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GREENING URBAN MOBILITY: EXAMINING THE ADOPTION OF ZERO-EMISSION PUBLIC TRANSPORT

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Abstract:

This study is based on a quantitative survey of a sample of Polish local government units (LGUs) and existing data for these entities. Cluster analysis identified two groups of municipalities - those that are less and more engaged in implementing actions for sustainable transportation. Subsequently, an econometric logit model allowed the analysis of factors influencing Polish LGUs' compliance with the Act on Electromobility and Alternative Fuels. This Act mandates a specific quota of zero-emission vehicles in municipal fleets. Our research identifies key determinants affecting LGUs' adherence to these environmental standards, focusing on financial capacity, infrastructural readiness, environmental and socio-economic factors relevant to adopting zero-emission public transportation. This research contributes to the global discourse on environmental compliance and urban transport policy, underlining the importance of understanding local nuances in implementing such initiatives. It provides crucial information for policymakers internationally, aiding in the development of more effective and tailored green transportation strategies that are sensitive to local contexts.

Keywords: *sustainable transportation, green public transport, zero-emission vehicles, environmental policy, municipal transportation*

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1. Introduction

The transport sector consumes around 26% of the world's energy and is one of the primary contributors to greenhouse gas emissions (GHG) (Batur et al., 2019). Transport was responsible for approximately 30% of the EU's final energy consumption in 2022 (Figure 1). Moreover, energy consumption in the transport sector increased by 27% between 1990 and 2022, while industry and agriculture had a downward trend. The transport sector is a significant consumer of final energy in most EU countries, for example, the share of transport in final energy consumption in Luxembourg was 51%, Malta – 43%, Spain – 42%, Slovenia and Cyprus – 41%, Lithuania – 39%, and Greece – 38%. In Poland, this sector accounted for 34% of the country's total final energy consumption in 2022 (Figure 1).

Consequently, analysing the different modes of transport in the EU, road transport is identified as the most significant energy user. Moreover, energy consumption in road transport is continuously increasing, and approximately 93% of the EU's transport energy needs are met by fossil fuels, primarily diesel and gasoline (European Commission, 2024; Ajanovic & Haas, 2021; Gonera et al., 2024). Biofuels or renewable electricity consumed by the transport sector were found to be moderately insignificant.

Since a substantial amount of energy consumed in the transportation sector is derived from fossil fuels, transportation generates over 32% of total GHG emissions in the EU (in million tonnes CO_2 equivalent) (Figure 2). The largest emissions come from Germany (19% of EU transport emissions), France (15%), Spain (11,5%), Italy (13%), and Poland (8%) (European Commission, 2024). In Poland, transport contributes 22% of the country's total CO_2 emissions (Figure 2).

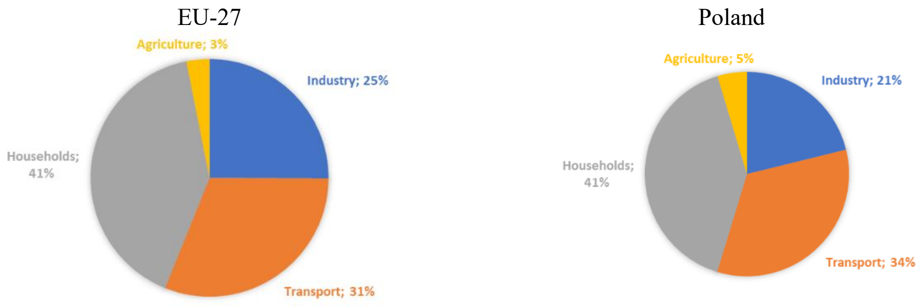

Fig. 1. Energy consumption by sector in the EU and Poland in 2022 (shares of total consumption in the EU and Poland, respectively). Source: (European Commission, 2024).

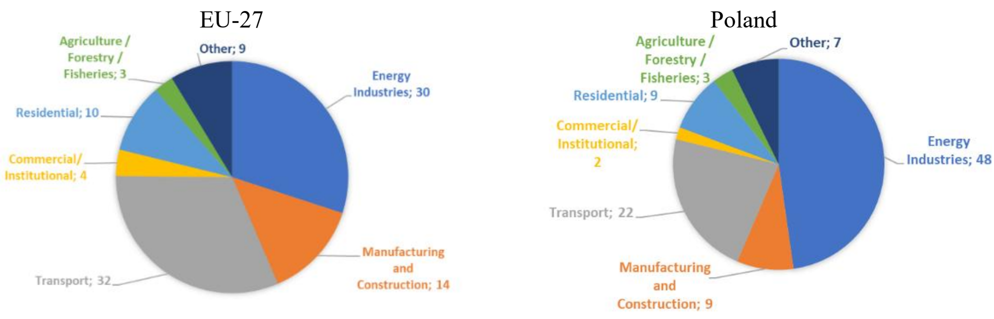

Fig. 2. Comparison of GHG emissions in different sectors in the EU and Poland in 2022 (shares of total emissions in the EU and Poland, respectively). Source: (European Commission, 2024).

In recent years, interest in renewable energy sources has grown, shifting from an initial focus on conventional biofuels such as bioethanol and biodiesel to the current emphasis on the electrification of transportation, supported by most EU policies (Ajanovic et al., 2021; Bezdek, 2019). Some authors focus on the use of electric vehicles in urban areas (Ajanovic, Siebenhofer, et al., 2021; H. Zhang et al., 2020) and conduct environmental assessments of mobility (Ajanovic & Haas, 2019; Xiong et al., 2020). Electromobility can contribute to a substantial reduction in GHG emissions. However, the environmental benefit depends on the primary energy sources used for electricity generation. Moreover, battery development and related energy prices are fundamental uncertainties for the future market development scenarios of electrified powertrains. The International Energy Agency has analysed several electric vehicle sales scenarios. Its findings indicate that the global electric vehicle stock across all transport modes will expand from over 11 million in 2020 to almost 145 million vehicles by 2030, an annual average growth rate of nearly 30%. In this scenario, the global electric bus fleet is projected to increase from 600,000 in 2020 to 3.6 million in 2030, reaching 10% market share (IEA, 2021). In Europe, the largest share of electric buses, motor coaches, and trolleybuses in the stock of all vehicles of the same type is held by the Netherlands, Luxembourg, Latvia, Sweden, and Denmark (Table 1).

