

LOW EMISSION ZONES - PLANNING AND IMPLEMENTATION

A PIARC BRIEFING NOTE

TECHNICAL COMMITTEE 3.4 ENVIRONMENTAL SUSTAINABILITY IN ROAD
INFRASTRUCTURE AND TRANSPORT



STATEMENTS

The World Road Association (PIARC) is a nonprofit organisation established in 1909 to improve international co-operation and to foster progress in the field of roads and road transport.

The study that is the subject of this report was defined in the PIARC Strategic Plan 2020– 2023 and approved by the Council of the World Road Association, whose members are representatives of the member national governments. The members of the Technical Committee responsible for this report were nominated by the member national governments for their special competences.

Any opinions, findings, conclusions and recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of their parent organisations or agencies.

This report is available from the internet site of the World Road Association (PIARC): <http://www.piarc.org>

Copyright by the World Road Association. All rights reserved.

*World Road Association (PIARC)
Arche Sud 5° niveau
92055 La Défense cedex, France*

International Standard Book Number: 978-2-84060-831-8

Front cover © Authors

LOW EMISSION ZONES - PLANNING AND IMPLEMENTATION

A PIARC BRIEFING NOTE

**TECHNICAL COMMITTEE 3.4 *ENVIRONMENTAL SUSTAINABILITY*
*IN ROAD INFRASTRUCTURE AND TRANSPORT***

AUTHORS/ ACKNOWLEDGEMENTS

This report has been reported by Technical Committee TC 3.4 Environmental Sustainability in Road Infrastructure and Transport of the World Road Association (PIARC).

The contributors to the preparation of this report are:

- Janusz Wl. Bohatkiewicz (Poland)
- Eva Van den Bossche (Belgium)
- Tamara Nicholson (USA)
- Eric Dimnet (France)

Eric Dimnet (France) was responsible within the Technical Committee of the quality control for the production of this report.

The Technical Committee was chaired by Eric Dimnet (France). Tamara Nicholson (USA) and Mathieu Chabot-Morel (Québec, Canada) were respectively the English and French-speaking secretaries.

LOW EMISSION ZONES – PLANNING AND IMPLEMENTATION

A PIARC BRIEFING NOTE

Air pollution problems are often observed in the roadside areas of metropolitan regions, where a lot of emission sources such as factories, business offices, residential houses and vehicles accumulate. Increasing congestion in cities with no or limited restrictions on driving in urban areas is contributing to a number of social- and health-related problems. Many countries are considering various types of restrictions on car traffic – especially in urban centers.

The fastest-growing scheme since 2019 is the introduction of Low Emission Zones (LEZs). During the 2019-2023 cycle, PIARC Technical Committee 3.4, Environmental sustainability, assessed the different the different ways of setting up LEZs and their consequences.

The aim of this briefing notes is to illustrate the different types of automobile traffic restrictions and the methods associated with them. Therefore two case studies (Krakow, Poland, and Antwerp, Belgium), representative of the different ways of designing LEZs at different times and socio-economic conditions, are presented. Finally, the note presents some assessment elements and proposes recommendations on the elements to be taken into account for LEZs, especially in legislative frameworks, planning and implementation.

CONTENTS

1. INTRODUCTION	3
2. INCREASE IN AUTOMOTIVE TRANSPORTATION AND STRATEGIES TO ADDRESS IMPACTS	4
2.1. INCREASE IN THE NUMBER OF VEHICLES AND VEHICLE AGE	4
2.2. NEGATIVE SCENARIO OF TRANSPORT SYSTEM DEVELOPMENT IN CITIES.....	5
2.3. THE IDEA AND TYPES OF AREAS WITH RESTRICTION FOR CARS	6
3. CASE STUDY: KRAKOW, POLAND	8
3.1. EXAMPLE OF SOLUTIONS IN POLAND.....	8
4. CASE STUDY: ANTWERP, BELGIUM	12
4.1. LEGISLATIVE FRAMEWORK.....	12
4.2. LEGISLATION AT THE FEDERAL LEVEL	12
4.3. LEGISLATION AT THE FLEMISH LEVEL.....	12
4.4. LEGISLATION AT THE LOCAL LEVEL.....	12
4.5. FEASIBILITY STUDY	13
4.6. IMPACT OF LOW-EMISSION ZONE IN ANTWERP.....	19
5. CONCLUSIONS	22
6. RECOMMENDATIONS	23
7. REFERENCES.....	24

