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PUBLIC PERCEPTIONS AND ACCEPTANCE OF ELECTRIC BUSES AMONG URBAN RESIDENTS IN POLAND

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ABSTRACT

Electrification of the bus fleet is a key element in the transformation of transportation systems in many cities worldwide. This process involves significant investments in both vehicles and infrastructure. Given the funding mechanisms of public transportation systems, it is crucial that investments in electric buses receive broad public support. In the context of achieving sustainable development goals, increasing the share of public transport at the expense of individual car travel is particularly important. To facilitate this shift, it is essential that city residents perceive the benefits of using electric buses compared to conventional vehicles.
The aim of this study is to assess public perceptions of bus fleet electrification and determine the level of support for this process. The analysis considers both indirect support, reflected in the acceptance of municipal investments in electric vehicles, and direct support, measured by the willingness to bear higher travel costs for electric bus services. The results show that residents of large Polish cities perceive electric buses as significantly more environmentally friendly, quieter, more comfortable, and more modern than diesel-powered buses, while rating both vehicle types similarly in terms of reliability. The experience of traveling by electric buses has a positive effect on the evaluation of these attributes . Respondents expressed a moderately high level of indirect support for electric buses investments, yet their willingness to accept higher ticket prices was lower. Weak but positive correlations were observed between willingness to pay more and higher ratings of electric buses features, particularly reliability, comfort, and environmental impact. In addition, the experience of traveling by electric buses was positively associated with expectations that cities should continue to invest in such vehicles but not with willingness to pay higher fares. Furthermore, frequent public transport users were significantly less likely to be indifferent to the type of bus they use, suggesting that the strongest supporters of electric buses are those who benefit from them in daily travel. These findings provide empirical insights into the determinants of public acceptance of BEB investments and highlight the importance of both experiential factors and perceived vehicle attributes in shaping societal support for zero-emission public transport.

KEYWORDS: *Electric buses, Transport preferences, Urban mobility, Urban transport policy, User acceptance.*

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INTRODUCTION

Electrification of transportation, including vehicles used for road-based public transport services, is currently considered one of the primary methods for reducing external costs associated with meeting the transport needs of city residents (Holland et al., 2021; Lajunen & Lipman, 2016; Olindo et al., 2021). The deployment of battery electric buses (BEBs) in urban transport systems is expected to mitigate negative impacts of transport activities, including noise emissions, air pollution, and greenhouse gas emissions (Chhugani & Rahmani, 2025; Nordelöf et al., 2019; Xylia et al., 2019). Consequently, the ongoing electrification of public road transport should contribute to improving the quality of life, aligning with the core principles of sustainable development (Höjer & Wangel, 2014; Hull, 2008).

The transition of bus fleets in Polish cities from diesel-powered buses (DBs) to BEBs requires substantial public support, both now and in the future. This need arises from two main factors. First, investment costs for vehicle procurement and infrastructure development are considerably higher for BEBs than for DBs (Hanhee Kim & Niklas Hartmann, 2022; Jagiełło, 2021; Muñoz et al., 2022; Triatmojo et al., 2023; Xiao et al., 2024). Second, urban public transport services are inherently non-commercial. This stems from the fact that the purpose of public transport systems is not to generate profits for their owners but rather to provide an inclusive service that enables the largest possible proportion of city residents to meet their mobility needs (Kuo et al., 2023; Miller et al., 2016; Wyszomirski, 2008). As a result, ticket revenues often fail to cover the full operational costs of public transport systems. In major Polish cities, the fare recovery ratio typically ranges between 25% and 45% (Wolański, 2022). Some authors therefore argue that higher ticket prices for BEB services may be justified (Tan & Lin, 2019). Public support for public transport is thus essential, as residents and visitors finance this system both directly through ticket purchases and indirectly through taxes that subsidize its operation. Fleet investments involve public funds, which should be allocated transparently, on a justified basis, and with public approval (Bernardin Akitoby et al., 2020; David Drysdale et al., 2023; Gaspar et al., 2015).

Despite the importance of public opinion, knowledge of how residents of Polish cities perceive the characteristics and role of zero-emission buses in sustainable development remains limited. This article addresses this gap by formulating the following research questions:

RQ1: Do residents of Polish cities recognize differences between different types of urban buses?

RQ2: Does the actual experience of traveling on an electric bus influence the perception of its specific attributes?

RQ3: Do residents of Polish cities support fleet policies that prioritize investments in electric vehicles?

RQ4: Is support for investments in electric buses dependent on the frequency of public bus use?

Answering these questions enables the identification of factors influencing public acceptance of BEBs investments and an assessment of the extent to which actual travel experience affects the perception and evaluation of their attributes.

The remainder of this article is organized as follows. The literature review outlines the current state of knowledge and identifies key research gaps. The methodology section describes the research design, measurement tools, and sample characteristics. The results section presents the findings, followed by an analysis of the influence of BEB travel experience, willingness to support BEB investments, and the relationship between perceived attributes and public support. The article concludes with a discussion of the results and their practical implications, as well as the limitations of the methodology applied and possible directions for future research.

LITERATURE REVIEW: WHAT DO WE KNOW ABOUT THE PERCEPTION AND ACCEPTANCE OF ELECTRIC BUSES BY URBAN RESIDENTS?

The dynamic development of urban transport electrification, in both public and private sectors, has stimulated numerous studies on public perception, acceptance, and evaluation of electric vehicles. Successful electrification of urban transport, including public transportation, requires strong public support (Rodrigues & Seixas, 2022; Xylia et al., 2019). Alongside adequate investment financing and effective subsidy schemes that do not shift excessive costs to end users, public acceptance can play a decisive role in overcoming barriers that slow the transition (Sunitiyoso et al., 2022). These barriers include financial constraints, insufficient development of technical infrastructure, technological challenges, as well as institutional and organisational difficulties (Gopi et al., 2024; Jagiełło, 2021; Rodrigues & Seixas, 2022; Sclar et al., 2019). A high level of public support and residents' pressure on local decision-makers can therefore act as catalysts for change, facilitating the implementation of policies that support the decarbonisation of urban transport.