Table 1. Share of zero-emission buses, motor coaches, and trolleybuses in vehicles of the same type (motor energy: electricity) 2013-2022

Countries	Share of zero-emission buses, motor coaches, and trolleybuses in the stock of all vehicles of the same type on December 31 (type of motor energy: electricity). Data in percentages			Share of new zero-emission buses, motor coaches, and trolleybuses in all new vehicles of the same type (motor energy: electricity). Data in percentages		
	2013	2018	2022	2013	2018	2022
EU-27	0.4	0.5	1.7	0.4	1.6	10.5
Belgium	0.0	0.1	0.7	0.0	1.3	7.1
Bulgaria	2.0	1.8	1.4	7.0	3.4	0.0
Czechia	2.8	0.4	0.7	0.1	15.7	3.4
Denmark	0.0	0.1	6.2	0.0	0.3	56.3
Germany	0.1	0.3	2.3	0.1	0.7	12.9
Estonia	2.0	0.0	0.0	0.0	0.0	0.0
Ireland	0.0	0.0	0.1	0.0	0.0	4.8
Greece	0.0	0.0	0.0	0.0	0.0	0.4
Spain	0.1	0.2	0.7	0.0	0.6	5.8
France	0.3	0.5	2.2	0.4	1.4	12.7
Croatia	0.0	0.1	0.1	0.0	0.0	1.8
Italy	0.5	0.5	0.8	0.0	1.3	3.0
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0
Latvia	0.0	5.3	6.9	0.0	3.4	7.6
Lithuania	3.5	5.5	5.9	0.0	1.8	38.4
Luxembourg	0.2	1.4	12.7	0.0	8.3	45.8
Hungary	0.0	0.1	0.7	0.2	0.1	5.7
Malta	0.0	0.4	0.5	0.0	0.0	2.1
Netherlands	0.7	4.0	16.3	3.2	18.3	40.1
Austria	1.5	1.5	1.9	2.1	1.5	2.8
Poland	0.0	0.6	1.0	0.9	0.7	3.8
Portugal	0.1	0.2	1.1	0.0	4.2	0.2
Romania	0.0	0.0	0.8	0.0	0.8	20.2
Slovenia	0.0	0.1	0.4	0.0	1.1	2.0
Slovakia	2.8	0.3	0.5	0.0	5.1	0.2
Finland	0.0	0.1	2.8	0.0	0.2	66.9
Sweden	0.1	0.7	6.4	0.2	4.7	20.6

Source: Eurostat, 2023.

Most of the electrification is limited to urban buses. There is less electrification of intercity buses, which have longer routes and require longer charging times. In 2022, in the EU, the share of new electric buses, motor coaches, and trolleybuses in all new vehicles of the same type was 11%. The leaders in this aspect were Finland, Denmark and Luxembourg. In Poland, the share of zero-emission buses, motor coaches, and trolleybuses in all new vehicles was 4% (Table 1).

Despite the increasing global emphasis on sustainable transportation, there is still a limited understanding of how local government units (LGUs) in transitioning economies respond to environmental legislation. Existing research has predominantly examined the technological aspects or environmental outcomes of zero-emission vehicle adoption, while giving considerably less attention to the interplay of financial, socio-economic, infrastructural, and environmental factors that shape compliance at the municipal level. Moreover, previous studies have rarely employed integrative methods such as cluster analysis to explain differences in local governments' capacity to meet statutory requirements. This underexplored dimension is particularly evident in the context of the Polish Act on Electromobility and Alternative Fuels[1] (Electromobility Act) of 2018, where a comprehensive understanding of these multifaceted influences on LGUs' decision-making and implementation strategies is currently lacking.

Until recently, the provisions of the Act required municipalities and counties with a population exceeding 50,000 to ensure that, as of January 1, 2028, at least 30% of the public transport fleet operating in their jurisdiction consisted of zero-emission or biomethane-powered buses[2]. However, meeting this requirement proved challenging for local governments. A 2022 report by Bank Gospodarstwa Krajowego (BGK) indicated that only 31% of the obligated municipalities would be capable of achieving this target. Similar conclusions were drawn by the Ministry of Climate and Environment, which found that as of 2022, only 6% of the obligated local governments had already met the threshold set for 2028[3]. Consequently, the amendment to the Act, adopted on November 21 2024, introduced more flexible conditions, differentiating between municipalities based on population size. The revised regulation eliminates the 30% threshold, replacing it with a more flexible requirement that municipalities with a population exceeding 50,000 must "at least partially" incorporate zero-emission or biomethane-powered buses into their public transport systems. Additionally, municipalities with a population exceeding 100,000 are now required to procure only zero-emission buses for public transport services within their jurisdiction. Due to the *vacatio legis* period, these amendments will enter into force from January 1, 2026. It means that, at the time of the study, the previous, more strict version of the Act was in force; therefore, it is this version that is considered in the evaluation of local governments' investment plans.

This article aims to fill the research gap by applying an econometric logit model to analyse the diverse factors influencing Polish LGUs' compliance with the Electromobility Act, including financial capacity, environmental pressure, infrastructural readiness, and socio-economic characteristics. Complementing this, the study employs a k-means clustering approach to classify municipalities according to their engagement in sustainable transport, providing a multidimensional perspective on local readiness and commitment.

In methodological terms, clustering techniques have proved particularly useful for identifying patterns in sustainable transport and mobility behaviour. Previous studies have grouped counties or regions according to their transport profiles, revealing how urbanisation levels shape priorities for zero-emission mobility (Shiau, 2013), or have segmented European countries by their progress in electromobility to highlight clusters with comparable infrastructural maturity and policy frameworks (Ziółko et al., 2025). Other applications include density-based clustering of GPS trajectories to capture recurrent travel patterns (Zhang et al., 2021) and grouping of public transport users from smart-card data to

[1] Particular obligations are stipulated in Article 36 of the Act of January 11, 2018, on Electromobility and Alternative Fuels.

[2] Although the Act on Electromobility and Alternative Fuels also permits the use of biomethane-powered buses, such solutions are not yet widely adopted in Poland. Recent data indicate that the biomethane market in Poland is significantly underdeveloped. Therefore, the rest of the article refers only to the electric fleet of vehicles used in local governments. Access online on 10th June, 2024 at address: https://www.teraz-srodowisko.pl/aktualnosci/rozwoj-biometanu-w-polsce-i-na-zachodzie-14775.html.

[3] Access online on 17th December, 2023 at: https://elektromobilni.pl/autobusy-elektryczne-na-zakrecie/.

uncover heterogeneous travel demand (Fulman et al., 2023; Rafiq & McNally, 2021). Despite their versatility in uncovering operational and spatial heterogeneity, clustering methods have rarely been applied to explain institutional compliance with environmental legislation.

Alongside clustering, regression models - particularly discrete choice and logit frameworks - have been used to identify the determinants of low-emission transport uptake. Studies of electric bus adoption in Asian cities confirmed the role of perceived cost, convenience, and environmental awareness (Prasetio et al., 2019; Sunitiyoso et al., 2022), while other research has emphasised that city size, financial conditions, and regulatory frameworks are decisive predictors of municipal engagement in electromobility (Wang et al., 2022). Building on these insights, our study contributes by integrating clustering and econometric modelling to capture both the structural diversity of municipalities and the determinants of their compliance with statutory zero-emission fleet requirements.

The study's broader aim is to contribute to the global discourse on environmental compliance and urban transport policy, emphasising the critical need for policies cognizant of local specificities and challenges. By filling this gap, the paper extends existing research that has primarily focused on the technological or environmental dimensions of electromobility, but has rarely examined the combined institutional, financial, and infrastructural determinants of local government responses. This research aims to provide policymakers in Poland and internationally with practical insights and guidance on formulating and implementing more effective, context-sensitive green transportation strategies.

2. Literature review

2.1. Zero- and low-emission public transport – research review

This section presents a systematic literature review. Data for the study were collected from the Web of Science (WoS) database on January 30, 2025. WoS is one of the most widely used and comprehensive databases of research publications. To ensure relevant search results, keywords were categorised into three groups: public transport, low-carbon transport, and urban/municipal areas. The documents ranged from 2009 to 2025. The data set consisted of 243 publications. Table 2 presents the search query.

