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Low emission zones in Poland: a synthetic review of evidence, regulatory frameworks, and implementation experiences

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Abstract. This article addresses the issue of implementing low emission zones (LEZs) in Poland against the backdrop of European experiences. Its aim is to diagnose the state of implementation, discuss the evolution of legal frameworks, and synthesize domestic contributions in comparison with international research. The analysis is based on a narrative review of literature and normative documents, with the selection limited to works concerning Polish conditions after 2018. Within the European Union context, LEZs remain a relatively new instrument in Poland, and evidence gaps primarily concern the assessment of the effects of restrictions, changes in air quality, and transport behaviors. The analysis of legal frameworks shows that the 2018 Act has been amended multiple times; the key amendment of 2024 linked the obligation to establish LEZs to exceedances of permissible nitrogen dioxide levels in cities with more than 100,000 inhabitants, while maintaining the possibility for municipalities to introduce zones voluntarily. Currently, one LEZ operates in Warsaw (since July 2024), while other large cities are at various stages of the process, from preparation and consultations to legal disputes and temporary suspension of work. The literature review indicates that domestic publications focus on legal conditions and the rationale for intervention, whereas foreign studies more broadly analyze health impacts, environmental effectiveness, emission relocation phenomena, cost-benefit distribution, and social acceptance. Key research gaps have been identified: the need for *ex ante* and *ex post* procedures, data triangulation (air quality, traffic intensity, mobility), distributional analyses, and studies on risk communication and acceptance mechanisms. Practical implications include prioritizing monitoring, phasing restrictions, adapting access criteria to local contexts, and linking LEZs with parking policies, public transport development, and active mobility.

Keywords: low emission zones (LEZs), air quality, urban mobility, transport policy, legal frameworks, Poland.

Introduction

A noticeable trend in Europe is the steady increase in the number of passenger cars. This process can be analyzed using the motorization rate, which indicates the number of passenger cars per 1,000 inhabitants. Between 2015 and 2024, the motorization rate grew by an average of approximately 14% across the vast majority of European Union (EU) member states[1] (Eurostat, 2025). It should be noted, however, that these increases vary in intensity. Countries such as Austria, Belgium, and France recorded only modest growth of around 3%, whereas Lithuania, Croatia (about 40%), and Romania (around 70%) significantly exceeded the European average. One possible explanation for this wide disparity

[1] The exceptions are Malta (a decrease in the number of cars by 5.9%) and Sweden (a decrease by 0.8%).

lies in the initial motorization levels in 2015. For instance, Romania's rate was twice as low (261) as the European average (508), while France's was higher (558).

Poland occupies a relatively high position in this ranking, with an increase of 32%. At the same time, initial data from 2015 show that Poland's motorization rate (474) was close to the European average (508). Nearly a decade later, in 2024, it reached 629, surpassing the EU average by 50 units and ranking sixth among European countries[2]. This phenomenon is confirmed by a study conducted by Statistics Poland (SP) on travel patterns by mode of transport and household location. More than half of respondents (approximately 60%) indicated that the dominant mode of transport in the identified modal split was the passenger car (travel as a driver or passenger) (Statistic Poland, 2025a). It is worth noting that trips made by rail, buses (urban or coaches), and bicycles accounted for only about 15% in total. This highlights a significant imbalance in transport choices and the central role of the passenger car in respondents' mobility.

In Polish urban centers, individual transport plays a dominant role in shaping residents' mobility. The reasons for this situation can be traced to economic development, which translates into growing car availability, the affordability of vehicles on the secondary market, and the process of suburbanization (Mężyk & Zamkowska, 2019; Wójcik, 2022). Undeniable advantages of a high motorization rate include speed and flexibility, while its drawbacks encompass excessive pollutant emissions, noise, and congestion. These negative phenomena intensify in city centers, where traffic volumes are particularly high. The decline in the attractiveness and significance of European city centers has led to depopulation of central areas and a lack of interest in their offerings, ultimately resulting in the emergence of crisis zones (Bernaciak, 2015; Brzosko-Sermak, 2023). These factors correspond to the causes of population migration to suburban areas (Michalak & Szyja, 2025). Urban sprawl is a complex process characterized by the deconcentration of population and services. It increases the number of vehicles, especially in inner-city areas, and reinforces the dominance of individual car transport within the urban transport system (Kudłacz & Karwińska, 2021; Michalak & Szyja, 2025)[3]. This results from the inability to meet all needs in one location, as commuting from suburbs to the city center typically serves basic purposes (e.g., education, work), given the concentration of services there (Mężyk & Zamkowska, 2019; Wójcik, 2022). Peripheral areas often remain underinvested because, from the perspective of municipal authorities, creating new public transport connections proves economically unviable. From the perspective of municipal authorities, creating new public transport connections may prove economically and institutionally challenging, particularly in metropolitan areas characterised by suburbanisation processes. This problem concerns especially suburban municipalities, which are often not directly affected by the costs of congestion, air pollution, parking pressure, or traffic accidents generated in the central city and therefore may have limited incentives to co-finance transport connections to urban centres. This leads to a reduced bus network

[2] To compare the years 2015-2024, the author used Eurostat data for Poland. This approach was motivated by the removal by the Central Register of Vehicles and Drivers in Poland of cars that had not been insured or subjected to periodic inspections for the past 10 years. This led to a significant discrepancy in Statistics Poland data between 2023 and 2024.

[3] A transport system can be defined as a set of interconnected technical, organizational, and human elements enabling the efficient movement of people and goods in space (Grinke, 2012; Mężyk & Zamkowska, 2019). It forms a coherent organism in which, similar to a living organism, the failure of one part (lack of alternative means of transport) threatens the others (occurrence of congestion).

offer – fewer routes, greater distances between stops, and the exclusion of certain social groups (Wójcik, 2022). Transport exclusion is a serious issue affecting both rural and sparsely urbanized areas (Rosik et al., 2018; Borowska-Stefańska et al., 2019; Hoff & Izdebski, 2022; Sydorów, 2024). Consequently, the most efficient means of transport remain individual ones, with the passenger car being the most popular choice. Some researchers point to the phenomenon of forced motorization, prevalent in rural areas, which can be described as the choice of a passenger car as the primary mode of transport due to the lack of available alternatives (Ciechański, 2020; Koliński, 2021; Fiedeń, 2024).

Various measures are being implemented to counteract the negative effects of transport. Among them is the Sustainable Development Agenda adopted by the United Nations General Assembly in 2015, whose objectives align with the concept of sustainable transport and, more broadly, sustainable mobility (United Nations, 2015). Mobility means moving from one place to another in order to meet one's needs. For individuals, it depends on numerous factors, including age (Borowska-Stefańska & Wiśniewski, 2019; Ciechański, 2020), the availability and quality of transport services (Tomanek, 2017), motorization rate, wealth, and lifestyle (Janczewski & Janczewska, 2021). Balancing mobility involves traveling in a way that generates the lowest possible costs, understood as an incurred expense or time loss (Kamiński, 2021; Beim et al., 2023). This can be achieved through the concept of intermodal transport, which diversifies modes of transport to reduce expenses, shorten travel time, and increase comfort (Janczewski & Janczewska, 2021; Kamiński, 2021; Beim et al., 2023).