Existing analyses on the perception and level of acceptance of electric vehicles have covered both the private user sector (electric cars) and public transport

services (electric buses). They examine such factors as perceived environmental benefits, travel comfort, safety, reliability, openness to new technologies, perceived economic impacts, and willingness to bear related costs (Buenavista et al., 2024; Kwon et al., 2020; Lin & Tan, 2017; Wicki et al., 2023). An overview of the key features of the applied methodology and the conclusions of individual studies is presented in Table 1. Studies on public transport perception reveal that user expectations vary widely depending on local social, economic, spatial, and organisational conditions, including city size, transport infrastructure, and environmental concerns. Individual characteristics, such as age, income, education, and environmental awareness, also shape attitudes toward service quality and the need for modernisation, including electrification. Younger, well-educated, higher-income residents tend to support green innovations, while those with lower incomes or education prioritise affordability and reliability (Alam & Zakaria, 2013; Muzammel et al., 2023; Yozwiak et al., 2022).

A review by Wicki et al. (2023) demonstrates that public acceptance of electric vehicles is highly diverse and complex. The authors found that the same factors influenced the acceptance of electric vehicles differently across various studies, sometimes positively, sometimes negatively, and sometimes not at all. Only a few results related to specific variables were entirely consistent, showing the same patterns across studies. Moreover, findings often diverged from initial assumptions or intuitive expectations. For example, higher environmental awareness did not always correlate positively with the use of electric vehicles (Adnan, 2014). Additionally, passengers more often prefer vehicles that emit low levels of noise rather than those that are completely silent. (Sunitiyoso et al., 2022).

The aim of the studies mentioned above was, among other things, to determine the extent to which city residents accept, support, and expect the further adoption of zero-emission vehicles in urban areas. On the one hand, it can be assumed that individuals who recognise the advantages of electric vehicles over conventional ones will also tend to evaluate electric buses more favourably compared to their combustion-engine counterparts. On the other hand, it is crucial to distinguish between the results obtained for private and public vehicles, as they differ both in terms of usage and in the scope of user decision-making. Investment in a private electric car involves directly and consciously bearing costs throughout its life cycle, including purchase, operation, maintenance, insurance, and potential resale. Owners are typically more aware of both the benefits and the expenses involved. In public transport, however, passengers' perceptions of economic and technological aspects are far less developed or explicit. For most users, the primary evaluation criteria remain service quality, including punctuality, comfort, accessibility, and safety (Redman et al., 2013; Suman & Bolia, 2019; Tavares et al., 2021; Wyszomirski, 2008). In contrast, aspects related to the financing of fleet purchases, the construction of charging infrastructure, or operational costs remain outside the direct interest and knowledge of the average passenger. Therefore, public support for the electrification of public transport is based primarily on general beliefs about the characteristics of electric vehicles and their contribution to environmental protection as well as improving quality of life in the city, rather than on an in-depth economic or technological analysis of specific fleet solutions.

Research on the social perception and acceptance of electric vehicles, including urban buses, is highly context-specific and cannot be universally applied across different cities or countries. Such studies reflect local social, economic, and spatial conditions, offering detailed insights only into specific cases. Therefore, it is crucial to conduct research across various locations, even if comparisons are limited. This is especially important in the EU, where a common transport policy drives the electrification of public transport. Despite local differences, member states must align with EU goals of reducing emissions, improving air quality, and promoting sustainable, innovative, and competitive transport systems.

The lack of universality in findings should also be assumed for studies on willingness to bear higher costs, such as increased tickets prices, associated with the electrification of bus transport. Numerous analyses indicate that a significant share of urban residents express readiness to co-finance such investments, either through higher fares or via the tax system (Lin & Tan, 2017; Nyga et al., 2020; Salvo & Wong, 2024; Son et al., 2022; Tan & Lin, 2019). At the same time, these studies reveal significant variation in the level of cost acceptance, which strongly correlates with factors such as age, gender, income, environmental awareness, and other socio-demographic variables. These findings again highlight the local nature of public perception and the strong dependence of social attitudes on the specific economic, social, and environmental context of a region. This points to ongoing research gaps regarding public perception and acceptance of electric buses, as well as residents' willingness to bear the related costs, especially in underrepresented regions like Central Europe, including Poland. These gaps are further widened by the fact that most studies focus on the perspective of vehicle owners (local authorities or public transport operators) rather users themselves, i.e.

TABLE 1. Overview of Key Insights on Electric Bus Acceptance and Perception

Source	City (country)	Method	Key findings
(Flaris et al., 2023)	Salt Lake City (USA)	Multivariate Binary Probit Estimation Participants were recruited on board UTA bus lines, using electronic and paper surveys; later supplemented with an online survey targeting riders of both BEBs (UTA Line 2) and non-electrified lines. Final sample: 224 respondents.	Public acceptance of electric buses is shaped by several key factors, including the purpose of travel, individual attitudes toward environmental issues, perceptions of the environmental impact of battery electric buses and non-instrumental ride attributes such as comfort and perceived social image.
(N. Wang et al., 2022)	China	Online survey among Chinese residents. Oversampling was used to reduce non-response bias. A total of 1185 questionnaires were collected, of which 990 were valid (83.5% validity rate). Data were analysed using the PLS-SEM.	Public acceptance of electric buses is primarily influenced by factors such as individual attitudes, performance expectancy, personal norms, and social influence. Furthermore, ascription of responsibility and effort expectancy act as indirect antecedents, exerting a significant impact on users' willingness to adopt electric shuttle bus services.
(Aldenius et al., 2022)	Nottingham, City of York (UK), Gothenburg, Eskilstuna (Sweden)	Semi-structured in-depth interviews with various stakeholders (local government, PTAs, operators, manufacturers, national government, partnerships) to understand challenges of electric bus rollout.	Common challenges to the successful implementation of electric buses include infrastructural limitations, high costs, stakeholder coordination difficulties, and knowledge gaps. The severity of these challenges, however, varies depending on contextual factors such as geographical conditions, passenger demand, and the level of national support.
(Krumnikl et al., 2024)	Ostrava (Czechia)	Interviews (Sample size not specified)	Passengers generally do not perceive substantial differences in comfort or service quality between diesel and electric buses. Regarding social impact, e-bus users tend to prioritize ride comfort over environmental considerations.
(Clairand & González-Rodríguez, 2022)	Quito, (Ecuador)	Exploratory Data Analysis. Survey of 217 public transport users (min. once a week).	Respondents generally expressed confidence in traveling by electric buses (EBs) or electric taxis (ETs), despite some concerns about range and speed. Notably, women and individuals aged 25 to 34 were more willing to pay a premium to travel in EBs or ETs. Pearson's chi-squared test showed that women demonstrated a significantly higher willingness to pay for electric transport compared to men, potentially reflecting a greater concern for comfort and environmental sustainability.
(Sunitiyoso et al., 2022)	Jakarta (Indonesia)	Survey, 1029 respondents at 12 survey points.	Electric buses are predominantly favoured over buses powered by internal combustion engines (ICEs). The analysis confirms positive attitudes toward e-buses adoption, aligning with previous research concerning mode selection, with travel duration as a significant variable. Lower ticket prices increase the likelihood of usage, while environmental considerations, particularly those related to emissions, exert a weaker influence on mode selection.
(Buenavista et al., 2024)	Philippines	Survey, sample size 438 citizens aged above 18 Sample: users of electric transport (e-jeepneys, e-buses, e-tricycles) in NCR, Philippines. Used SEM.	Hedonic motivation is identified as the strongest factor influencing the intention to use electric public transportation, while effort expectancy is weaker. The evidence emphasizes the imperative of developing and implementing electric public transport services that prioritize user-friendliness and convenience. Furthermore, the findings suggest that users also favour electric public transportation for its reduced environmental footprint, sustainability, and energy efficiency.
(Nguyen & Pojani, 2023)	Hanoi, (Vietnam)	Survey, 800 students	The study found that 99% of adolescents use buses, and a majority of students intend to use electric buses. Intention is strongest among current users (99%), followed by former users (51%) and non-users (28%). While environmental awareness plays a role, factors such as safety, security, and innovation are equally important to young adults. Notably, the environmental benefits alone are not decisive. In contexts like Vietnam, the introduction of e-buses should be supported by measures that emphasize their broader advantages and present them as a distinct and modern alternative to traditional buses.

