a sustainable urban mobility system that is universally accessible and meets the basic mobility needs of all users requires a readjustment of the financial environment [66]. It is also said that sustainable mobility transformations are not just technical or engineering challenges; they are results of power arrangements [67]. It is also argued that sustainable mobility is achieved not just through "green technology", but through a holistic integration of urban design, public policy, and social engagement [68]. Higher public transport quality and better cycling facilities are important for improving sustainable urban mobility [69]. However, progress toward sustainable transport modes is slow and needs a step-change [70]. A truly sustainable urban system must address the symbiotic association between personal mobility and freight transportation as an integrated whole [71]. A sustainable mobility system does not necessarily aim to completely ban cars, but it does seek to impose some barriers to their excessive usage [72]. The future will be decided by whether human beings worldwide are able to organize their urban mobility in a sustainable fashion [73]. Researchers generally agree that sustainable urban mobility is a profound societal transformation that requires balancing environmental health with social equity. Moving beyond green technology, scholars emphasize that success depends on a holistic integration of urban design, public policy, and power dynamics, supported by a significant shift in financial priorities. While progress has been criticized as slow, the consensus points toward a system that integrates personal and freight transport, prioritizes high-quality transit and cycling, and focuses on reducing excessive car dependency rather than simple bans.

The findings of this research highlight a significant tension between aggressive European decarbonization policies and the practical operational realities of urban logistics, where internal combustion engines still comprise over 91% of the total vehicle fleet as of 2024. While qualitative expert evaluations and SWOT analysis favor electric vehicles (EVs) for their energy efficiency and green credentials, the experimental data challenges the narrative of immediate EV superiority. Specifically, the data demonstrates that while an electric vehicle appears theoretically €1144 cheaper to operate over 28,100 km, this advantage remains vulnerable to energy market unpredictability, where price spikes can increase charging costs by up to 50%. This highlights that sustainability is a multi-dimensional trade-off between immediate environmental goals and operational reliability. While the experimental data identifies the diesel vehicle's direct impact—4.7 tons of annual CO_2 emissions requiring approximately 225 trees to offset—a comprehensive assessment must consider the broader carbon context. The 'zero-emission' status of the electric vehicle (EV) is limited to the operational phase; however, its total sustainability is inextricably linked to the grid carbon intensity of the region where it is charged. In energy markets still reliant on fossil fuels for electricity generation, the CO_2 is not eliminated but merely shifted from the vehicle's tailpipe to the power plant's smokestack. Furthermore, a significant portion of an EV's carbon debt is 'front-loaded' during the energy-heavy manufacturing of batteries, which requires the extraction and processing of raw materials like lithium and cobalt. By contrast, the diesel vehicle's sustainability context is defined by its extreme mechanical longevity. With an odometer reading of 1,500,000 km, the test vehicle has effectively amortized its initial manufacturing carbon footprint over a period three times longer than the projected 500,000 km lifespan of modern EVs. This suggests that the CO_2 per kilometer of total vehicle life may be more competitive than direct operational comparisons imply. To provide a truly 'green' path for existing fleets, the context should shift toward renewable biofuels (HVO), which can utilize existing internal combustion architectures to achieve up to a 90% reduction in CO_2 without the environmental cost of manufacturing new battery-electric units.

While this study provides empirical insights into the efficiency of diesel and electric vehicles, several limitations should be noted. First, the experimental data is based on a single high-mileage diesel vehicle and manufacturer-specified data for electric vehicles; future research should include a larger fleet of various EV models to account for real-world battery degradation over time. Second, the geographical scope of the experiment was limited to specific urban environments, meaning results may vary in different climates or topographical conditions that affect battery performance and fuel consumption. Finally, while the study addresses energy sourcing, it does not include a full Life Cycle Assessment (LCA) covering the environmental impact of vehicle manufacturing and battery disposal, which are critical components of the overarching sustainability dimension.

A detailed analysis and experiment similar to our research, evaluating the actual parameters of electric vehicles, would help to make a more constructive comparison of the impact of the energy efficiency of diesel and electric vehicles on the sustainability of urban logistics. Such an evaluation would provide the empirical basis to move beyond the basic, theoretical 'green' label applied to electric vehicles and into the critical dilemma of whether they actually deliver superior sustainability in the unique context of urban logistics. While EVs do not have emissions, the fact is that their true impact has often been obscured by factors like grid carbon intensity, the energy-heavy manufacturing of batteries, and efficiency losses associated with an innumerable number of stop-and-go delivery cycles. Measuring actual energy consumption and operational performance via professional experiments against traditional diesel fleets would provide the required basis on which to deduce if electrification indeed offers a genuine step-change or just shifts the environmental burden elsewhere. Ultimately, such data-driven insights are crucial for making rational trade-offs between propulsion technology and urban design

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so that the transition to sustainable mobility is based on measurable reality rather than optimistic assumptions.

7. Conclusions

The literature analysis concludes that urban transport is at a turning point, struggling to balance green goals with the fact that over 91% of vehicles still run on gas or diesel. Making cities sustainable is about more than just switching fuel types; it requires a full shift toward electric vehicles, better public transit, and new fees for road use. While an all-electric future is the goal, the next decade will likely be a mix of new electric technology and older engines running on renewable fuels to help meet climate targets by the 2030s.

Qualitative research has shown that electric vehicles are now favored because of their efficiency and green credentials, even though diesel engines remain the preferred option because of their reliability, range, and cost of ownership. According to the SWOT analysis and expert opinion, there is a clear compromise: diesel vehicles are still the "work-ready" option, but there are increasing maintenance and regulatory risks. In contrast, electric vehicles provide a contemporary, affordable solution in urban settings, suggesting that diesel will eventually be replaced.

The study demonstrated the energy efficiency of electric vehicles in the context of sustainable mobility, which was supported by theoretical data. The experiment and calculations showed that, theoretically, it would be twice as cheap to travel the same distance in an electric vehicle as in a diesel vehicle over the course of a year. Since it is not possible to conduct a real test with an electric vehicle, the data was taken from the manufacturer. A similar experiment with a real electric vehicle would help to obtain more accurate data in the future. In this respect, it could be argued that an old diesel vehicle would not be more expensive, and might even be cheaper, than driving an electric vehicle.

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Abbreviations

The following abbreviations are used in this manuscript:

SWOT	Strengths and Weaknesses, Opportunities and Threats
EU	European Union
EV	electric vehicle
LEZ	Low-Emission Zone

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