Table 2. SQL query syntax

Database	SQL query syntax
Web of Science N =243	TS = (public transport*) AND TS= ("low-carbon" OR "zero-emission" OR "low-emission") AND (urban OR municipal OR city OR cities) Refined by: English (Languages) Indexes: Science Citation Index Expanded (SCI-EXPANDED) or Social Sciences Citation Index (SSCI) (Web of Science Index)

Note: The search strategy was performed on January 30, 2025.

The number of publications and citations in the WoS database for low-emission public transport from 2009 to 2025 is depicted in Figure 3. The data in the figure confirms the ever-growing interest in the topic being analysed. The number of publications on low-carbon public transport between 2009 and 2015 was only 27, and after the 2015 Paris Agreement, the number of research articles increased rapidly. The observed changes in publication trends are consistent with the results of other researchers (Castán Broto & Westman, 2020; Lu et al., 2023). Overall, 88.8% of articles appeared after 2015, demonstrating a heightened global attention towards sustainability, particularly environmental issues, which has compelled local governments to seek environmentally friendly solutions in public transport.

Most publications corresponded to research topics such as transportation and environmental science, green sustainable science, and energy fuels. Authors publishing low-emission public transport articles mostly originated from China, followed by Poland, England and Spain.

The reviewed articles present several thematic threads. The first relates to alternative fuels in public transport. Pyza et al. (2022) analysed the use of hydrogen in the public transport system for enterprises of various sizes. Using hierarchical analysis, they indicated that hybrid electric buses are suitable short-to-medium term substitutes. However, electric buses might be optimal if appropriate distances are ensured (Tzeng et al., 2005). Other researchers have proposed a methodology for switching from conventional to electric buses in conjunction with route prioritisation. The proposed multi-criteria method makes it possible to determine the order of selection of routes for the transition to electric mobility (Wenz et al., 2021). A significant part of the articles

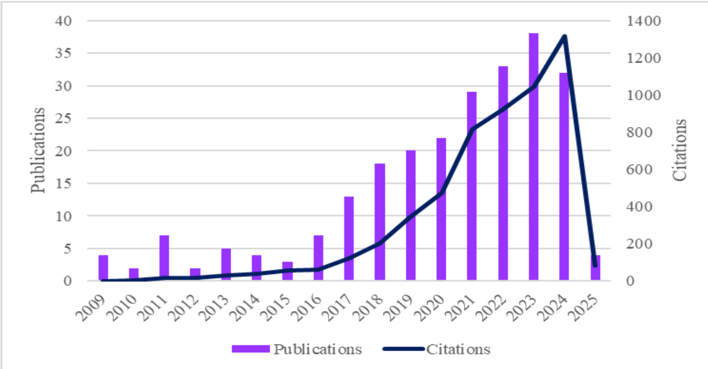

Fig. 3. Citations and number of publications related to low-emission public transport in the period 2009–2025 in WoS. Source: own elaboration based on WoS database.

concerns electric buses and the analysis of environmental aspects. Introduction of electric buses in public transport and their impact on reducing GHG emissions (Zhang et al., 2022), carbon dioxide emissions (Grijalva & López Martínez, 2019) and air quality was analysed (Qian et al., 2024).

The second research thread analyses public transport infrastructure requirements for low-emission vehicles. Silva & Peres (2022) presented methodologies for planning urban bus fleet electrification, considering infrastructural and energy demands. Wang et al. (2017) investigated the optimal locations for electric bus charging stations, and Kozera et al. (2024) evaluated the level and regional differentiation of low-emission investments in public transport in Poland. Other researchers analysed the wireless charging of an electric tram (Ko, 2019) or charging management for low-emission buses (Fan et al., 2020).

A third research focus involves organising transport and selecting optimal routes for low-emission vehicles. Purnell et al. (2022) proposed a tool for estimating the energy and charging demand of electrified public transit use. Duda et al. (2022) planned public transport regarding the available bus fleet, cost reductions, and environmental impact. Jacyna et al. (2022) analysed the organisation of public transport using electric vehicles, taking into account pollutant emissions, fuel consumption and the limited availability of conventional vehicles in the city. Basso et al. (2021) used machine learning to predict route energy consumption and deviations. They confirmed their estimates with data from electric public transport buses in Gothenburg, Sweden, and realistic traffic simulations in Luxembourg. Experimental research suggests that the range of electric vehicles may vary significantly due to traffic conditions and road types (Shankar & Marco, 2013). Additionally, Polish city case studies provided practical insights into fleet electrification processes (Chamier-Gliszczynski et al., 2024).

The last group of articles are publications related to sharing urban vehicles. Silvestri et al. (2021) analysed the contribution of car sharing to low-emission mobility. They emphasise that the critical factors in sharing vehicles compared to other types of transport are the availability of parking lots, road prices, and convenience. According to Bösehans et al. (2023), younger people, public transport users, and also cyclists expressed greater interest in using different modes of transport other than electric cars. Furthermore, several studies underline bicycle-sharing systems as crucial components complementing electric vehicles in urban decarbonisation strategies (Lai et al., 2021; Maclean et al., 2022; Nawaro, 2021).

2.2. Factors influencing the implementation of zero-emission public transport

Stakeholder perspectives on public transportation can significantly differ even within the same region (Pelletier et al., 2019). EU subsidies have been identified as essential for Polish municipalities' involvement in electromobility projects (Połom, 2021). Drożdż et al. (2022) emphasised that substantial external funding makes low-emission transportation financially advantageous compared to traditional combustion vehicles. However, municipal per capita budget revenue alone does not directly influence electromobility decisions (Trębecki et al., 2022). In contrast, Guzik et al. (2021) observed that economically stronger and larger cities demonstrate higher infrastructural readiness and financial capacity, suggesting disparities in resource allocation and strategy implementation between municipalities of varying sizes. These results support the hypothesis suggesting a positive relationship between financial situation and the level of engagement in low-emission public transportation.

This complexity of local factors can also be observed in international contexts, where the adoption of electromobility varies according to institutional, cultural, and infrastructural conditions. A review by Avenali et al. (2024) identifies technological, economic, and managerial factors as major barriers, while social, environmental, and institutional aspects generally accelerate the adoption of zero-emission buses. Similarly, Foecke et al. (2025), examining the US context, emphasise financial challenges, highlighting that despite significant governmental support, the purchase costs of zero-emission buses remain substantially higher than conventional vehicles, and transit agencies continue to face operational and infrastructural hurdles. Comparable findings were presented by Brdulak et al. (2020), forecasting that only a few EU countries — those with robust regulatory frameworks and stable financing — are expected to achieve substantial integration of electromobility by 2030. Additionally, studies from various global regions, such as Li et al. (2018) across multiple cities, underline the critical importance of proactive local governance, clearly defined institutional frameworks, comprehensive infrastructure planning, and targeted financial incentives in successfully deploying zero-emission public transport. Collectively, these international experiences demonstrate that tailored, context-sensitive policies addressing technological readiness, infrastructure investment, and socio-economic acceptance are vital to the effective adoption of electromobility globally.