Other initiatives present in cities include paid parking zones (PPZs), aimed at reducing car traffic and improving the availability and organization of parking spaces (Kubala & Kulpa, 2015). A more restrictive measure, whose primary goal was to improve air quality, was the low emission zone (LEZ) introduced in the city center of Stockholm in 1996, the first in Europe (Holman et al., 2015; Pawłowski, 2022; Bergeling, 2024; Bulanda & Dziedzic, 2024). A case study conducted by Bergeling (2024) indicates that the LEZ in this city was gradually expanded over decades, applying increasingly stringent requirements. Following this successful transport policy, other European cities adopted similar measures, with the trend intensifying after 2006 (Pawłowski, 2022). As a result, some LEZs in Western Europe have been in operation for decades (e.g., Rome since 2001, Lisbon since 2011, Paris since 2015, and Madrid since 2018-Donggyun et al., 2020). The effects of implementing transport policies and their impact on urban transport systems have been studied in cities such as Rome (Cesaroni et al., 2011), Lisbon (Ferreira et al., 2012), Paris (Bernard et al., 2020), and Madrid (Cárdenas-Montes, 2020). It should also be noted that LEZs in European countries exist in various forms, under different names, and often with distinct regulations governing their operation. This diversity stems from the adaptation of transport policies to local conditions. For example, in Italy, a LEZ is referred to as *zona a traffico limitato*, in Germany as *die Umweltzone*, and in France as *zones à faibles émissions mobilité* (Bulanda & Dziedzic, 2024)[4]. In Poland, the introduction of such zones is regulated by the Act of 11 January 2018 on Electromobility and Alternative Fuels. According to this law, the purpose of LEZs is to ensure the sustainable development of electromobility and to create

[4] For this reason, Polish literature sometimes uses literal translations, such as "low emission zone", especially before 2018. Due to the legislator introducing the possibility of establishing strefa czystego transportu (clean transport zone) , which in principle is synonymous with the English term low emission zone or zero emission zone, the author will refer to this transport policy as low emission zone or by the abbreviation LEZ.

a foundation for the widespread use of alternative fuels, as well as to reduce the negative impact of transport-related pollutant emissions on human health and the environment. The term electromobility encompasses "all technical and operational aspects of electric vehicles, as well as charging technology and infrastructure" (Beim et al., 2023, p. 238). Under the provisions of the Act, a municipal council may establish an LEZ within its territory for a period of no less than five years. The adopted resolution specifies the zone's boundaries, traffic organization, methods of disseminating the resolution's content, and any fees for entry by vehicles other than those permitted[5].

In Poland, unlike in other EU countries, LEZs are a new element of urban transport systems, which underscores the innovative nature of research conducted on this topic. The legal act regulating LEZs dates back to 2018, and currently only one zone has been implemented in Warsaw (Act of 11 January 2018 on Electromobility and Alternative Fuels, 2018). A noticeable research gap also exists, resulting from a lack of information on the actual impact of LEZs under national conditions. Currently, there is a shortage of data on the effects of introducing restrictions, changes in air quality (before and after zone implementation), impacts on residents' mobility, and shifts in transport behavior. For this reason, the aim of this article, exploratory in nature, is to diagnose the current state of implementation and operation of LEZs in Poland, as well as to analyze and evaluate research conducted in this area.

Materials and methods

This article employs a mixed methodological approach combining legal analysis, comparative policy analysis, a literature review and a review of statistical and strategic planning documents related to the implementation of LEZs in Poland. The study is based primarily on an analysis of national legal acts, draft legislative amendments, local government resolutions, municipal policy documents, air quality protection programmes, transport strategies, and publicly available transport and environmental datasets. Particular attention was paid to the evolving legal framework governing LEZ implementation in Poland and the institutional conditions affecting the capacity of municipalities to introduce and enforce such measures. The research also includes a comparative assessment of selected Polish cities that have introduced or considered introducing LEZs, with a focus on the legal, institutional, transport-related, and socio-economic determinants shaping implementation processes. The selection of case studies was based on the relevance of individual cities to the national debate on LEZs, the availability of regulatory measures and public policy documents, as well as the visibility of public and political discussions concerning clean transport policies. The analysis additionally considered differences in local governance structures, transport systems, and levels of social acceptance for transport restrictions. The literature review included open-access articles retrieved using Google Scholar, Scopus and Web of Science. The search was conducted using the following terms "low emission zone (LEZ)" and the Polish phrase "strefa czystego transportu (SCT)". The search

[5] These include electric vehicles, hydrogen-powered and natural gas-powered vehicles, as well as vehicles specified as exceptions by the municipality. The legislator also listed several categories of vehicles exempt from the entry ban, including those belonging to the police, fire brigade, emergency services, armed forces, Chief Inspectorate of Environmental Protection, and the Prime Minister, among others.

covered publications from 2018 to 2025, as 2018 marked the adoption of the Electromobility and Alternative Fuels Act in Poland (Act of 11 January 2018 on Electromobility and Alternative Fuels, 2018). Subsequently, the author subjectively selected articles that referred to Polish conditions. Acknowledging the existence of advanced tools for literature searches, the study notes its limitations and the potential incompleteness of the review. Furthermore, due to the limited number of available publications (twelve articles), none were omitted in compiling the literature review. The legal analysis presented in this article reflects the state of legislation as of 31 October 2025, while publicly available data were collected up to the same date.

Literature review and discussion

Low emission zone – principles of operation

Among the challenges faced by contemporary cities, combating air pollution is a critical issue not only for the natural environment. Toxic substances contained in exhaust fumes pose a threat to human health and can lead to numerous diseases (Watkins et al., 2024). According to a report prepared by The Intergovernmental Panel on Climate Change (IPCC) greenhouse gases (GHG) emissions in 2019 were highest in the energy sector (34%), followed by industry (24%), agriculture (22%), and transport (15%) (IPCC, 2022). In this comparison, the transport sector does not appear dominant; however, the report also highlights average annual GHG growth rates between 2010 and 2019. It turns out that in energy, the growth rate declined compared to the previous decade (from 2.3% to 1%), and similarly in industry (from 3.4% to 1.4%). Only the transport sector maintained a steady growth rate of 2%. As indicated by the European Environment Agency (EEA), fuel combustion in road transport is a common source of harmful emissions: nitrogen dioxide (NO_2) and particulate matter (PM_{10} and $PM_{2.5}$). In 2019, the transport sector accounted for 46.6% of nitrogen oxide (NOx) emissions and 12% of particulate matter emissions in EU countries (EEA, 2022). These pollutants are particularly problematic in densely urbanized areas because combustion occurs close to the ground, reducing the dilution effect in the air (EEA, 2022). Similar conclusions are presented in a report by The Chief Inspectorate for Environmental Protection (CIEP), which notes that the concentration of car traffic in central urban areas (characterized by dense street networks and high traffic volumes) leads to increased emissions. It was also found that in Poland, in 2024, road transport contributed to elevated emissions of NO_2, PM_{10}, $PM_{2.5}$, and ozone (O_3It should be mentioned that a significant share of PM_{10} originates from individual sources in the municipal-residential sector (heating and domestic purposes). According to the CIEP report, road transport is the second-largest source category for national PM_{10} emissions (CIEP, 2025).

Emissions from transport are considered harmful because they negatively affect human health. According to the World Health Organization (WHO), air polluted with PM_{10}, NO_2, and similar substances increases morbidity and mortality from cardiovascular and respiratory diseases, as well as heightens the risk of premature births and other causes of death among children and infants. An analysis of data at the European level indicates that Poland ranks among the leading countries in terms of emissions related to road transport (Eurostat, 2022). In a dataset prepared by Eurostat estimating the number

of premature deaths attributed to long-term exposure to $PM_{2.5,}$ Poland ranked second out of 37 countries included in the statistics in 2022 (Eurostat, 2023).

To reduce the negative impact of particulate matter and other compounds, LEZs began to be introduced in Europe in 1996. Regardless of their location, a common element defining an LEZ is the temporal and spatial restriction on the entry of vehicles that do not meet specified exhaust emission standards into areas with significant traffic intensity (Pawłowski, 2022; Borowska-Stefańska et al., 2024; Bulanda & Dziedzic, 2024; Watkins et al., 2024). The time component in this description refers to the period during which entry into the zone is permitted for vehicles otherwise subject to restrictions. The spatial scope of an LEZ typically covers the city center, although its boundaries may change depending on the implementation stage. The criteria for allowing vehicles into the zone include, among others, year of manufacture, type of fuel (petrol engine, diesel engine, including LPG), and the level of pollutant emissions defined by EURO standards. These requirements necessitate adapting the city's transport system to new conditions. The universal goal of creating low emission zones is considered to be the permanent reduction of air pollution (Ferreira et al., 2012; Tarriño-Ortiz et al., 2022).