Source	City (country)	Method	Key findings
(Kwon et al., 2020)	Korea	Online survey, 586 respondents	The findings indicate that safety is the most valued attribute in the use of electric buses (preference share: 41.3%), followed by eco-friendliness (14.3%) and ride comfort (13.6%). Exterior design was least important (1.8%). Additionally, gender-based differences were observed in attribute evaluation.
(Tan & Lin, 2019)	Beijing, Shanghai, Guangzhou, and Shenzhen (China)	Interviews with 940 respondents; Regression and sample selection model.	Younger respondents, better-informed respondents, and those who believe such vehicles improve air quality are more willing to pay higher fares. Among 940 valid responses, 192 participants (20.43%) refused to pay more. Only 2 respondents (1.04%) believed that local air quality was already sufficient, while the remaining 190 (98.96%) provided protest responses. Of these, 18.75% cited low household income, 21.35% believed polluters should bear the cost, and 25% felt it was the government's responsibility. The most common reason (33.85%) was the belief that taxes already cover such expenses.
(X. Li et al., 2003)	26 cities across 14 countries	Eight interviews with practitioners involved in implementation cases	Public grants and innovative strategies to reduce costs and risks are key to the adoption of electric buses.

urban residents (Sunitiyoso et al., 2022).

The literature also includes studies on related topics, such as public acceptance of hydrogen-powered and autonomous buses (Bigerna & Polinori, 2015; Kassens-Noor et al., 2020; Niavis et al., 2025; O'Garra et al., 2007; S. Wang et al., 2023). There is a growing interest among researchers in the broader technological transformation of public transport, emphasizing the need to consider the social perspective when implementing innovative urban mobility solutions. This highlights the need for comprehensive, context-specific qualitative and quantitative analyses to better understand residents' attitudes toward public transportation and diverse low- and zero-emission technologies, as well as the factors that promote or impede their acceptance.

METHODOLOGY

To address the research questions, primary data were collected through a Computer-Assisted Web Interview (CAWI) administered via an online survey. The study sample comprised 447 respondents, all of whom reported permanent residency in cities with populations exceeding 500,000 inhabitants. In the Polish context, cities of this size are classified as large urban areas. These cities have well-developed transport systems, including public transport networks. At the same time, transport-related challenges are most pronounced in these cities, significantly impacting residents' quality of life. The selection of the largest Polish cities was further motivated by their substantial investments in zero-emission buses (ZEBs) in recent years. Nevertheless, due to the large fleet sizes, a considerable number of DBs remain in operation. Consequently, residents of these urban areas have daily access to both BEBs and DBs, enabling them to directly compare the two vehicle types in the context of everyday mobility. Therefore, their assessments and perceptions on the differences between DBs and BEBs from a passenger perspective, along with their attitudes toward supporting investments in BEBs, are particularly valuable. Survey participants were recruited from a nationwide, representative research panel comprising approximately 200,000 individuals. A detailed demographic profile of the sample is provided in Table 2.

A proprietary questionnaire, included as Appendix 1 to this article, was developed for the study. Before the primary survey, a pilot test was carried out with a convenience sample of 30 university students. The pilot aimed to evaluate the clarity, relevance, and comprehensibility of all questionnaire items and response scales, as well as to identify potential drop-off points, i.e., questions most likely to be perceived as confusing, ambiguous, or overly complex by respondents. The feedback obtained was used to refine question wording, adjust the order of selected items, and improve the formatting of the response scales to ensure consistency in interpretation. This step was intended to enhance both the face validity and the reliability of the research instrument before its deployment in the main study.

TABLE 2 Characteristics of the Research Sample

Response Category	Count	Percentage (%)
Gender		
Male	154	64.9
Female	290	34.5
Prefer not to define	3	0.7
Age		
18-29 years	128	28.6
30-39 years	109	24.4
40-49 years	75	16.8
50 years and older	135	30.2
Number of passenger cars in the household		
0	80	17.9
1	260	58.2
2	91	20.4
3	12	2.7
4 or more	4	0.9
Main mode of urban travel		
Private car	187	41.8
Train, tram, or metro	77	17.2
Bus or trolleybus	98	21.9
Walking	69	15.4
Bicycle/scooter, etc.	16	3.6
Socio-occupational status		
Retired/Pensioner	57	12.8
Unemployed	21	4.7
Part-time stationary work	31	6.9
Full-time stationary work	222	49.7
Part-time remote/hybrid work	22	4.9
Full-time remote/hybrid work	80	17.9
Self-employed	24	5.4
Studying/Attending school	33	7.4

SOURCE: Own elaboration

RESULTS: PERCEPTION OF KEY ATTRIBUTES OF URBAN BUSES BY CITY RESIDENTS

During the study, respondents were asked to evaluate various types of urban buses with respect to key attributes identified in the literature (Hamurcu & Eren, 2020; Kwon et al., 2020; Palma et al., 2025). Specifically, participants assessed the environmental impact of different vehicle types, the level of noise they generate, the comfort of the ride they provide, and their degree of reliability. In fleet procurement decisions, reliability indicators should play a crucial role. These indicators should be based on reliable and objective data derived from real-world vehicle operations under various topographical, climatic, and urban traffic conditions (Alkubati et al., 2023; Chen et al., 2009; Currie et al.,