Beyond the municipalities' economic standing, Stec and Szymańska's (2022) study reveals that municipalities with lower population densities allocate significantly more financial resources per capita to implement modern climate and energy policy solutions. This counterintuitive finding may be explained by the fact that less densely populated areas often have longer distances between destinations, creating a greater need for efficient transportation solutions. Additionally, these areas might rely more on external funding due to limited local resources. It explains why rural communes have invested more per capita than other types of entities in energy innovations in transportation (one reason is the limited accessibility of cycling infrastructure).

While infrastructure design impacts operational efficiency, demographic factors also play a crucial role, as evidenced by the correlation between education levels and electromobility rates (electromobility rates refer to the proportion or level of adoption of electric vehicles (EVs) within a specific region, market, or population). As the results of Guzik's (2021) study suggest, in Poland, electromobility rates are strongly correlated with the education level observed in local government units, as measured, among other things, by the number of students per thousand residents. Conversely, Player et al. (2023) research shows no significant relationship between the number of students and the Low Emission Zones.[4]. The same authors also showed no relationship between the number of employed status (% employed) and Low Emission Zones. These discrepancies may be attributed to varying cultural, socio-economic, and educational landscapes across different regions, which underlines the necessity of a nuanced, context-sensitive approach to electromobility policies. Therefore, further comparative studies are essential to identify conditions under which educational and employment factors become relevant to electromobility initiatives.

Adhikari et al. (2023) believe that persuading local authorities of the significance of environmental considerations could be an extra route to facilitate the smoother execution of specific environmental measures. The education and awareness factor is important, given the results of studies directly relating to Poland, which show that local government representatives' awareness and commitment to sustainability vary widely (Boguszewski et al., 2023). In doing so, the study identified three groups of local governments: those involved and aware (22.2%), those aware but not involved (39.5%), and those unaware and not involved (38.3%). Such differentiation not

[4] Low Emission Zones (LEZs), also known as Clean Air Zones, are designed to reduce the use of vehicles powered by combustion in city centres while promoting the adoption of ultra-low-emission vehicles (Szarata et al., 2017).

only reflects varying degrees of engagement but emphasises the importance of tailored educational and awareness-raising initiatives. These initiatives should be designed with consideration for the distinct barriers each group faces, whether informational, financial, or motivational. As Ryghaug and Toftaker (2016) argue, even local authorities' imaginaries concerning electric vehicles (i.e. perceptions, expectations, and mental associations) significantly shape their approach towards the transition to low-emission transport.

The level of environmental pollution can also influence decisions regarding participation in low-carbon fleets. In environmental research, particularly when investigating the interplay between air pollution emissions and transportation, PM2.5 (Leroutier & Quirion, 2022; Morales Betancourt et al., 2022) and PM10 (Xue et al., 2017) are vital variables[5]. While both PM2.5 and PM10 are emitted by public transportation (Hueglin et al., 2005; Slezakova et al., 2007), there is a nuanced distinction in their respective impacts and origins. For instance, PM2.5 is predominantly associated with combustion processes, such as those found in diesel engines commonly used in public transport vehicles (Pope 3rd et al., 2002). Due to their smaller size, these fine particles pose a greater risk to health as they can penetrate deep into the lungs and even enter the bloodstream, leading to various respiratory and cardiovascular issues. Despite the relevance of both measures, our study included only PM10 due to its high correlation with PM2.5, thereby avoiding multicollinearity. Although most studies assess the impact of public transport on air pollution, research on the reverse relationship—the influence of air quality on public transport structures, particularly regarding low-carbon fleet shares —is relatively scarce. Thus, our research makes a significant contribution by addressing this underrepresented aspect.

Based on other authors, the most crucial general factor of national importance has been legislation and the regulation of EU funds, including the Cohesion Fund, the Green Transport Program or the Act on Electromobility and Alternative Fuels (Kołoś et al., 2023). Some scholars suggest that public transport stakeholders often introduce electric vehicles in response to stringent environmental regulations, although in certain instances, the decision is made voluntarily (Domański et al., 2016; Taczanowski et al., 2018). Regardless of the potential importance of regulatory pressure, we did not directly assess this factor, as all municipalities considered in our study were subject to the same legal provisions stipulated in the Electromobility Act. Nonetheless, understanding regulatory frameworks remains crucial for interpreting municipalities' investment decisions in electromobility.

All in all, the literature review identifies four key factor groups affecting local government attitudes towards low-emission public transportation: financial capabilities, environmental pressures, social awareness, and infrastructural readiness. This study aims to synthesise these factors to determine what influences Polish local governments in meeting statutory requirements for zero-emission public transport fleets.

3. Data and methods

The primary data source for the study is the survey conducted from August 3 to October 14, 2022. It covered local governments subject to obligations from the Act on Electromobility and Alternative Fuels (which, at the time of the study, applied to municipalities with a population exceeding 50,000) and several other local governments that were previously engaged in initiatives aimed at modernising their public transport (participating in the government's "Green Public Transport" program[6]). The study used CATI (Computer-Assisted Telephone Interview) and CAWI (Computer-Assisted Web Interview) techniques. The survey was conducted for an analysis prepared by the BGK (Polish development bank) to assess the current level of advancement of the Polish local governments in complying with legal requirements related to the fleet composition, as well as to estimate expected progress assuming the realisation of the ongoing investments and investment plans for the coming years.[7]. What is important is that data concerning the expected levels of zero-emission vehicles in fleets makes this database

[5] PM2.5, particles with a diameter of fewer than 2.5 micrometres, and PM10, particles with a diameter of fewer than 10 micrometres.

[6] The program enables co-financing of projects aimed at reducing the use of emission fuels in public transport, for example, the purchase of electric buses, hydrogen buses or trolleybuses.

[7] The report based on the survey is available in Polish at: https://www.bgk.pl/przydatne-informacje/sprawozdania-i-raporty/ekspertyzy-i-badania/. Access on January 4, 2024.

unique. Ultimately, the survey gathered responses from 93 entities, 60 of which (excluding local government consortia) declared that they are subject to the provisions of the Electromobility Act. Only these 60 entities were included in the analyses conducted for this article.

Importantly, due to the selection criteria applied in the survey, the entities included in our study are not representative of the entire population of Polish local governments. The sample used in our analysis includes only municipalities subject to the Electromobility Act. This group primarily consists of cities with county rights (35 entities, accounting for 53% of all such entities in Poland) and urban municipalities (20 entities, representing 8.47% of all urban municipalities in Poland). The sample does not include voivodeships and counties.[8]

The data gathered in the survey enabled us to construct the variable *zero_emission_vehicles*, which represents the current share of zero-emission vehicles in a given municipality's fleet. Information provided by local governments in the survey was also used to identify municipalities that will surpass the threshold defined for 2028 in the Electromobility Act. This estimation was based on declarations regarding the ongoing and planned investments. Moreover, it was assumed that new vehicles entering the fleets would replace vehicles with combustion engines currently present in fleets. A binary variable constructed in this way was used as a dependent variable in the logit model.

As indicated, the article focuses on four dimensions of factors that affect local governments' attitudes toward zero-emission transport. The set of variables taken from the secondary sources approximates these dimensions – they are enumerated in Table 3[9]. All variables from sources other than the survey were calculated as the 5-year averages (in the absence of data for the five years, averages were calculated considering the available data)[10]. This made it possible to mitigate the impact of the business cycle and recent special events (e.g., the war in Ukraine and the COVID-19 pandemic).