For this reason, the vast majority of studies on LEZs focus on their effectiveness in reducing transport-related pollutant emissions. As it turns out, initial results are not always conclusive. After three months of LEZ operation in Seville, no improvement in air quality was observed (Pastor-Fernández et al., 2025). In contrast, in Grenoble, France, the introduction of an LEZ produced an unexpected effect: restrictions that forced drivers to choose alternative routes outside the zone led to increased traffic on the outskirts of the city center. Consequently, particulate matter concentrations decreased locally, while air quality deteriorated across the entire city (Fosset et al., 2016). In London, prior to the implementation of an LEZ in 2008, the city recorded the highest NO_2 concentrations in Europe (Broster & Terzano, 2025), mainly attributed to vehicle exhaust emissions. Initial studies indicated limited effectiveness of the LEZ (Ellison et al., 2013), a finding confirmed by subsequent research (Wood et al., 2015). Only the study conducted by Prieto-Rodriguez et al. (2022) confirmed a significant reduction in NO_2 and $PM_{2.5}$ concentrations, achieved after the introduction of a more restrictive form of LEZ known as the Ultra Low Emission Zone (ULEZ). A similar situation occurred in Amsterdam, where greater reductions were observed during the second stage of LEZ implementation (Panteliadis et al., 2014). In Lisbon, the expansion of the zone combined with stricter emission policies resulted in reductions of PM_{10} and NO_2 by more than 20% (Ferreira et al., 2015; Faria et al., 2017; Santos et al., 2019). The effectiveness of reducing exhaust emissions through LEZ implementation is further confirmed by case studies from European cities, Rome (Cesaroni et al., 2011), Munich (Fensterer et al., 2014), as well as Asian cities such as Seoul (Park et al., 2024) and Tokyo (Kang et al., 2024).

Improving air quality through the introduction of low emission zones has a measurable impact on public health. Low-emission transport reduces air pollution and noise, improves quality of life, and enhances urban mobility (Wieczorek, 2021). In London, a decline in diseases associated with air pollution has been documented (Broster & Terzano, 2025). Similarly, Valdés et al. (2025) observed that adolescents living within a local LEZ achieved better academic performance. Establishing a zone can also influence changes in residents' travel behavior, including modal split and route choice (Borowska-Stefańska et al., 2024). As demonstrated in a study by Xiao et al. (2024), children who previously commuted

to school by car switched to bicycles after the introduction of an LEZ. The implementation of a zone may also affect other urban subsystems. For example, LEZs can improve living conditions in city centers, but there is a risk that adaptation costs will be borne by lower-income residents or shifted to areas outside the zone[6]. This may lead to justified resistance from stakeholders toward unpopular measures (Sfendonis et al., 2017; Tarriño-Ortiz et al., 2022). Barriers may include apathy or reluctance among residents due to the need to purchase new vehicles that meet emission standards. LEZ implementation may also contribute to social inequalities and mobility disadvantages, particularly among lower-income groups that rely on older vehicles for everyday travel and lack adequate transport alternatives. In such cases, restrictions on vehicle use may indirectly reduce accessibility to employment, education, or public services (De Vrij & Vanoutrive, 2022; Borowska-Stefańska et al., 2024). As Watkins et al. (2024) note, a key condition for successful LEZ adoption by decision-makers is understanding the local context. This can be achieved through public consultations, collecting data on available public transport fleets, and monitoring air quality checkpoints. LEZ implementation should not be treated solely as a technical process, as improperly transferring solutions from other cities may lead to conflicts and social inequalities. Therefore, gaining public acceptance and gradually introducing regulations is essential to allow everyone the opportunity to adapt.

The literature reviewed indicates that LEZs, are not merely a response to improving urban air quality. They align with broader concepts in social sciences advocating for: reducing exhaust emissions; diversifying transport modes; decreasing the dominance of private cars in favor of public transport, walking, and cycling; promoting pedestrian-friendly urban spaces; and striving in the long term to return cities to people. The introduction of LEZs supports the idea of a compact city by reducing greenhouse gases and minimizing car use, which addresses the crisis of city centers in Polish metropolitan areas. LEZs may contribute to broader sustainable mobility objectives by incentivising a shift from private car use towards public transport and active mobility. As a result, they can support the development of more pedestrian- and cyclist-friendly urban spaces. While LEZs should not be equated with transit-oriented development (TOD), they may nevertheless complement selected TOD-related objectives, particularly those associated with reducing car dependency and promoting integrated urban transport systems (the same postulates can be found in the New Athens Charter and in the concept of smart growth). Consequently, they aim to fulfill Goal 11 of the United Nations Sustainable Development Agenda (UN, 2015). As research from other European countries shows, LEZs can be part of the solution to many challenges faced by contemporary cities. They are only part of the answer, as their successful implementation depends on accompanying measures and long-term planning. Currently, more than 300 LEZs have been successfully introduced across Europe (Azdad et al., 2022).

Research perspectives on Low Emission Zones (LEZs) in the national discourse

Following the adoption of the 2018 Act on Electromobility and Alternative Fuels the issue of LEZs became the subject of legal analysis. Płatek (2019) discussed the traffic rules applicable within the zone and examined liability for violations of LEZ restrictions. Similar issues

[6] Costs in a broad sense: expenses incurred due to the need to purchase a vehicle meeting standards; the need to obtain a sticker authorizing entry into the zone; lost time due to detours or waiting in areas with heavy traffic.

were addressed by Zięty (2023), who, in studying the consequences of infringing individual interests related to LEZ implementation, concluded that there are no legal grounds for pursuing claims in this regard. Leciak (2020) assessed regulations concerning the entry of vehicles not permitted in LEZs, pointing out inconsistencies and limited practical applicability of provisions when issuing fines. Ruczkowski (2024) classified LEZs as an example of a special area, i.e., a space subject to a specific legal regime. Based on an analysis of the Act, he emphasized that in Poland, establishing an LEZ is a right of each municipality, not an obligation, and that the law does not impose population requirements for creating such zones. Pawłowski (2022) reached a similar conclusion when considering whether their introduction should be mandatory. Due to numerous amendments to the Act altering the conditions for adopting LEZs, the literature includes analyses of individual provisions. Scholars highlight the need to distinguish between the concepts of low emission zone and ultra low emission zone in the Polish context. An analysis of statutory provisions suggests that their restrictive nature justifies using the latter term as a synonym (Pawłowski, 2022). LEZs are also linked to studies on sustainable urban mobility – a valid approach, as this issue is significant from both social and environmental perspectives. The implementation of zones forms part of global strategies aimed at reducing emissions in urban environments. In recent years, policy reviews have been conducted, analyzing both the role of LEZs and their impact on residents' travel behavior (Koczan, 2021; Szagała et al., 2024).

Other issues discussed in the context of LEZs include decision-makers' knowledge of tools supporting adaptation to climate change and the level of social acceptance when implementing unpopular policies. It turns out that among 40 municipal climate adaptation plans, 39 cities do not link LEZs with the potential to reduce pollution. According to Hładyj and Domagała (2021), this indicates low awareness among decision-makers regarding the connection between air pollution and climate protection at the local level. It should be emphasized that LEZs can effectively contribute to improving air quality only when they are properly designed and socially accepted. Only under such conditions is it possible to sustainably shape new patterns of transport behavior (Kowalska-Pyzalska, 2022).