TABLE 3 Evaluation of Key Attributes of Urban Buses

Category	Diesel Bus			Electric Bus			Wilcoxon Test	
	Mean	SD	Median	Mean	SD	Median	Test Statistic	P-value
Environmental Impact	3.10	1.70	3	5.28	1.56	6	5866.5	3.45376e-44
Noise Level	3.76	1.68	4	5.45	1.70	6	10975.0	2.09696e-31
Comfort	4.33	1.33	4	5.21	1.31	5	7519.5	7.46171e-23
Reliability	4.42	1.33	4	4.40	1.46	4	23263.0	0.884024
Modernity	3.77	1.57	4	5.66	1.33	6	6498.5	7.215625e-43

Source: Own elaboration

2011). However, subjective perceptions and opinions of users and city residents also warrant consideration, as they can influence both the level of public acceptance of fleet policies and the propensity to use particular bus types. The reliability of public transport services is linked not only to the objective quality of service but also to subjective assessments, including perceived waiting times and the willingness to use public transport for daily travel (Göransson & Andersson, 2023; Li et al., 2010; Yoh et al., 2011).

As indicated by the results presented in Table 3, residents of large Polish cities perceive statistically significant differences between BEBs and DBs across most attributes. DBs were rated as less environmentally friendly, noisier, less comfortable, and less modern than BEBs. In contrast, the two vehicle types received comparable ratings for reliability. Furthermore, the Wilcoxon test confirmed that there were no statistically significant differences in the assessment of BEBs and DBs in terms of their reliability as perceived by city residents.

IMPACT OF BEB TRAVEL EXPERIENCE ON PERCEPTIONS OF KEY URBAN BUS ATTRIBUTES

When analysing public support for BEB investments, it is essential not only to examine differences in the perceived attributes of various bus types but also to identify the factors that shape these perceptions. One such factor may be the actual experience of travelling by BEB, which may significantly influence how these attributes are perceived by users.

As the dataset did not meet the assumptions required for parametric tests, the Kruskal-Wallis test was applied. The results indicate that the experience of traveling by BEBs has a statistically significant impact on respondents' perceptions of most attributes (Table 4). Statistically significant differences were identified for noise generation, ride comfort, modernity, and, to a lesser extent, environmental impact ($p = 0.039$). This means that respondents who have travelled by BEBs rated these features more positively than those without such experience or those unsure whether they had it.

In contrast, no significant differences were found in the assessment of technological reliability ($p = 0.270$), suggesting that actual experience with BEBs does not influence perceptions in this domain. This is likely because attributes such as noise, comfort, and modernity are directly perceived through sensory experience, whereas reliability and environmental impact are assessed primarily on the basis of prior knowledge or beliefs, which may remain unaffected by a single travel experience.

Notably, respondents with experience traveling on BEBs tend to rate them higher across the analyzed attributes. This finding suggests that as the share of BEBs in urban bus fleets increases and a larger share of residents use them regularly, public perception of these vehicles is likely to improve further. Such a shift could strengthen public acceptance and support for investments in electric public transport. Consequently, expanding the BEB share in urban fleets may not only reduce harmful emissions and noise levels in cities but also enhance overall user satisfaction with public transport services.

WILLINGNESS OF CITY RESIDENTS TO SUPPORT INVESTMENTS IN ELECTRIC BUSES

The willingness of city residents to support investments in BEBs was examined using two survey questions. The first question addressed indirect support, measuring the extent to which respondents believed that municipalities should prioritize investments

TABLE 4 The Impact of Traveling by Electric Bus on the Evaluation of Its Key Attributes

Category	Mean (Travelled)	Median (Travelled)	Mean (Not Travelled)	Median (Not Travelled)	U-Statistic	Z-Statistic	p-Value
Environmental Impact	5.338	6	5.112	5	17666.50	2.005	0.039923
Noise Level	5.559	6	5.184	5	16798.00	2.714	0.004921
Comfort	5.332	5	4.912	5	16110.00	3.275	0.000772
Reliability	4.428	4	4.328	4	18810.00	1.072	0.270571
Modernity	5.829	6	5.240	5	15385.00	3.866	0.000061

SOURCE: Own elaboration

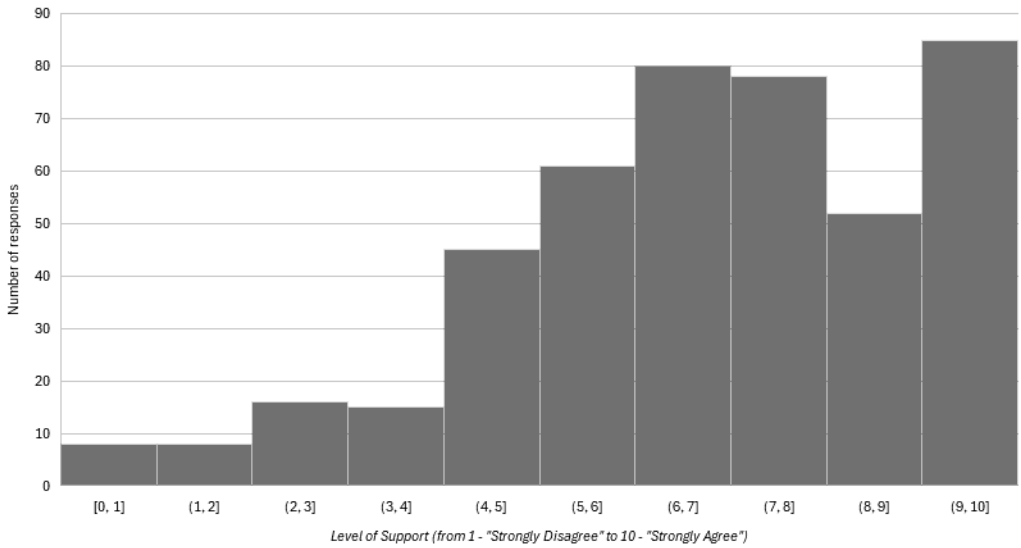

FIGURE 1. Level of Support for Municipal Investment in Zero-Emission Buses (1 = "Strongly Disagree" to 10 = "Strongly Agree")
SOURCE: Own elaboration

in BEBs over DBs. The question was formulated to present a balanced view by outlining both the main advantages and disadvantages of BEBs relative to DBs:

"To what extent do you agree with the statement that cities should invest in zero-emission buses, even if they are more expensive to purchase than diesel-powered buses, considering their lower environmental impact and potentially lower operating costs?" (1 - "Strongly Disagree" to 10 - "Strongly Agree").