Moreover, all variables were examined for missing values, outliers, and logical inconsistencies.

Based on two types of data – primary, taken from the survey conducted among selected Polish local governments, and secondary, retrieved mainly from the Polish Central Statistical Office – two types of analysis were conducted. A cluster analysis allowed us to identify two clusters of local governments – less and more engaged in implementing actions for sustainable transport. This step provides a deeper understanding of the factors that affect the attitude of local governments towards zero-emission transportation. In the second step of the analysis, a logit model was applied to formally assess the statistical significance of several factors affecting local governments' will and capability to meet legal requirements arising from the pursuit of zero emissions in public transport. All analyses were performed using IBM SPSS Statistics (v29) and R Studio software.

4. Results

According to data from the survey, fleets of Polish local governments considered in our research (60 local governments subject to the Electromobility Act) are still dominated by diesel-engine vehicles. They constitute, on average, 80% of all vehicles owned by the surveyed local governments. Significantly, the average declared age of the diesel fleet owned by these local governments was over ten years during the survey. Given that the operational lifespan of diesel buses ranges from 12 to 15 years, it is expected that a large portion of these diesel buses will need to be replaced with new models in the coming years, further justifying the necessity for investments in new fleets. The average share of all zero-emission buses in the local governments covered by the study is currently 6.1%. Simultaneously, only every twelfth local government (8.3%), which is obligated to have 30% zero-emission vehicles in its fleet by 2028, had already met this requirement when the survey was conducted. After concluding the ongoing investments in zero-emission buses (assuming that local governments will replace the aged diesel fleet with new vehicles), 26.7% of the local

[8] The entities included in our sample are relatively large in size. The average population size in these local governments is higher than the national average (in cities with county rights, 207,370 vs. 190,041, and in urban municipalities, 57,271 vs. 24,828).

[9] Unfortunately, a significant amount of interesting data provided by the Polish Central Statistical Office (potentially applicable to our study) is available at the level of voivodeships (provinces) and counties, but not at the level of our analysis (municipalities).

[10] In the case of a lack of pollution measurements (PM10) at stations located in a given commune or city, the value from a nearby locality was taken.

governments in our study were expected to meet the legal requirements. However, considering planned but not yet started investments, nearly half (46.7%) of the units covered by our study are expected to achieve the threshold of 30% zero-emission buses in the fleet by 2028.

Thus, it is natural to ask about the factors differentiating local governments that will ultimately meet the legal requirements from those that will not. These two groups are, on average, relatively similar in terms of their characteristics. The only feature that significantly distinguishes these two groups of local governments is the current share of zero-emission vehicles in their public transportation fleet.
In the case of local governments that will ultimately exceed the 30% threshold of zero-emission buses in their fleet by 2028, the current share of zero-emission vehicles in their fleet is nearly seven times higher than in other local governments in our study.

Table 3. Data sources and definitions of variables

Variable	Definition	Source	Dimension
financial_position	Financial position is calculated as the ratio of operating surplus (the difference between current income and expenses) to total income. This measure captures the average financial condition of a local government (%).	Ministry of Finance	financial
investment_intensity	Investment intensity is calculated as ratio of property expenditures to total expenditures (%).	Ministry of Finance	financial
debt	Debt is calculated as a ratio of debts to total income (%).	Ministry of Finance	financial
PIT_pc	Personal Income Tax per capita serves as a proxy measure of the wealth of a given local government (PLN). It is the sole available indicator of wealth at the municipal level.	Ministry of Finance	financial
bike_paths	The length of bike paths per 10,000 residents in kilometres.	Central Statistical Office	infrastructural
students	The number of university students per 1,000 residents in the local government territory.	Central Statistical Office	human capital
working	Persons engaged in work generating income, calculated per 1,000 residents. Excludes employees in national defence and public security, those working in individual farms, clergy, and persons employed in organisations, foundations, or associations, as well as enterprises with fewer than 10 employees.	Central Statistical Office	human capital
forest_cover	The ratio of the percentage of forest cover to the total area of a given local government (%).	Central Statistical Office	environmental
population_density	The number of residents per square kilometre of a given local government.	Central Statistical Office	demographic
area	The area of the local government is in square kilometres.	Central Statistical Office	infrastructural
pre_working_share	The share of people of pre-working age (%).	Central Statistical Office	demographic
working_share	Share of people of working age (%).	Central Statistical Office	demographic
bus_stops	Bus stops per 1,000 residents.	Central Statistical Office	infrastructural
roads	Municipal hard-surfaced roads per 1,000 residents in kilometres.	Central Statistical Office	infrastructural
share_green_expenditure	Share of green expenditures in total expenditures (%).	Ministry of Finance and Budzeń, Marchewka-Bartkowiak [57]	environmental
debt_pc	Debt per capita (PLN).	Ministry of Finance	financial
pollution	Average pollution levels in 2022 (PM10). PM10 pollution refers to airborne particulate matter with a diameter of 10 micrometres or less, which can negatively impact air quality, human health, and the environment.	Chief Environmental Inspectorate	environmental

These local governments, compared to those that do not meet the requirements imposed by the law, have slightly higher Personal Income Tax (PIT) revenues, are characterised by a higher population density, but also a greater number of students per 1,000 residents, and relatively longer bicycle route lengths. They have comparatively fewer bus stops per 1,000 residents and fewer paved municipal roads. However, only the difference in the fleet's current share of zero-emission vehicles is statistically significant (Table 4).

The execution of ongoing and planned investments will increase the share of zero-emission vehicles in the entire fleet from 11.2% to 48.1% in local governments, thereby meeting the legal requirement set for 2028. In the case of other local governments considered in our study, an increase from 1.6% to 11.6% can be expected. This means that the group of local governments at risk of not meeting the requirements stipulated in the Electromobility Act, after completing their current and planned investments, will find themselves at a point where the pioneering local governments are currently in terms of sustainable transport.

Since a simple comparison of local governments expected to comply with the requirements imposed by the Electromobility Act with the group of entities that are most likely to fail to meet the legal conditions does not reveal clear differences, it is reasonable to consider other possible classifications. The application of *k*-means cluster analysis, which included a range of financial, infrastructural, social, and environmental variables (details in Table 5), enabled us to distinguish two coherent and independent groups of units among the local governments subject to the requirements of the Electromobility Act considered in our study.

For the cluster analysis, all continuous variables were standardised using *z*-scores to ensure comparability across different scales. The *k*-means algorithm was applied using Euclidean distance as the similarity measure. The optimal number of clusters ($k = 2$) was determined using the elbow method, which evaluates the within-cluster sum of squares (WCSS) across different values of *k*. The final solution was validated using silhouette scores and non-parametric Wilcoxon tests to confirm significant differences between clusters.