National research largely reflects studies previously conducted in Western Europe, focusing on forecasting the effects of introducing LEZ. An example is a simulation carried out prior to the adoption of an LEZ in Warsaw, which used a traffic model. The study indicated that the zone would contribute to reducing NO_2 and $PM_{2.5}$ concentrations in the city. However, it emphasized that the decrease in particulate matter levels would be limited due to national conditions, including the dominant role of coal combustion in the Polish economy (Holnicki et al., 2023). Similar results were obtained in a study conducted a year later, based on two LEZ scenarios presented during public consultations. It was demonstrated that, as in other European countries, greater reductions in pollution can be achieved by implementing a zone with broader boundaries, stricter regulations, and accompanying subsidy policies (Kowalska-Pyzalska, 2022; Nahorski et al., 2024).

Legal basis for the implementation of Low Emission Zones

The legal basis for introducing low emission zones in Poland is provided by Articles 39 and 40 of the Act of 11 January 2018 on Electromobility and Alternative Fuels (Act of 11 January 2018 on Electromobility and Alternative Fuels, 2018). However, the provisions contained in these articles also refer to the Act of 20 June 1997 – Road Traffic Law (Act

of 20 June 1997 Road Traffic Law, 1997) and the Act of 27 April 2001 – Environmental Protection Law (Act of 27 April 2001 Environmental Protection Law, 2001). Since its adoption, the 2018 Act has undergone 19 amendments, four of which were the most significant and substantially modified the original text (Fig. 1)[7]. In its initial wording, the regulations concerning the establishment of LEZs were concise and limited to the requirement that the zone cover an area of compact residential development with a concentration of public utility buildings (Act of 11 January 2018 on Electromobility and Alternative Fuels, 2018). Such criteria gave municipalities broad discretion in designating zones, as high-density residential and service areas are not confined solely to the city center. A significant provision, one that partially limited the effectiveness of the new policy, was the exemption allowing owners of vehicles (with a total weight of up to 3.5 tons) residing within the zone boundaries to avoid compliance with the rules set out in the resolution.

Half a year later, in June, the first amendment was introduced (Act of 6 June 2018 amending the Act on Bio-components and Liquid Biofuels and certain other acts, 2018). It clarified that LEZs could be established only in municipalities with more than 100,000 inhabitants. The method of delineating the zone was specified in greater detail: from that point on, the designated area had to correspond to inner-city development as defined in the local spatial development plan, or if such a plan did not exist, in the study of conditions and directions of spatial planning. Additionally, the provision applied only to roads for which the municipality was the managing authority. The new regulations also included the possibility of allowing entry to non-compliant vehicles upon payment of a fee[8]. These changes meant that, from that moment, LEZs could be introduced exclusively in larger cities. In 2018, among the 2,478 rural, urban, and mixed municipalities in Poland, only 38 had more than 100,000 inhabitants (Statistics Poland, 2025b). As a result, the potential for establishing LEZs at the local-government level was reduced to approximately 1.5% of the initial scope.

The articles regulating the functioning of LEZs occupied a single page of the act and did not address several issues that are essential from the perspective of research conducted in this field. For example, they did not refer to the situation of groups particularly vulnerable to exclusion (e.g., persons with disabilities). Moreover, as studies from other EU countries demonstrate, the foundation and defining principle of LEZs is the reduction of exhaust emissions. The legislator adopted a similar wording, linking emissions with improvements in public health and reduced environmental impact. However, neither the original text of the act nor the amendment introduced six months later referred to the indicators commonly used to evaluate the effectiveness of this urban policy (e.g., measurements of NO_2 or $PM_{2.5}$ and PM_{10} concentrations). The 100,000-inhabitant criterion appeared to be a step in the right direction, as research shows that the negative effects of emissions most often affect densely built-up urban areas. Nevertheless, this requirement was not combined with any additional criteria. A good practice was the attempt to specify the area in which the zone could be established more precisely, thereby providing municipalities with a clearer framework on which to base further work.

[7] Four of them referred to low emission zones to some extent.

[8] The resolution adopted by the municipal council included the possibility of entry for vehicles other than those permitted, for a period not exceeding three years from the establishment of the zone and upon payment of a fee.

A major turning point came several years later, when at the beginning of 2021 the European Commission called on Poland to comply with the directive related to air quality (Pawłowski, 2022). Later that year, the amendment to the Electromobility Act introduced numerous modifications (Act of 2 December, 2021 amending the Act on Electromobility and Alternative Fuels and certain other acts, 2021). First, the requirement that only municipalities with more than 100 000 inhabitants could establish an LEZ was removed. Next, the categories of vehicles exempt from the provisions of the act were redefined. The regulation exempting zone residents from the obligation to comply with the new rules was eliminated, and a new provision was added, allowing entry for vehicles used by persons with disabilities. Furthermore, the minimum duration of an LEZ was clarified, stipulating that the zone had to be established for a period of no less than five years. The rules for spending revenues generated from the sale of entry permits were expanded to include the possibility of an annual subscription fee. Initially, these funds could be allocated to zone signage and the purchase of zero-emission buses; following the amendment, trams and other forms of public transport were added to the eligible categories. For the first time, a detailed description of the legislative process appeared: the village mayor, town mayor, or city president was responsible for preparing a draft resolution and conducting public consultations, after which the municipal council had up to 60 days from receipt of the draft to adopt the resolution.

Despite the new provisions introduced in the act, the establishment of low emission zones was still not linked to pollutant emissions. This situation changed on 21 November 2024 with the adoption of the most recent amendment to the act (Act of 21 November, 2024 amending the Act on Electromobility and Alternative Fuels and certain other acts, 2024). Under this amendment, exceeding the permissible NO_2 limit in a city with more than 100,000 inhabitants triggers the obligation to introduce a low emission zone as of 1 January of the year following the date on which the city mayor receives the air quality assessment results prepared by the Chief Inspectorate for Environmental Protection[9]. Making the obligation to establish an LEZ dependent on exceeding nitrogen dioxide standards aligned the reason for implementation with its overarching objective.

At the same time, this created a degree of inconsistency in media communications, which do not offer a clear answer regarding the nature of LEZ implementation. Some sources emphasise the statutory obligation, while others point to municipal discretion. According to Article 39, point 1 of the Act of 11 January 2018 on Electromobility and Alternative Fuels, a municipality may introduce a low emission zone (Act of 11 January 2018 on Electromobility and Alternative Fuels, 2018). This possibility, despite previous provisions, is currently not conditional. If local authorities decide to establish a zone, they may do so following the legislative procedure set out in the act. However, two conditions must be met for the introduction of an LEZ to become mandatory. The first is that the urban municipality must exceed 100,000 inhabitants. Only then is the second condition considered, exceeding the nitrogen dioxide limit as demonstrated in the air quality assessment prepared by CIEP in accordance with Article 87, point 1 of the Act of 27 April 2001. These

[9] "The Chief Inspector for Environmental Protection shall, by April 30 of each year, assess the levels of substances in the air […]. If the assessment shows that the annual permissible level of nitrogen dioxide has been exceeded in a city with more than 100,000 inhabitants, the Chief Inspector of Environmental Protection shall immediately forward the results of this assessment […] to the mayor of that city" (Act of 27 April, 2001 Environmental Protection Law, 2001).

legal regulations governing the establishment of LEZs are contained in the act. Nevertheless, the obligation to introduce a zone in a given city may also be linked to provisions contained in regional air protection policy documents. In the case of Wrocław, the Air Protection Programme adopted by the Lower Silesian Regional Assembly on 20 July 2023 identified the implementation of an LEZ as one of the corrective measures aimed at improving air quality (Resolution No. LVII/1201/23 of the Regional Assembly of the Lower Silesian Voivodeship, 2023). However, the resolution itself did not directly impose a statutory obligation on the municipality to establish the zone. Rather, it defined the framework of regional air protection policy, which, in conjunction with national legislation and air quality exceedances identified in CIEP assessments, could generate specific obligations for the city authorities. It should be noted that this occurred prior to the 2024 amendment to the act, meaning that the direct statutory link between CIEP air quality assessments and mandatory LEZ implementation had not yet been introduced. A similar situation took place in Kraków, where the regional assembly recommended the gradual introduction of an LEZ in 2020 (Resolution No. XXV/373/20 of the Regional Assembly of the Małopolskie Voivodeship, 2020).