Analysis of the response distribution (Figure 1) indicates that residents of Poland's largest cities generally support the integration of BEBs into their urban transport systems. This tendency is consistent across all measures of central tendency. The arithmetic mean of responses stands at 7.19, suggesting a moderately high level of support. The median, at 7, confirms that at least half of the respondents rated their support at this level or higher. Notably, the mode is 10, indicating that a substantial proportion of participants expressed the highest possible level of support.

Respondents expressed support for the adoption of BEBs in urban transport fleets, even though they were aware that these investments entail higher initial costs due to the significantly higher purchase price of BEBs compared to DBs. Market data indicate that BEBs remain approximately 2 to 2.5 times more expensive than DBs at the point of purchase (Dirks et al., 2022; Khan & Onat, 2022; Razy-Yanuv & Meron, 2024; Thorne et al., 2021; Triatmojo et al., 2023; Vijaykumar et al., 2021). Such investments therefore require not only

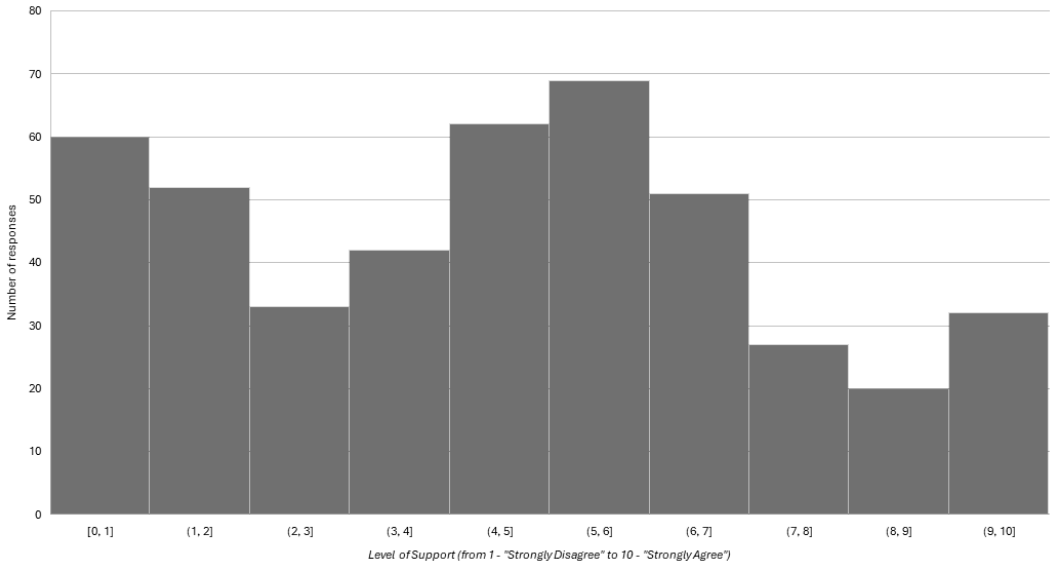

Figure 2. Level of Support for Paying Higher Fares for Zero-Emission Buses (1 = "Strongly Disagree" to 10 = "Strongly Agree")
Source: Own elaboration

public approval but also adequate financial capacity for implementation. Given the financial context of urban bus systems in major Polish cities, it should be noted that these systems already operate with structural funding deficits, as reflected in the low farebox recovery ratios reported in 2023 in Poland's largest urban centres (Urząd Miasta Krakowa, 2024; Urząd Miasta Łodzi, 2024; Urząd Miasta Poznania, 2024; Urząd Miasta Warszawy, 2024; Urząd Miasta Wrocławia, 2024):

- Warsaw (26.3%),
- Kraków (38.6%),
- Wrocław (24%),
- Łódź (34%),
- Poznań (30%).

Given the strong dependence of public transport systems on public subsidies, it is crucial to examine public acceptance of higher ticket prices for BEB journeys compared to DBs. Therefore, the study analyzed not only respondents' declarative support for cities investing in zero-emission buses but also their willingness to bear direct costs through higher ticket prices. The respondents' attitudes toward paying a higher price for tickets on zero-emission buses were assessed using the following survey question:

"To what extent do you agree with the statement that you are willing to pay more for tickets on zero-emission buses to support environmentally friendly transport solutions compared to diesel buses?" (1 - "Strongly Disagree" to 10 - "Strongly Agree").

The results (Figure 2) indicate substantially lower support for higher fares compared to the general endorsement of BEB investments. The central tendency measures for this question were as follows: arithmetic mean – 4.97, median – 5, and mode – 6. These findings suggest that while respondents generally favour the expansion of BEBs as an environmentally friendly public transport option, they are less inclined to incur personal financial costs associated with such investments. The response distribution of responses, along with the relatively high mode, indicates that a certain group of respondents fully accepts the idea of directly contributing to the costs of fleet electrification. On the other hand, the low mean value suggests that this support is not widespread and that further efforts are needed to increase public acceptance and awareness of the advantages of BEBs over DBs.

THE IMPACT OF PERCEIVED FEATURES OF ELECTRIC BUSES ON WILLINGNESS TO SUPPORT FLEET INVESTMENTS

The study also investigated the extent to which residents' willingness to accept higher ticket prices for BEBs is associated with their subjective evaluations of specific vehicle attributes. A strong correlation between these variables would suggest that the willingness to bear additional costs is largely determined by perceived quality benefits of BEBs, which may be experienced during travel.