Table 4. Comparison of local governments subject to the Electromobility Act in terms of meeting the minimum share of zero-emission vehicles in the entire fleet after completing investments by 2028

Variable	**Local governments that comply with the statutory minimum**		**Significance of difference in averages (Wilcoxon non-parametric test)**
	No (N=32)	**Yes (N=28)**	
zero_emission_vehicles	1.62	11.20	**0.004***
financial_position	5.73	5.87	0.894
investment_intensity	15.05	15.68	0.358
debt	35.18	36.34	0.953
PIT_pc	1393.44	1428.45	0.965
bike_paths	4.71	5.09	0.514
students	39.02	51.73	0.588
working	317.81	310.84	0.630
forest_cover	16.22	15.61	0.382
population_density	1507.11	1638.86	0.335
area	96.93	95.32	0.419
pre_working_share	17.34	16.91	0.273
working_share	58.65	58.49	0.976
bus_stops	3.77	3.01	0.155
roads	2.17	1.64	0.847
share_green_expenditure	17.65	17.95	0.790
debt_pc	2298.53	2272.14	0.906
pollution	23.32	24.50	0.314
share of zero-emission vehicles after current and planned investments	11.64	48.11	**<0.001***

*** p ≤ 0.05**

Mathematically, the clustering procedure minimises the following objective function:

$$J = \sum_{i=1}^{k} \sum_{x \in C_1} ||x - \mu_i||^2 \quad (1)$$

where C_i denotes the set of observations in cluster i, and μ_i is the centroid of cluster i. This formulation ensures that each observation is assigned to the cluster with the nearest mean, thereby minimising intra-cluster variance.

The smaller group of 14 LGUs includes entities that are clearly more committed to sustainable urban transport. They are already in a relatively better situation, as the average share of the zero-emission vehicles in their fleets is about 15% (11.5 percentage points higher than in the second group). After implementing planned investments, it will reach 64%. These local governments are characterised by larger areas and higher revenues, leading to more investments, although they also incur debt more frequently. Additionally, they exhibit higher human capital, as measured by the number of employed individuals per 1,000 residents and the number of students per 1,000 residents.

Finally, to formally verify the importance of factors in determining local government policies, we conducted a logit regression. Our explained binary variable (y_i) is derived from declarations of local governments collected in the survey, as briefly explained in Section 3. The y_i variable takes two possible values:

$$y_i = \begin{cases} 1 \text{ if the LGU is expected to satisfy} \\ \quad \text{the legal requirements;} \\ \quad 0 \text{ otherwise} \end{cases} \quad (2)$$

The functional form of the model was selected in a stepwise manner using the Akaike Information Criterion (AIC). It involves adding and subtracting various predictor variables until the lowest possible AIC value is reached. As a result, the most important explanatory variables are included in our logit model – they explain the likelihood of meeting the legal requirements regarding the minimum share of zero-emission vehicles in the entire transportation fleet in the most pronounced way. The functional form of the model is as follows:

$$ln \frac{p_i}{1-p_i} = \beta_0 + \beta_1 \text{zero\_emission\_vehicles}_i + \beta_2 \text{financial\_position}_i + \beta_3 \text{area}_i + \beta_4 \text{pollution}_i + \beta_5 \text{students}_i + \beta_6 \text{bus\_stops}_i \quad (3)$$

where p_i denotes the likelihood of surpassing the threshold of 30% zero-emission vehicles in the fleet by the entity i, assuming that all ongoing and planned investments will be concluded.

Table 5. The cluster analysis identified two groups of local governments subject to the Electromobility Act

Variable	Clusters		Significance of difference in averages (Wilcoxon non-parametric test)
	1 (N=14)	2 (N=46)	
zero_emission_vehicles	14.93	3.41	**<0.001***
financial_position	5.89	5.76	0.889
investment_intensity	17.67	14.63	**0.012***
debt	53.65	30.26	**<0.001***
PIT_pc	1838.67	1279.25	**<0.001***
bike_paths	4.87	4.89	0.848
students	123.70	20.99	**<0.001***
working	392.30	290.90	**<0.001***
forest_cover	20.98	14.40	0.196
population_density	1670.34	1537.62	0.345
area	205.79	62.82	**<0.001***
pre_working_share	16.46	17.35	0.072
working_share	58.82	58.50	0.286
bus_stops	2.91	3.57	0.221
roads	1.19	2.14	**<0.001***
share_green_expenditure	19.07	17.40	0.336
debt_pc	3848.42	1810.76	**<0.001***
pollution	22.93	24.16	0.363
share of zero-emission vehicles after current and planned investments	64.29	41.30	0.100

*** p ≤ 0.05**

To ensure the validity of our logit regression, we tested the key assumptions associated with it. The results indicate that the assumptions are met, supporting the robustness of our calculations. The response variable only takes on two possible outcomes (yes and no), and the independence of observations is satisfied. To check for multicollinearity, we examined the variance inflation factor (VIF) for each independent variable. The results indicate that all VIF values are below the commonly accepted threshold of 5, confirming that multicollinearity is not a concern. To assess the impact of individual observations on the model, Cook's distance values were identified, indicating that no single observation disproportionately influenced the results. Additionally, leverage values remained within acceptable limits, confirming that the model was not unduly affected by outliers. Logit regression assumes a linear relationship between continuous explanatory variables and the log odds of the response variable. This was checked using the Box-Tidwell test, which evaluates whether the interaction terms between continuous predictors and their natural logarithms are statistically significant. The Box-Tidwell test results indicate that none of the interaction terms between the continuous predictors and their natural logarithms are statistically significant ($p > 0.05$), confirming that the assumption of linearity in the logit model holds. Specifically, the score test for the null hypothesis that all lambdas are equal to 1 has an F-value of 0.9366 with a p-value of 0.478. A p-value greater than 0.05 indicates that we fail to reject the null hypothesis, meaning there is no significant evidence that the relationship between the continuous predictors and the log odds of the response variable is non-linear. Therefore, based on the Box-Tidwell test results, we can conclude that the assumption of linearity in the logit model holds.

As indicated in Table 6, the statistically significant variables that affect meeting the requirements of the Electromobility Act turned out to be the share of zero-emission vehicles in the entire fleet at the starting point (positive relation), as well as the financial situation of local governments (positive), the size of the area of the local government (negative), the level of PM10 pollution (positive). Significance at the 0.05 level was also achieved by the variable denoting the number of bus stops per 1,000 residents (negative).

Despite not being statistically significant, the variable referring to the number of students per 1,000 residents remained in the final model. It is intended to cover the dimensions of human capital and social awareness. This means that the variables included in the final model cover all four dimensions defined based on the literature review. Consequently, the logit takes the following form:

$$lln\frac{p_i}{1-p_i} = -4.366 + 0.177\text{zero\_emission\_vehicles}_i + 0.334\text{financial\_position}_i - 0.015\text{area}_i + 0.208\text{pollution}_i + 0.015\text{students}_i - 0.873\text{bus\_stops}_i \quad (4)$$

$ln\frac{p_i}{1-p_i}$We typically calculate the odds ratios to interpret the logit regression results. Odds ratios express the result of the increase of a given explanatory variable by a unit, *ceteris paribus*, on the chances of the explained variable taking the value of 1. They are defined as $\frac{p_i}{1-p_i}$, so they depict the relation of the probability that $y_i = 1$ to the probability that $y_i = 0$.