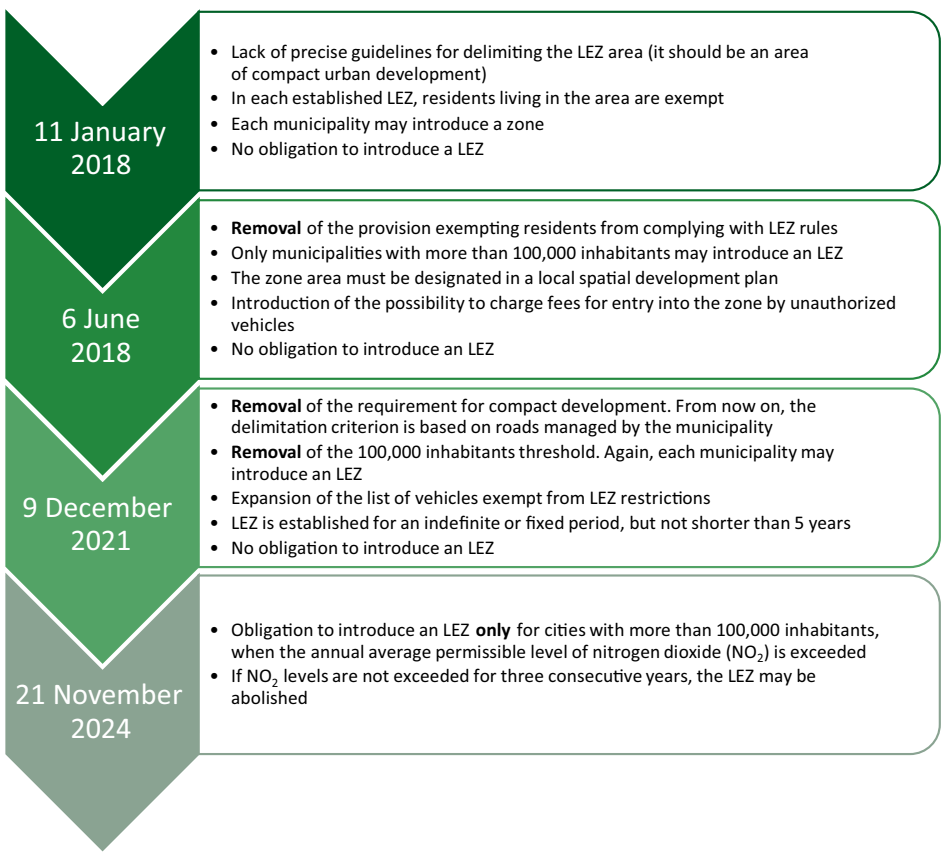

Fig. 1. Timeline of key legislative changes concerning Low Emission Zones in Poland between 2018 and 2024
Own elaboration.

Low Emission Zones in Poland

Densely urbanised areas are particularly vulnerable to the negative effects of transport-related emissions. As already noted, the statutory obligation to establish a low emission zone may be applied in cities with more than 100,000 inhabitants. In Poland, this requirement could apply to 34 urban municipalities in 2024 (Statistics Poland, 2025b). In all other cases, the decision to establish an LEZ depends on local authorities. Since the act regulating the functioning of LEZs has been in force since 2018, it is therefore essential to determine which municipalities are working towards implementing an LEZ or are considering such a prospect.

The Gorzów Wielkopolski city office states that one of the actions included in the Sustainable Urban Mobility Plan (SUMP) for 2030 is the implementation of comprehensive studies on transport emissions in order to assess the rationale for establishing a low emission zone (Resolution No. LXIV/1115/2023 of the City Council of Gorzów Wielkopolski, 2023). According to the document, the conduct of these studies and the analysis of results aimed at potential LEZ implementation have been assigned high priority. Furthermore, the planned zone boundaries have been indicated and defined as "key built-up areas" (Fig. 2).

Considerations regarding the justification for introducing an LEZ are also taking place in Poznań, although the city simultaneously emphasized that there are no further plans to proceed with its implementation. Such plans will only be initiated if a CIEP report confirms that NO_2 limits have been exceeded. Municipal authorities note that other me-

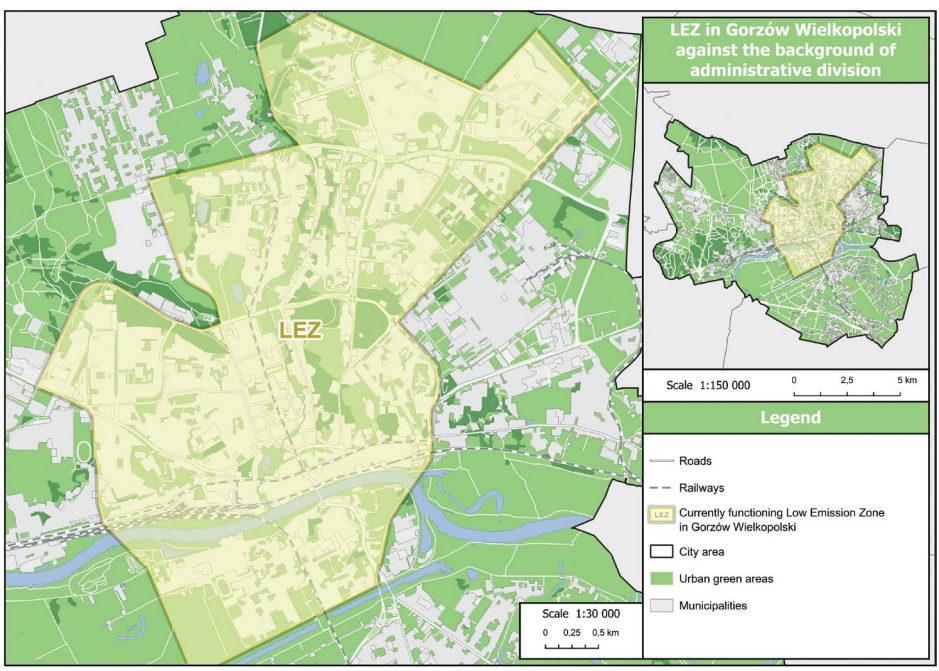

Fig. 2. Proposed area of the Low Emission Zone in Gorzów Wielkopolski
Own elaboration based Resolution No. LXIV/1115/2023 of the City Council of Gorzów Wielkopolski (2023).

asures aimed at improving the city's transport system are currently being implemented. These include the expansion of the paid parking zone (PPZ) and changes in traffic organisation intended to reduce traffic volume (e.g., by prioritising pedestrians, cyclists, and public transport). In Bydgoszcz, similar substitute measures are being pursued, such as the expansion of the PPZ and the replacement of the existing tram fleet with newer vehicles, along with the purchase of electric buses. In Białystok, local social, economic, and traffic-related conditions are cited as unfavourable for the introduction of an LEZ, although the city may consider such a possibility in the future.