TABLE 5 Correlation Between Willingness to Directly Fund Electric Bus Fleet Investments and the Perceived Quality of Their Key Attributes

Variable	I am willing to pay more for tickets on zero-emission buses	Environmental Impact	Noise Level	Comfort	Reliability	Modernity
I am willing to pay more for tickets on zero-emission buses	1.00					
Environmental Impact	0.23**	1.00				
Noise Level	0.10*	0.48**	1.00			
Comfort	0.24**	0.54**	0.48**	1.00		
Reliability	0.33**	0.50**	0.24**	0.52**	1.00	
Modernity	0.14**	0.53**	0.43**	0.60**	0.40**	1.00

(* p<0.05, **p<0.01)
SOURCE: Own elaboration

The correlation matrix between the declarative willingness to directly contribute to the costs of zero-emission bus fleet investments and the evaluation of specific BEB attributes is presented in Table 5. The data indicate that while there is a positive correlation between the willingness to pay higher fares and higher ratings of BEB features, this correlation remains weak. Further analysis suggests that acceptance of higher ticket prices is particularly evident among individuals who perceive BEBs as more reliable, offering greater travel comfort, and being more environmentally friendly. These findings align with previous research, which has demonstrated that higher ratings of BEB features are associated with a greater willingness to pay (WTP) for public transport services provided by BEBs (Tan & Lin, 2019).

It is also noteworthy that, regardless of the variation in correlation strength, a consistently positive relationship exists between the evaluations of different quality attributes of BEBs. This suggests that individuals who assign high ratings to one attribute tend to evaluate other attributes favourably as well.

THE IMPACT OF ACTUAL EXPERIENCE TRAVELING BY ELECTRIC BUS ON THE WILLINGNESS TO SUPPORT FLEET INVESTMENTS IN SUCH VEHICLES

The analysis further examined whether actual travel experience with BEBs influences willingness to support investments in these vehicles, either directly (through ticket purchases) or indirectly (through the tax system and public subsidies for public transport). The results presented in Table 6 indicate that having travelled by BEB is statistically significantly associated with the expectation that the city should continue purchasing such vehicles. This relationship may stem from the fact that individuals who are particularly interested in fleet investments are also active users of BEBs. As a result, they perceive investments in BEB fleets as a potential means of improving their own travel comfort.

On the other hand, no statistically significant relationship was found between having travelled by BEB and the declared willingness to pay higher fares for using this type of bus. The findings suggest that simply using BEBs and thus experiencing their advantages, such as reduced noise levels, is not a sufficient factor to encourage users to accept higher ticket prices in exchange for improved service quality.

As part of the study, respondents were also asked to indicate their level of agreement on a five-point scale from "Strongly Agree" to "Strongly Disagree" with the following statement:

"I do not care whether I travel on a zero-emission bus or a diesel bus."

The results, presented in Table 7, show that ap-

TABLE 6 The Impact of Traveling by Electric Bus on Willingness to Provide Direct and Indirect Support for Investments in Electric Buses

Category	Mean (Travel)	Median (Travel)	Mean (No Travel)	Median (No Travel)	U-Statistic	Z-Statistic	p-Value
I am willing to pay more for tickets on zero-emission buses	5.05	5	4.81	5	19298.00	0.678871	0.497220
Cities should invest in zero-emission buses	7.46	8	6.58	7	15386.00	3.911062	0.000092

SOURCE: Own elaboration

TABLE 7 Preferred Mode of Urban Transport and Level of Agreement with the Statement: "I Do Not Care Whether I Travel on a Zero-Emission Bus or a Diesel Bus"

Preferred Mode of Transport	Strongly Disagree	Somewhat Disagree	Neutral/No Opinion	Somewhat Agree	Strongly Agree	Total
Public Transport	43 (20.7%)	71 (34.1%)	42 (20.2%)	39 (18.8%)	13 (6.3%)	208
Other than Public Transport	33 (13.8%)	55 (23.0%)	63 (26.4%)	70 (29.3%)	18 (7.5%)	239
Total	76 (17.0%)	126 (28.2%)	105 (23.5%)	109 (24.4%)	31 (6.9%)	447

SOURCE: Own elaboration

proximately 45% of respondents disagreed with this statement, suggesting a clear preference for one bus type over another. Meanwhile, around 31% of respondents agreed, indicating that they had no strong preference between BEBs and DBs. The study also investigated whether indifference toward bus type is associated with respondents' transport behaviour. A chi-square test (χ^2) was conducted to assess the relationship between the preferred mode of transport (public transport vs. other modes) and attitudes toward BEBs compared to DBs. The analysis revealed a statistically significant relationship between these variables: Chi-square statistic (χ^2 = 15.09, p-value = 0.0045.)

These results indicate that frequent public transport users are less likely to agree that the type of bus they travel on is irrelevant. This finding further supports the conclusion that those who benefit most from BEBs in their daily travel are also the most supportive of investments in such vehicles.

DISCUSSION AND CONCLUSIONS

This article has examined how residents of Poland's largest cities perceive BEBs compared to DBs, emphasizing the crucial role of public acceptance in the ongoing transformation of public transport. These considerations are particularly relevant in light of current national and European transport policies, which prioritize a rapid transition from conventional diesel-powered vehicles to zero-emission alternatives, primarily BEBs.

Regarding RQ1, which concerned the extent to which residents of Polish cities recognize differences between various types of urban buses, the results show that respondents recognize positive differences between BEBs and DBs in key aspects relevant to urban residents and public transport passengers. These aspects include noise levels, travel comfort, modernity, and environmental impact. Notably, respondents did not express significant concerns about the reliability of BEBs compared to DBs, as the assessment of this feature was similar for both types of vehicles. The differences in reliability ratings were found to be statistically insignificant.

As for RQ2, which asked whether actual experience of traveling on an electric bus influences the evaluation of its specific attributes, the respondents who had travelled on BEBs provided higher ratings, particularly in comfort, modernity, and environmental performance. This finding suggests that greater exposure to BEBs within urban fleets may further enhance perceptions of service quality. The implementation of this policy is reflected in the fleet strategies of Polish cities, which are increasingly shifting away from purchasing conventional DBs in favour of more environmentally friendly alternatives. However, it is important to note that decisions regarding the acquisition of BEBs are largely driven by targeted national and European funding programs. The evaluation of these investments, measured by public satisfaction with transport services and willingness to use public transport, largely depends on whether BEBs are perceived as more attractive, comfortable, and beneficial than their diesel counterparts.

With respect to RQ3, which investigates whether residents of Polish cities support fleet policies that prioritize investments in electric vehicles, the findings reveal broad approval for municipal strategies favouring BEBs over DBs. However, this support is substantially constrained by economic considerations. While the majority of respondents express the expectation that municipalities should invest in BEBs, most are unwilling to accept fare increases as a means of financing such investments. In practical terms, this indicates that respondents endorse the purchase of BEBs only insofar as the associated costs do not directly affect them through higher ticket prices.