Table 6. Results of estimating the parameters of the logit model for meeting the requirements of the Electromobility Act in terms of a minimum of 30% zero-emission vehicles in the fleet by 2028

Explanatory variables	Estimate	Standard errors	Statistics from Wald	Significance p	Odds Ratio
zero_emission_vehicles	0.177	0.065	2.719	**0.007***	1.194
financial_position	0.334	0.161	2.077	**0.038***	1.396
area	-0.015	0.007	-2.049	**0.040***	0.985
pollution	0.208	0.093	2.232	**0.026***	1.231
students	0.015	0.010	1.520	0.128	1.015
bus_stops	-0.873	0.436	-2.000	**0.046***	0.418
Constant	-4.366	2.508	-1.741	0.082	

*** p ≤ 0.05**

More specifically, as the share of zero-emission vehicles in the current fleet increases by 1%, the chance of achieving the legal requirements, *ceteris paribus*, increases by 19.42%. Each 1% increase in the share of operating surplus in total income increases this chance by 39.62%. An increase in pollution by 1 unit positively affects local governments and results in a 23.07% increase in the chance of achieving the requirements. On the other hand, an increase of 1 square kilometre in area decreases the chances by 1.45%, and an increase of one more active bus stop per thousand residents decreases the chances of achieving the goals by as much as 58.22% ceteris paribus.
AUC (Area under the curve) is a metric used to evaluate the performance of a classification model, specifically in the context of the ROC (Receiver operating characteristic) curve. The ROC curve plots the true positive rate against the false positive rate, showing how well a model distinguishes between classes at different threshold levels (Figure 4).
In this case, the AUC value is 0.8582, which means the model performs quite well. It suggests that the model has a strong ability to differentiate between positive and negative cases, making it a reliable predictor.
We conducted an analysis of the model without the non-significant variable (the number of students per 1,000 residents). In this variant, the AUC value is 0.8282, which indicates a lower predictive ability. It is important to note that the model selection method based on AIC considers both the model's fit to the data and its complexity. AIC does not rely directly on the statistical significance of individual variables – it evaluates the model. Although individual p-values may suggest a lack of significance, a given variable can still improve the overall model fit, as observed in our case.

5. Discussion

The results of our research contribute to the strand of literature studying factors that support and inhibit the adoption of zero-emission local transport, meticulously summarised by Avenali et al. (2024). The outcomes of our logit regression confirm most of the expectations derived from previous studies and prevailing theories. This can be interpreted as a sign of relative coherence in challenges linked to the green transformation in cities, and potentially a promise of replicability of solutions. Polish cities do not seem unique in the field of public transport transformation. Thus, Polish local authorities can infer that it is justified to trustfully benefit from the experiences of other, more advanced local communities. However, forecasts suggest that the attempt to replace traditional vehicles with zero-emission buses poses a serious challenge not only for Poland but also for most EU countries (Brdulak et al., 2020).
The positive relation between the local government's fiscal capacity and the probability of surpassing the 30% threshold of zero-emission vehicles in the fleet is probably our model's most natural and expected outcome. This finding is consistent with previous

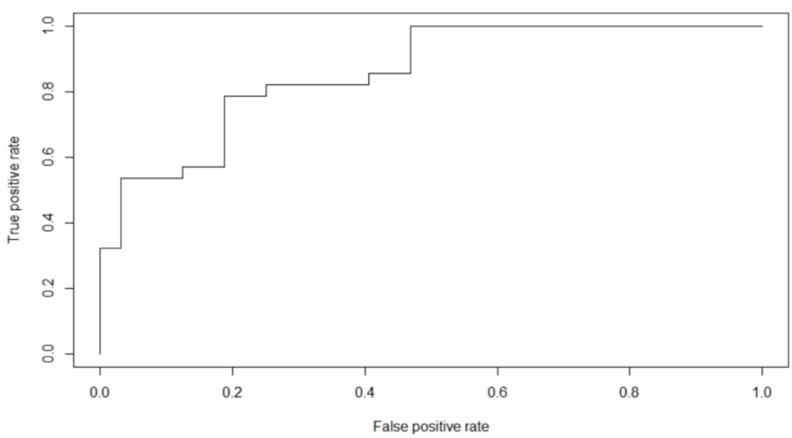

Fig. 4. ROC Curve

studies on electromobility in Poland (Guzik et al., 2021). It also corresponds with outcomes of previous studies focused on different regions. Foecke et al. (2025), Avenali et al. (2024) and Li et al. (2018) also emphasised that financial support and fiscal incentives granted to local authorities are vital for the successful adoption of zero-emission local transportation.

Fiscal capacity is a strong determinant of municipal investments. This interdependency is well established in the literature related to local governments (Banaszewska, 2018; Bremer et al., 2023; Haraldsvik et al., 2023; Zawora, 2020). Dylewski (2018) explains that operating surplus is a decisive factor in determining the ability to incur liabilities by Polish local governments, not only because of practical reasons related to financial credibility but also due to legal provisions of Polish financial law[11]. Although, as highlighted by Połom (2021), green investments of Polish municipalities are extensively supported by grants from European funds and the central budget, some engagement of own resources is usually required. A positive operating surplus enables local authorities to generate necessary contributions from debt.[12].

The local government's geographical surface negatively affects the odds of surpassing the threshold of 30% zero-emission buses in public transport. This variable should be treated as a measure of the magnitude of the transformative challenge the given local government faces. From two identical local governments, the one with the larger surface area will be less likely to achieve the goal set by Polish law. This result is coherent with the findings of Stec and Szymańska (2022), who argued that transportation investments are often more difficult and costly in less densely populated regions, which are generally characterised by above-average land area. Moreover, Dingil et al. (2019) argue that cities with relatively low population density are characterised by higher energy consumption in transport. It stems from the fact that in such municipalities, people are more prone to use private cars for daily commuting. We can presume that in such areas, investments in public transport are relatively less expected by society. Our outcomes are largely coherent with this argumentation. However, population density was not a statistically significant predictor in our model. The observed inverse relationship between territorial size and the adoption of low-emission transport suggests that spatial dispersion, rather than density per se, is the critical factor. Large municipalities, even with similar density levels, often involve greater distances between settlements. Therefore, territorial size may provide a more meaningful indicator of implementation challenges, which may explain the insignificance of population density in our study.

To some extent, the same story can be attached to the variable describing the number of bus stops per thousand inhabitants – it can be treated as a proxy for the complexity and coverage of public transport in the given municipality. What is important is that these two variables, measuring the scale of challenge, are not correlated (the Pearson correlation is around 0.06). The geographical surface simply describes the area that has to be serviced by public transport, whereas the number of bus stops is a variable that also considers the density of the transportation network in a particular municipality. Due to objective reasons (both geographical and historical), two municipalities of the same size may adopt slightly different approaches to their local transport networks, resulting in different levels of saturation by bus stops and other transportation infrastructure within their respective territories.[13]. Moreover, as argued by Grijalva and López Martínez (2019) and Vepsäläinen et al. (2018), more bus stops entail more frequent stops, and consequently, also higher electricity consumption. This means that zero-emission buses may be relatively less attractive in areas with a higher number of bus stops. Our outcomes seem to confirm these findings.

As expected, severe air pollution increases the likelihood of achieving legal goals regarding the share of zero-emission vehicles in the urban transport system. When low air quality is particularly acute,

[11] According to Article 243 of the Public Finance Act, budgets of Polish local governments must guarantee the fulfilment of a particular relation between the sum of instalments and interest paid in a given year and operating surpluses from a few previous years.