Currently, only one low emission zone is in operation in Poland (as of 31.10.2025). It is located in Warsaw, and it began functioning in July 2024. When public consultations commenced in January 2023, residents were presented with the first draft map of the zone (City of Warsaw, 2023), and in mid-year, the Warsaw City Hall announced an expansion of its boundaries (Warszawa.pl, 2023). The publication of a new visualization showing an updated zone area – twice as large as the original – led to numerous protests, the most significant of which occurred during the city council session at which the LEZ was to be adopted (Polsatnews.pl, 2023). As a result of public opposition, an amendment restoring the original boundaries was approved (Fig. 3; Resolution No. XCI/2974/2023 of the Council of the Capital City of Warsaw, 2023).

Difficulties associated with implementing an LEZ, stemming from concerns about social exclusion and overly ambitious policy design, are illustrated by the case of Kraków, where the first pilot zone in Poland was established. In December 2018, the Kazimierz LEZ was adopted (Resolution No. III/27/18 of the Kraków City Council, 2018), covering several

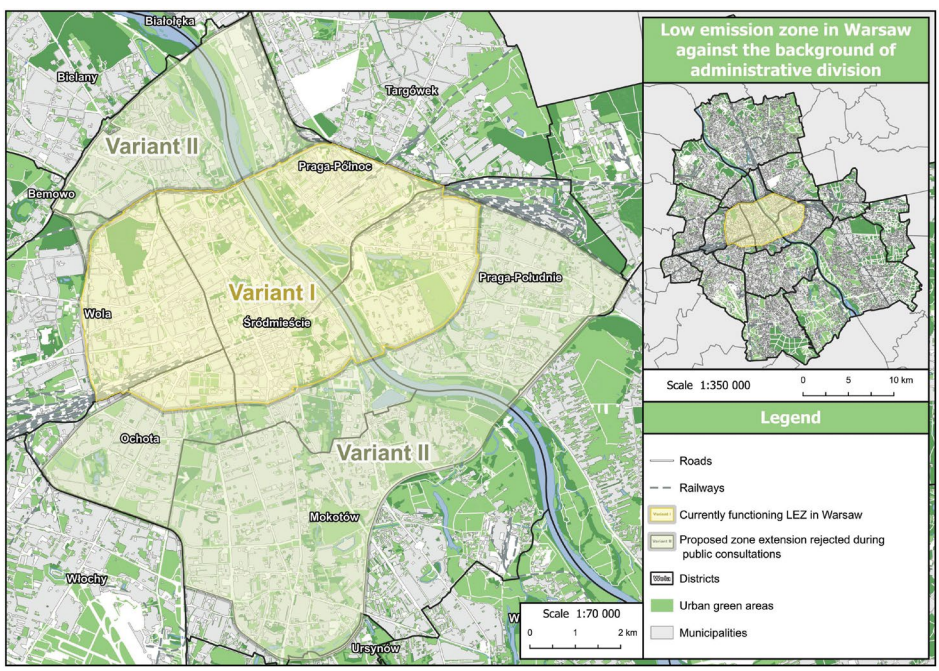

Fig. 3. Low Emission Zone in Warsaw
Own elaboration based on Warsaw City Council resolutions and media reports.

streets in the city centre (Fig. 4), nearly one year after the Electromobility Act came into force. Initially, the zone was introduced for a six-month period; however, following residents' protests (KRKNEWS.pl, 2019), the provisions of the resolution were amended. The most significant modification concerned entry exemptions, as from that point onward, the exemption applied also to vehicles belonging to customers of businesses located within the zone. The implementation of this provision resulted in a situation in which any vehicle could enter Kazimierz, provided that a declaration confirming the use of services was submitted. The duration of the zone was also changed: it was to remain in force until the definition of the "inner-city paid parking zone" was established. This definition appeared as early as July in an amendment to the paid parking zone resolution (Resolution No. XXII/456/19 of the Kraków City Council, 2019). According to its provisions, the Kazimierz LEZ ceased to operate in August 2019. Despite its short period of operation, the zone achieved its intended effect, eliminating most private vehicles from the designated area (Rynek Infrastruktury, 2019).

However, the abolition of the Kazimierz zone did not end the municipal authorities' efforts to reduce pollution and decrease the share of private cars in the modal split. In October 2020, the Regional Assembly of the Małopolskie Voivodeship adopted a resolution on the Air Protection Program for the Małopolskie region. The document included proposed boundaries for the LEZ in Kraków as part of so-called corrective measures aimed at reducing transport-related emissions. The Assembly recommended a phased implementation of the zone and the use of EURO standards as the basis for exemptions from entry – an important element, as these standards had not been considered in the original

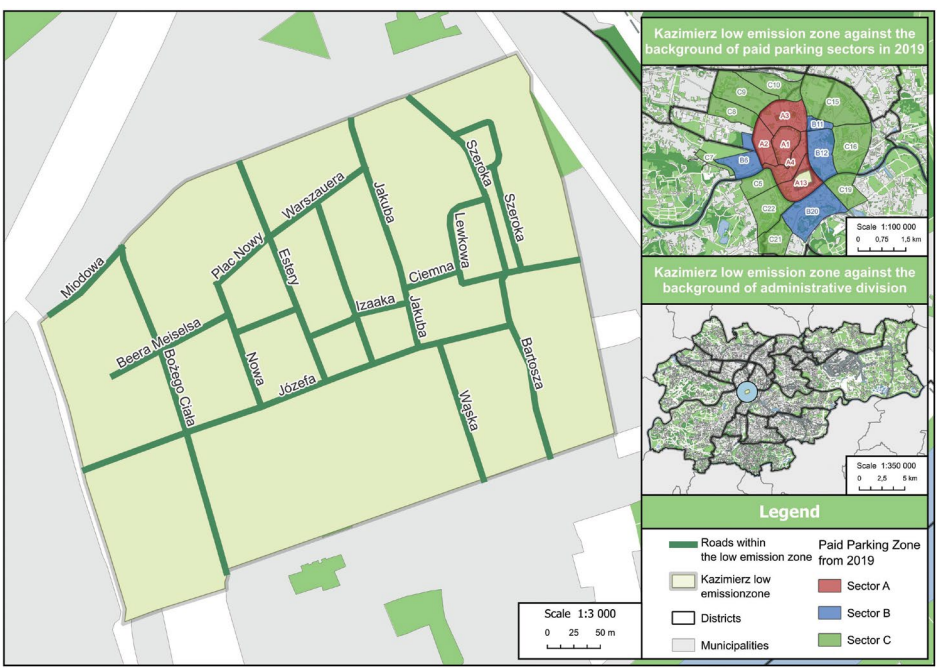

Fig. 4. Kazimierz Low Emission Zone in Kraków
Own elaboration based on Resolution No. III/27/18 of the Kraków City Council (2018).

Kazimierz resolution. Two years after the publication of the document, the Public Transport Authority in Kraków announced the commencement of work on a new LEZ in the city (Public Transport Authority in Kraków, 2022).

The pace of work appeared to be appropriate. Three months after the announcement, public consultations were initiated; by November, the first findings were published, and in December, a resolution was adopted (Resolution No. C/2707/22 of the Kraków City Council, 2022). According to this resolution, the low emission zone was to cover the entire administrative area of the settlement unit, thereby rejecting the recommendations of the Regional Assembly included in the Air Protection Program. This approach was justified by the intention to protect all residents (Public Transport Authority in Kraków, 2023). On the one hand, this decision can be considered reasonable, as research shows that low emission zones are more effective when their coverage area is larger (Panteliadis et al., 2014; Ferreira et al., 2015; Faria et al., 2017; Santos et al., 2019; Prieto-Rodriguez et al., 2022). However, other studies indicate that overly ambitious and radical approaches may provoke resistance among residents and create fears of exclusion (Sfendonis et al., 2017; Tarriño-Ortiz et al., 2022). Residents' protests led the Voivode of Małopolskie to challenge the resolution before the Regional Administrative Court in March 2023, resulting in a non-final annulment of the zone in January 2024. The court justified its decision primarily by the imprecise definition of the zone's boundaries (Regional Administrative Court in Kraków, 2024). Concerned about the ruling becoming final, the city authorities adopted a new resolution in June, stipulating that the LEZ would come into force in July 2025, and launched a series of public consultations (Resolution No. V/74/24 of the Kraków City Council, 2024). During the drafting process, several visualizations of the LEZ area were presented. The first, published in December 2024, excluded the eastern part of the city and the main bypass roads (Public Transport Authority in Kraków, 2024). Another, provided at the author's request in April 2025 by the Kraków City Office, removed additional road sections located in the east. The final visualization, adopted with the June resolution, returned to the recommendations prepared by the Regional Assembly, delineating the zone around the main transport arteries (Fig. 5) (Resolution No. XXXII/619/25 of the Kraków City Council, 2025). In addition to the new boundaries, the resolution set another implementation date for the LEZ, early 2026. Despite numerous changes resulting from protests, court rulings, and public consultations, the date specified in the document may still change, as media reports suggest that the Voivode of Małopolskie plans to challenge the resolution again (TVN24, 2025).