Turning to RQ4, which addresses whether support for investments in electric buses depends on the frequency of public bus use, the results confirm this relationship. Frequent public transport users demonstrate stronger support and a greater willingness to contribute financially than occasional users. This suggests that those who stand to benefit most from investments in modern, zero-emission bus fleets (regular passengers) are also the most inclined to advocate for and participate in the funding of such initiatives.

When assessing the role of zero-emission buses in sustainable urban development, it is essential to consider not only their advantages and public perception but also the cost of fleet investments and their potential impact on fare policies. On the one hand, numerous studies have demonstrated that public transport services exhibit low price elasticity of demand (Brechan, 2017; Fearnley et al., 2017; Offiaeli & Yaman, 2023; Vasudevan et al., 2021; Yaman & Offiaeli, 2022). This means that an increase in ticket prices results in a less than proportional decrease in demand for these services. On the other hand, the findings of this study align with previous research, which has shown that respondents in survey-based studies exhibit low willingness to accept higher ticket prices to fund zero-emission bus investments (Hidrue et al., 2011; Ito et al., 2013; Lin & Tan, 2017; O'Garra et al., 2007; S. Wang et al., 2023). However, the willingness to pay for BEBs is higher in (Lin & Tan, 2017; O'Garra et al., 2007; Son et al., 2022; S. Wang et al., 2023):

- Highly developed countries,
- Individuals with higher income levels,
- People with strong environmental awareness,
- Frequent public transport users,
- Individuals with higher education levels.

These findings suggest that fare policies for bus systems investing in BEBs should take into account both the low price elasticity of demand for public transport services and the low willingness of users to accept higher fares to support zero-emission fleet development. In practice, this means that financial mechanisms should be implemented to limit the burden on passengers resulting from fleet investments (e.g., utilizing non-repayable external grants). At the same time, there should be a stronger focus on promoting the environmental and social benefits of fleet electrification (Wołek et al., 2021). By doing so, stable funding for investments can be ensured without the risk of excessive declines in public transport demand due to fare increases.

While city residents may not have expert knowledge about the economic or environmental efficiency of electric buses, it is crucial to research public perception and acceptance of these vehicles to ensure successful implementation of e-mobility solutions. Such studies are important for assessing how much residents expect local authorities to invest in zero-emission fleets and the potential impact of these investments on shifting transportation modes, particularly in terms of increasing public transport usage or slowing its decline. Additionally, these studies evaluate public awareness of the advantages of electric buses compared to conventional ones, focusing on measurable factors like emissions, noise, and public health, as well as more subjective aspects such as travel comfort. By identifying gaps in knowledge, effective information and education campaigns can be developed to enhance public understanding and acceptance of the shift toward zero-emission transport. Ultimately, these findings serve as a valuable resource for local governments and transport policymakers, aiding them in making informed strategic decisions.

Several limitations should be acknowledged. First, the study sample was limited to residents of Poland's largest cities, defined as those with populations exceeding 500,000. While this focus ensured relevance to urban areas with well-developed public transport

systems and significant ongoing BEB investments, it limits the generalisability of findings to smaller cities and rural areas. Future research should therefore consider increasing the sample size and including a more representative range of settlement types to strengthen the ability to draw conclusions for the general population. Second, the data were collected via an online CAWI survey, which, while efficient, may be susceptible to sampling bias despite the use of a large and diverse national panel. Third, the cross-sectional design precludes causal inferences regarding the relationship between travel experience and attitudes toward BEBs. The study sample, while diverse, shows certain deviations from the demographic structure of the general Polish population. Younger age groups (18–39 years) are overrepresented, whereas the share of respondents aged 50 and above is lower than in national statistics. Additionally, the sample comprises 64.9% male, 34.5% female, and 0.7% respondents who preferred not to define their gender, which differs from the population's gender distribution. These imbalances may influence the generalisability of the findings and should be considered when interpreting the results.

Future research should consider longitudinal approaches to assess how perceptions evolve as BEB penetration increases and as users accumulate more travel experience. Comparative studies across different socio-economic and cultural contexts, both within and beyond Central Europe, would also help to refine understanding of the determinants of public acceptance and willingness to pay for zero-emission buses.

This study demonstrates that BEBs enjoy generally positive public perceptions in Poland's largest cities, particularly in terms of comfort, noise reduction, modernity, and environmental benefits, and that these perceptions are enhanced by direct travel experience. However, there is an apparent discrepancy between general support for BEB investments and willingness to finance them through higher fares. For policymakers, these findings highlight the need to combine investment in zero-emission fleets with strategies to improve experiential familiarity, targeted public communication, and diversified funding mechanisms. The findings of this study carry important implications for local transport policy and investment strategies. Efforts to promote BEBs should focus on increasing opportunities for residents to experience these vehicles directly, as such encounters can foster more favourable perceptions, particularly with respect to comfort, noise reduction, and modernity. Given the relatively low willingness among the public to accept higher ticket prices, municipalities should give priority to securing external funding sources, including non-repayable grants from national and European Union programs, in order to reduce the financial burden on passengers. At the same time, public communication and educational initiatives should highlight both the environmental and service quality benefits of BEBs, addressing existing gaps in public understanding of their role in advancing sustainable urban development. Finally, investments in BEBs should be embedded within broader sustainable mobility strategies aimed at reducing dependence on private cars, improving air quality, and ensuring equitable access to transport.

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APPENDIX 1: QUESTIONNAIRE

Please rate how you perceive the following features of diesel buses.

- Noise generated (1: Very loud – 7: Very quiet)
- Ecology (1: Very non-ecological – 7: Very ecological)
- Travel comfort (1: Very uncomfortable – 7: Very comfortable)
- Technological reliability (1: Very unreliable – 7: Very reliable)
- Modernity (1: Very outdated – 7: Very modern)

Please rate how you perceive the following features of electric buses.

- Noise generated (1: Very loud – 7: Very quiet)
- Ecology (1: Very non-ecological – 7: Very ecological)
- Travel comfort (1: Very uncomfortable – 7: Very comfortable)
- Technological reliability (1: Very unreliable – 7: Very reliable)
- Modernity (1: Very outdated – 7: Very modern)

Please rate how you perceive the following features of hydrogen buses.

- Noise generated (1: Very loud – 7: Very quiet)
- Ecology (1: Very non-ecological – 7: Very ecological)
- Travel comfort (1: Very uncomfortable – 7: Very comfortable)
- Technological reliability (1: Very unreliable – 7: Very reliable)
- Modernity (1: Very outdated – 7: Very modern)

Have you used the following modes of transport in the past year?