[12] For example, in 2022, several municipalities in the Silesia region received a 90 million PLN grant from the "Green Public Transport" program. However, the total value of 35 buses and 20 chargers purchased by a few Polish cities exceeded 140 m PLN (Teraz Środowisko, 2022).

[13] For example, Wieliczka and Andrychów have a similar surface (around 100 km2), but the number of bus stops per thousand inhabitants is 1.5 in the former and 5.1 in the latter.

people are more willing to accept green investments. This line of reasoning is also supported by evidence provided by Bartczak et al. (2024). They found a link between the perceived health status and perceived severity of respiratory diseases, on the one hand, and citizens' support for the air quality improvement programs, on the other hand. Both studies suggest that external factors affecting the perceived health status of Polish citizens determine their political preferences and attitudes toward local green investments.

The insignificance of the students' density in a given municipality may be seen as the most puzzling result of our study. As explained, the number of students per thousand inhabitants is a variable intended to approximate the quality of the human capital in each area. It should also reflect the local community's environmental awareness and readiness to pressure the local authorities and spur them to pursue the green transformation. The lack of statistical significance of this variable can be interpreted in several ways, though.

Firstly, previous studies have already demonstrated that post-communist countries have experienced a deterioration of human capital, which may distort individuals' preferences for private and public services in the context of mobility (Łopaciuk-Gonczaryk & Nicińska, 2025). Secondly, the number of students per thousand inhabitants may be a weak proxy for the general quality of the local human capital and local attitude towards the climate crisis. Students of Polish universities are usually composed not only of local citizens but also of people migrating from small towns to gain a degree in regional centres (Urbański et al., 2021). Those migrants are usually still more connected to the cities of their origin, rather than the places where they received their education (at least during the study period). Consequently, their influence is more pronounced in cities of their origin (often, they do not even have voting rights in cities where universities are located). For these reasons, the high density of students in the given community does not necessarily entail adequate vigorous social support for the local green transformation. Moreover, the literature provides extensive evidence that the political engagement of youth is relatively modest, especially when considering traditional forms of political activity (Nolas et al., 2017; Sloam, 2016). Kitanova (2020) notes that this regularity is particularly evident in young democracies, such as Poland. Therefore, even if young individuals are, on average, more aware of challenges linked to climate change, it is not apparent that their views shape local politics.

The insignificant impact of the students' density on the probability of achieving a 30% threshold of zero-emission buses in the fleet may also stem from the limited variability of this factor in our database. Although this variable ranges from 0 to 195, more than half of our sample is located between values 0 and 50. Almost all observations used in our model represent big and medium-sized cities. It is possible that the expected effect would be more visible if cities were compared with small towns and villages. It appears that the same line of reasoning can be applied to explain the discrepancies between the outcomes obtained by Guzik (2021) and Player et al. (2023). The cultural and socio-economic landscapes of local government may determine the importance of the educational level of the community in shaping local green policies. Since our database primarily includes cities, their socio-economic landscapes are generally uniform.

Finally, the current share of zero-emission vehicles serving the local public transport is the most significant determinant of our explained variable. Cities with a high number of zero-emission buses in their fleets are more likely to meet the 30% threshold imposed by law. In our study, this indicator serves as a control variable that levels the starting positions of all cities included in our sample. These outcomes were well-expected and did not require a more elaborate interpretation.[14].

Almost all four dimensions considered in our research were relevant to the green transformation of local public transport. Fiscal capacity and general financial situation describe the potential of local governments to undertake transformative investments. A given municipality's surface and infrastructure density reflects the scale of the challenges ahead. The quality of the air reflects the urgency of the considered actions and, to some extent, also the pressure

[14] However, it might be a valid and exciting idea to consider separately the situation of the local communities with a particularly low share of zero-emission vehicles in their fleets. It can be expected that the probability of success is, in these cases, determined slightly differently than in entities that are not close to the legal threshold. Unfortunately, due to the low number of observations in our sample, such an analysis would not be informative or reliable.

exerted by the local community on the authorities. A relative number of students is an indicator intended to capture the importance of human capital. This variable proved to be insignificant. However, considering the abovementioned peculiarities and previous outcomes (Player et al., 2023, Łopaciuk-Gonczaryk & Nicińska, 2025), it does not necessarily mean that environmental awareness does not affect local politics. As demonstrated above, a few other explanations are possible.

6. Conclusion

The European Union's ambitious environmental goals require multidimensional activities undertaken not only by international bodies, European societies, and central officials but also by local governments. Greening transport is probably one of the most demanding and persistent challenges in this field. Although authorities can provide the necessary legislation, green transformation also requires extensive investments. Identifying conditions that support such undertakings and generating social support for them is crucial.

The outcomes of our research suggest that a successful transformation of public transport in local governments requires a list of prerequisites to be satisfied. Financial capability is a crucial factor, but the scale of the challenge (measured by the density of infrastructure and area of the local government) and the severity of environmental conditions are also critical. Since better environmental conditions are our ultimate goal, local authorities cannot change the area of the municipality; infrastructure is desirable and should be developed in parallel with the public transport fleets. Financial capabilities stand out as the most prominent factor that the central government, local authorities and European institutions can reinforce. It is essential that the notion of financial capabilities also embraces some degree of financial independence (measured by the operating surplus related to total income). On the other hand, the level of human capital and social awareness is the only dimension that is insignificant in determining the success of Polish local governments in transforming public transport. Despite some technical issues that may question this result, the conclusions that can be drawn from this outcome suggest that Polish society is sufficiently aware of environmental challenges, and further education may not be necessary to build social support around green investments (at least in the largest cities).

Our study contributes to the literature underpinning previous findings and demonstrates that all of them may be important for the successful green transformation of public transport. It reinforces the holistic approach to challenges faced by local governments in the field of green investments. The primary value added of our study stems from the application of a formal method of analysis to the unique database collected in a meticulous survey conducted among Polish local governments. Notably, even though our study is limited to Polish municipalities, its conclusions can be applied more broadly. Firstly, our conclusions maintain findings from the previous studies, corroborating the notion that the challenges faced in the field of public transport are, to some extent, universal. Secondly, Polish legislation reflects the more general tendencies observed at the European level. It is common for all members of the European Union – in this sense, the requirements imposed by Polish law on Polish local governments are not country-specific.

There are a few potential ways to extend and supplement our study. A more thorough analysis of factors that capture the dimensions of human capital and social awareness would be interesting and valuable. Our outcomes are not entirely conclusive in this field. Secondly, all factors considered in our study should also be assessed in other countries in similar situations to further support the hypothesis of the relative universality of transformative challenges in public transport. Ultimately, our study primarily focuses on urban areas. We can expect that factors determining the situation of rural municipalities may be different. It would be interesting to extend our research to include such entities. Moreover, because the sample was limited to municipalities subject to the Electromobility Act, the findings should not be generalized to all Polish local governments. This limitation highlights the need for comparative studies involving smaller municipalities and rural areas to verify whether the drivers and barriers identified here remain consistent across different settlement types. Such research could also reveal additional determinants specific to less urbanized contexts, enriching the understanding of electromobility adoption at the national level.

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