In the case of Kraków and Warsaw, controversies among local communities concerned both the areas of the zones and their restrictions. According to the adopted assumptions in Warsaw, at the current stage of implementation, vehicles older than 27 years (in 2024) with petrol engines and older than 19 years (in 2024) with diesel engines will not be allowed to enter the local LEZ. In Kraków, starting in 2026, the restrictions will apply to petrol vehicles older than 21 years and diesel vehicles older than 14 years. When these assumptions are compared with statistical data on passenger cars by age group in 2024, it becomes evident that the dominant group of vehicles are those aged between 16 and 20 years (24%). The next largest groups are cars aged 21-25 years (18%), 12-15 years (14%), and 26-30 years (10%). Vehicles older than 12 years constitute approximately 66% of the passenger car fleet in Poland. While only a portion of these vehicles would currently be affected by LEZ regulations adopted in Warsaw or proposed in Kraków, the relatively old age structure

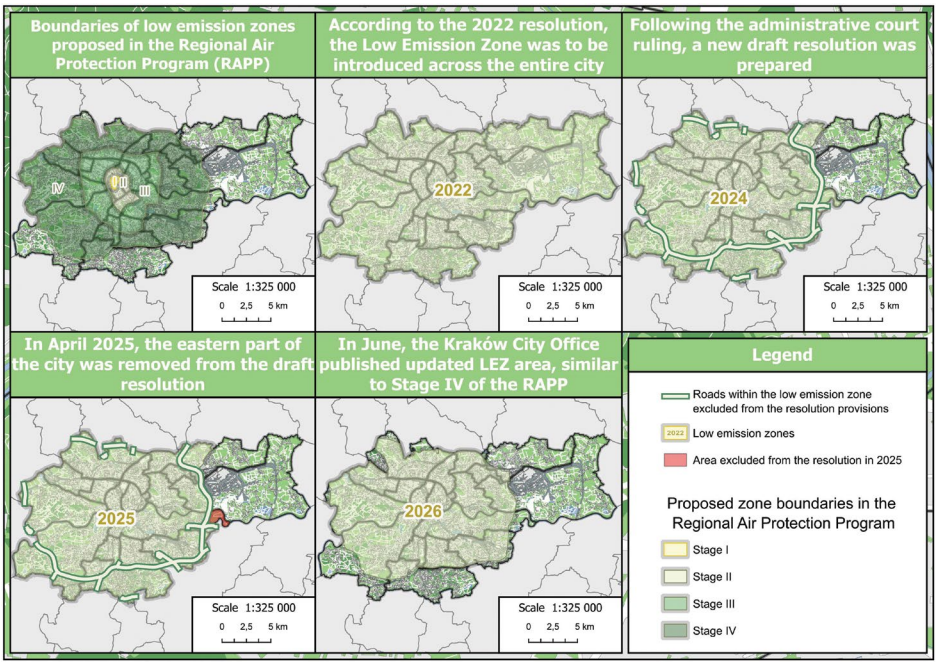

Fig. 5. Proposed boundaries of the Low Emission Zone in Kraków
Own elaboration based on Kraków City Council resolutions and media reports.

of the national vehicle fleet may intensify public concerns about the financial consequences of future transport restrictions and the potential need for vehicle replacement.

Wrocław is the last city where work on implementing an LEZ is underway. Between May and June 2022, exhaust emission measurements were carried out on 50,000 vehicles, and based on these, a report was prepared six months later recommending the creation of a low emission zone in three variants (Polskie Stowarzyszenie Paliw Alternatywnych, 2022). In line with the document, local authorities launched public consultations in March 2023. This step proved justified, as one month later the Chief Inspectorate for Environmental Protection indicated in a published report that NO_2 standards had been exceeded. Based on this, the Regional Assembly of the Lower Silesian Voivodeship updated the Air Protection Program, assigning the city mayor a new task (corrective action code – AwSCTr), under which an LEZ should be introduced in Wrocław by 2026 (Resolution No. LVII/1201/23 of the Regional Assembly of the Lower Silesian Voivodeship, 2023). Subsequent actions by the local government appeared to aim at achieving this goal. In October 2023, a consultation report was published selecting the second variant (Fig. 6); further consultations were held in November, and by the end of the month, posts appeared on the city office's website aimed at convincing residents to support the LEZ (City of Wrocław, 2023). However, at the beginning of the new year, interest in the zone significantly declined, and media reports on further consultations ceased. Only at the end of October 2024 did the Sustainable Mobility Office of the Marshal's Office address the situation, confirming earlier suspicions about the suspension of work on the draft resolution (TVP3 Wrocław, 2024). This

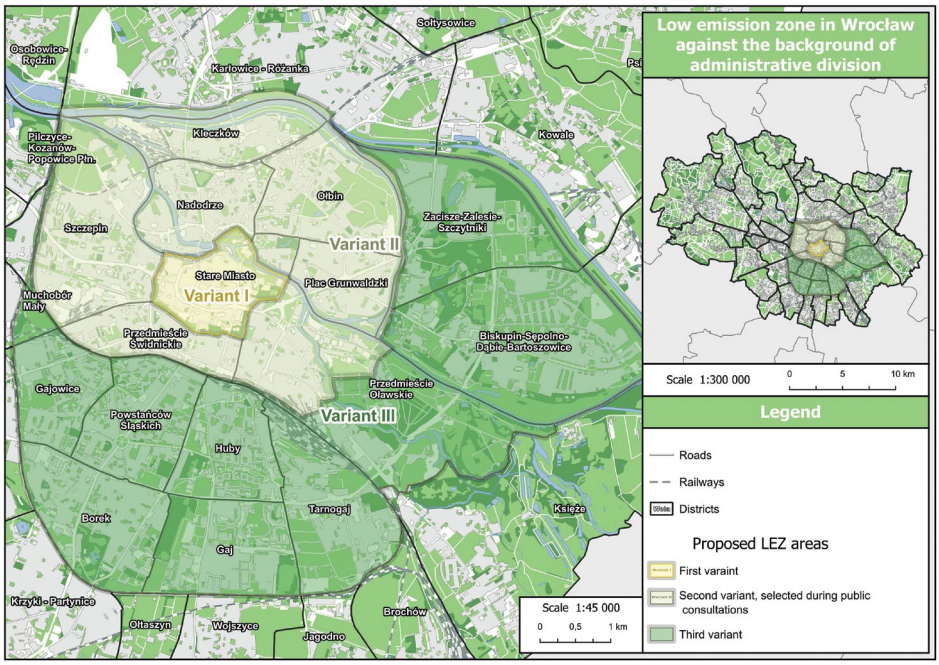

Fig. 6. Proposed boundaries of the Low Emission Zone in Wrocław
Own elaboration based on Polskie Stowarzyszenie Paliw Alternatywnych (2022).

information was again confirmed in May 2025, while also indicating that the CIEP report for 2024 does not oblige the city to introduce the zone (City of Wrocław, 2025).