Bus type	Yes	No	Don't know
Diesel bus			
Electric bus			
Hydrogen bus			

Please indicate how strongly you agree or disagree with the following statements:

Statements	Strongly disagree	Rather disagree	Don't know / No opinion	Rather agree	Strongly agree
All buses in the city should be zero-emission (electric and/or hydrogen)					
Decisions on zero-emission bus purchases should be based solely on economic reasons					
Decisions on zero-emission bus purchases should be based solely on environmental reasons					
New zero-emission buses should be purchased as quickly as possible					
Decisions on zero-emission bus purchases should be based equally on environmental and economic reasons					
It is acceptable to damage the natural environment if it brings significant economic benefits					
It is acceptable to damage the natural environment if it brings significant social benefits (e.g., income equality, poverty reduction)					

Statements	Strongly disagree	Rather disagree	Don't know / No opinion	Rather agree	Strongly agree
It is acceptable to trigger an economic recession if it brings significant environmental benefits					
It is acceptable to trigger an economic recession if it brings significant social benefits					

What percentage of your urban travel do you make using the following modes? (Sum should be 100%)

- Private car
- Bus or trolleybus
- Train, tram or metro
- Walking
- Bicycle / scooter, etc.

How do you assess your knowledge about public transportation offerings?
Scale: 1 to 10
1 = I know nothing: I don't know where stops are, which lines reach my destination, or what tickets exist or cost
10 = I have in-depth knowledge: I know all the stops I use, the line routes and schedules, and what tickets I can buy, where and for how much

What should be the maximum price (in PLN) for a single ticket for a ride on a diesel-powered bus?

What should be the maximum price (in PLN) for a single ticket for a ride on an electric bus?

What should be the maximum price (in PLN) for a single ticket for a ride on a hydrogen bus?

To what extent do you agree or disagree with the following statement?: "Cities should invest in zero-emission buses, even if they are more expensive than diesel buses, considering their lower environmental impact and potentially lower operating costs."
Scale: 1: Strongly disagree – 10: Strongly agree

To what extent do you agree or disagree with the following statement?: "I'm willing to pay more for zero-emission bus tickets to support eco-friendly transportation solutions compared to diesel buses."
Scale: 1: Strongly disagree – 10: Strongly agree

Please indicate which type of city bus you prefer.
(3 = no preference, 1 & 5 = strong preference, 2 & 4 = moderate)

- Electric vs Hydrogen bus
- Electric vs Diesel bus
- Hydrogen vs Diesel bus

e and company-owned cars do you and your household own?

Do you have a driving license?

- Yes
- No

How many people live in your household?

What is your socio-professional status? (Multiple answers allowed)

- I work full-time on-site
- I work part-time on-site
- I work full-time remotely or hybrid

- I work part-time remotely or hybrid
- I study
- Retired / Pensioner
- I am self-employed
- I am unemployed

What is your average net (take-home) income per household member? (Optional)
- Less than 500 PLN
- 501–1000 PLN
- 1001–2000 PLN
- 2001–3000 PLN
- 3001–4000 PLN
- 4001–5000 PLN
- 5001 PLN and more

Gender:
- Male
- Female
- Prefer not to say

Age
- 18–29 years
- 30–39 years
- 40–49 years
- 50 years and over

Size of locality
- Village or town up to 20,000 inhabitants
- Town over 20,000 up to 100,000 inhabitants
- City over 100,000 up to 200,000 inhabitants
- City over 200,000 up to 500,000 inhabitants
- City over 500,000 inhabitants

JAVNA PERCEPCIJA I PRIHVAĆANJE ELEKTRIČNIH AUTOBUSA MEĐU STANOVNICIMA URBANIH PODRUČJA U POLJSKOJ

SAŽETAK

Elektrifikacija autobusnog voznog parka ključan je element transformacije prometnih sustava u mnogim gradovima diljem svijeta. Taj proces uključuje značajna ulaganja u vozila i infrastrukturu. S obzirom na mehanizme financiranja javnog prijevoza, od presudne je važnosti da ulaganja u električne autobuse uživaju široku javnu potporu. U kontekstu postizanja ciljeva održivog razvoja, povećanje udjela javnog prijevoza na račun individualne automobilske mobilnosti posebno je važno. Kako bi se taj pomak ostvario, nužno je da stanovnici gradova prepoznaju prednosti korištenja električnih autobusa u odnosu na konvencionalna vozila. Cilj ovog istraživanja jest procijeniti percepciju javnosti o elektrifikaciji autobusnog voznog parka te odrediti razinu potpore tom procesu. Analiza obuhvaća i neizravnu potporu, koja se očituje u prihvaćanju komunalnih ulaganja u električna vozila, i izravnu potporu, mjerenu spremnošću na podnošenje viših troškova putovanja električnim autobusima. Rezultati pokazuju da stanovnici velikih poljskih gradova električne autobuse doživljavaju kao znatno ekološki prihvatljivije, tiše, udobnije i modernije u odnosu na dizelske autobuse, dok oba tipa vozila slično ocjenjuju u pogledu pouzdanosti. Iskustvo putovanja električnim autobusima pozitivno utječe na procjenu navedenih atributa. Ispitanici su izrazili umjereno visoku razinu neizravne potpore ulaganjima u električne autobuse, dok je njihova spremnost na prihvaćanje viših cijena karata bila niža. Uočene su slabe, ali pozitivne korelacije između spremnosti na plaćanje više i viših ocjena obilježja električnih autobusa, osobito u pogledu pouzdanosti, udobnosti i ekološkog učinka. Također, iskustvo putovanja električnim autobusima bilo je pozitivno povezano s očekivanjem da gradovi nastave ulagati u takva vozila, ali ne i s većom spremnošću na plaćanje viših cijena karata. Nadalje, učestali korisnici javnog prijevoza značajno su rjeđe bili ravnodušni prema vrsti autobusa kojim putuju, što sugerira da su najsnažniji zagovornici električnih autobusa upravo oni koji ih svakodnevno koriste. Ovi nalazi pružaju empirijski uvid u odrednice javnog prihvaćanja ulaganja u električne autobuse (BEB) te ističu važnost i iskustvenih čimbenika i percipiranih obilježja vozila u oblikovanju društvene potpore javnom prijevozu s nultom emisijom.

KLJUČNE RIJEČI: *električni autobusi, prometne preferencije, urbana mobilnost, prometna politika u gradovima, prihvaćanje od strane korisnika.*