Frequent references to the obligation to adopt an LEZ[10] raise the question of to what extent this requirement is enforced when permissible standards are exceeded. In Kraków, local authorities refer to the Chief Inspectorate for Environmental Protection (CIEP) report and indicate that, despite delays, the zone will be adopted. In Wrocław, the situation is more complex and requires consideration of several factors. In initial statements, city authorities referred to air quality assessments and exceedances of standards in 2023 and 2024 (Chief Inspectorate for Environmental Protection, 2023; Chief Inspectorate for Environmental Protection, 2024). However, CIEP publishes annual air quality assessments in April, while the amendment to the Electromobility and Alternative Fuels Act, which imposed an obligation on cities to introduce an LEZ, was adopted at the end of November 2024. The subsequent CIEP report published in 2025 did not indicate any exceedances in Wrocław; therefore, the city authorities rightly point to the lack of necessity to adopt the zone despite earlier reports (Chief Inspectorate for Environmental Protection, 2025). A similar and equally interesting situation occurred in Katowice, where, according to the CIEP report published in 2024, NO_2 emission standards were exceeded. However, the city authorities argued that the measurement point (located on Plebiscytowa Street) was situated near the A4 motorway and relocated it closer to the city center (to Dudy-Gracza

[10] In the event of NO_2 exceedances reported in the CIEP assessment.

Street)[11]. As a result of these actions, no exceedances were recorded in 2025, and consequently, there was no obligation to adopt an LEZ. This action raises reflections, as it can be assumed that relocating the measurement point did not solve the problem of exhaust emissions, which likely remains present in the city.

Conclusions

New forms of transport, technologies enabling traffic management, and demographic changes necessitate continuous research in this field so that local governments can effectively shape transport and spatial policies. For decades, low emission zones have been operating in hundreds of European cities. Consequently, foreign literature contains numerous studies analyzing LEZs in terms of their impact on residents' health and well-being. The legitimacy of their adoption is often questioned, and the effectiveness of this policy is assessed using indicators such as NO_2, O_3, PM_{10}, and $PM_{2.5}$.

In Poland, literature on LEZs is limited to a dozen or so publications due to the relatively recent Electromobility and Alternative Fuels Act of 2018. Moreover, despite the law being in force for seven years, only one LEZ exists in Warsaw, while another is planned for Kraków in 2026. This limits the possibility of understanding the long-term effects of LEZ implementation in Polish conditions. The experience of Kraków further demonstrates that the process of preparing and implementing a LEZ can take many years and may be burdened by numerous organizational, political, and social challenges. The introduction of such a zone requires not only the establishment of an appropriate legal framework, but also the conduct of public consultations, the achievement of political acceptance, and the adaptation of the city's transport system. In this context, the voluntary nature of implementing LEZs in most Polish cities appears particularly problematic. An analysis of recent years indicates that this voluntary approach often results in a lack of action on the part of local governments, whose decisions to establish LEZs are typically dependent on exceedances of air quality standards monitored by the CIEP. As a result, LEZs in Poland remain an instrument implemented primarily in a reactive manner rather than as part of a long-term, strategic transport and environmental policy. A significant portion of publications on LEZs in Poland focuses on legal aspects. An LEZ resolution constitutes a local law act, and its boundaries can be considered an example of a special area. Over the years, researchers have highlighted the legitimacy of statutory provisions, analyzed sustainable mobility policies, and defined the nature of zone implementation, which, as it turns out, is voluntary. The obligation was introduced at the end of 2024 and applies exclusively to cities with more than 100,000 inhabitants that exceeded the standards specified in the CIEP report. This solution should be regarded as a step toward strengthening national environmental and transport policy; however, it still does not eliminate all problems related to identifying areas requiring intervention. The case of Katowice demonstrates that air quality measurement results may be strongly dependent on the location of monitoring stations. Relocating a monitoring station may lead to a situation in which the problem of air pollution is no longer formally identified, even though the actual emission sources and their spatial impact continue to exist. This calls into question the validity of making

[11] In comments provided to the author, city authorities indicated that the relocation was carried out in cooperation with the Environmental Monitoring Department of CIEP.

the obligation to implement LEZs dependent solely on exceedances recorded by individual monitoring stations and indicates the need for a more comprehensive approach that also takes into account traffic intensity, vehicle fleet structure, spatial development patterns, and the actual mobility behavior of residents.

One of the key conclusions of this article is the instability and frequent variability of national legal regulations concerning LEZs. The evolutionary nature of these regulations, including numerous amendments to their legal foundations, contributes to regulatory uncertainty and makes it difficult for local governments to pursue long-term transport and environmental policies. Although current regulations impose an obligation to establish LEZs in selected large cities under specific environmental conditions, their actual implementation remains strongly dependent on local circumstances, including political decisions and the level of public acceptance. As demonstrated by the examples of Warsaw and Kraków, challenges related to the implementation of LEZs may also occur at the local level. The debate surrounding LEZs in Poland extends beyond environmental issues and is increasingly becoming a source of social conflict. Restrictions on car traffic are met with resistance from some residents, entrepreneurs, and social organizations. This opposition results not only from economic concerns, but also from the attachment to private cars as a primary means of transport and a symbol of independence. At the same time, an analysis of the literature and source materials indicates that inadequate public communication and insufficient informational activities may further intensify negative attitudes toward LEZs. Consequently, the effective implementation of such zones requires not only appropriate legal regulations, but also the development of long-term informational and participatory policies. A significant problem related to the functioning of LEZs in Poland remains the lack of clear legal provisions concerning the delimitation of these zones. The legislator allows for the designation of LEZs within the territory of a municipality; however, no precise criteria are provided regarding the method of defining their boundaries. In practice, this leads to considerable interpretative discretion on the part of local governments and hinders the development of uniform standards for LEZ planning. The absence of clear spatial guidelines also creates difficulties in determining which areas should actually be covered by restrictions.

The imprecision of statutory provisions also means that LEZ boundaries may be determined primarily on the basis of administrative or political criteria rather than the observed spatial extent of pollution impacts. Meanwhile, transport-related emissions are spatially differentiated and often concentrated within specific transport corridors, city centers, or areas characterized by high traffic intensity. The lack of an obligation to incorporate detailed spatial analyses may result in situations where LEZs cover areas of relatively minor importance for improving air quality. Conversely, areas particularly exposed to exceedances of pollution standards may also be omitted.

As examples from other European countries demonstrate, LEZs most commonly cover central urban areas, where traffic concentration and emission levels are the highest. Against this background, the case of Kraków may be regarded as controversial, as despite the recommendations included in the Regional Air Protection Programme, the decision was made to establish an LEZ covering the entire city. This solution generated significant public opposition and resulted in the resolution being challenged before an administrative court. Furthermore, imprecise provisions concerning the boundaries of the zone became one of the reasons for the court's annulment of the resolution. This demonstrates that the lack of clear spatial regulations may lead not only to organizational difficulties, but also

to challenges regarding the legality of adopted solutions. It is also worth emphasizing that the current legal framework does not define the relationship between LEZs and spatial planning documents or broader urban policies. LEZs function largely as a separate administrative instrument. The lack of integration between LEZs and the spatial planning system may reduce the effectiveness of this instrument and hinder the achievement of long-term objectives related to sustainable mobility and environmental protection. The conducted analysis therefore indicates the need to clarify the spatial dimension of LEZs within legal regulations. In particular, it appears justified to introduce an obligation to incorporate urban, transport, and environmental analyses when determining the boundaries of such zones. This would allow LEZs to be more rationally adapted to actual urban conditions and would increase the effectiveness of measures aimed at improving air quality.

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