1. INTRODUCTION

The increasing congestion in cities is often held responsible for health-related problems. This is why increasing number of countries are considering to impose various types of restrictions on car traffic – especially in urban centers. The aim of this paper is to point out the different types of automobile traffic restrictions and the methods associated with them such as Low Emission Zones (LEZs). Numerous European cities have already decided to do so to comply with the directive EU 2016/2284 of the European Parliament and Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants. Transitional forms of car traffic restrictions have been introduced in some of them. Therefore, after presenting general information on car traffic volume and methods for reducing car traffic in Europe, we focus on how Krakow (Poland) has been preparing for many years for changes and the development of LEZs. The description also includes information about public consultations and their effects, as well as the experience already gained in the creation of the LEZs in the city which also provides valuable information about the social acceptability. The second case study presented is the introduction of a LEZ in Antwerp, Belgium in 2017 and its impacts through 2020.

For the Krakow LEZ Case Study, publicly available materials in the field of automotive statistics (Eurostat, *Polish Automotive Industry Association*) as well as the Public Transport Authority of Krakow and the City of Krakow were used to prepare this study.

A case study for the Flemish LEZ in Antwerp, Belgium was provided by the Agency for Roads and Traffic, Flanders, Belgium. Publicly available materials were used to prepare this study.

2. INCREASE IN AUTOMOTIVE TRANSPORTATION AND STRATEGIES TO ADDRESS IMPACTS

2.1. INCREASE IN THE NUMBER OF VEHICLES AND VEHICLE AGE

Many developing countries or countries undergoing political transformations, such as central and central-eastern Europe, have so far maintained a similar scenario related to automotive development. In the past, the car and its low availability has initially become a social differentiator in these countries, a sign of luxury and prosperity, as well as comfortable living. Very quickly, however, one starts to notice and feel the phenomena and problems associated with full accessibility of the car and the possibility of its almost unlimited use. Very high rates of motorization, older vehicles often imported from neighboring countries, streets crowded with cars, and large areas of cities polluted by exhaust fumes and noise are the main problems caused by unrestricted car use.

The characteristic phenomenon associated with the development of motorization in some of the countries that joined the European Union after April 1, 2004 can be seen in Fig. 2.1, showing the increase in the rate of motorization (number of passenger vehicles per 1,000 inhabitants) between 2011 and 2020. Most Central and Central and Eastern European countries have seen very large increases in the rate of motorization, from 29.6% (Czech Republic from 436 to 565 passenger cars per 1,000 inhabitants) to 75.5% (Romania: from 216 to 379 passenger cars per 1,000 inhabitants) [5]. The largest increase in terms of the passenger vehicle number per 1,000 residents between 2011 and 2020 occurred in Poland, rising from 476 to 664. This rate is one of the highest in EU countries – only Italy has a higher rate, at 670 passenger cars per 1,000 residents.

The mean age of cars is 11.5 years, with 11.6 years for light commercial vehicles, 13 years for trucks, and 11.7 years for buses [2] ¹. The youngest passenger cars are in Luxembourg (6.5 years) and Austria (8.3 years), and the oldest are in Lithuania, Estonia and Romania (over 16 years). The youngest truck fleet is in Austria (6.4 years) and the oldest in Greece (21 years). The trend of decreasing diesel car popularity is becoming more and more noticeable – in the European Union (EU) countries, the share of cars with this engine in the entire passenger vehicle group amounted to 42.3%, while gasoline cars accounted for 52.9%. In 2019, electric vehicles accounted for 0.2% and hybrids 1%. This condition has been changing significantly in recent years.

The phenomena described above related to the development of motorization, the age of vehicles, and the migration of old cars from wealthier to developing countries cause a number of problems that are best seen in cities.

¹ Depending on the data source, these values may vary

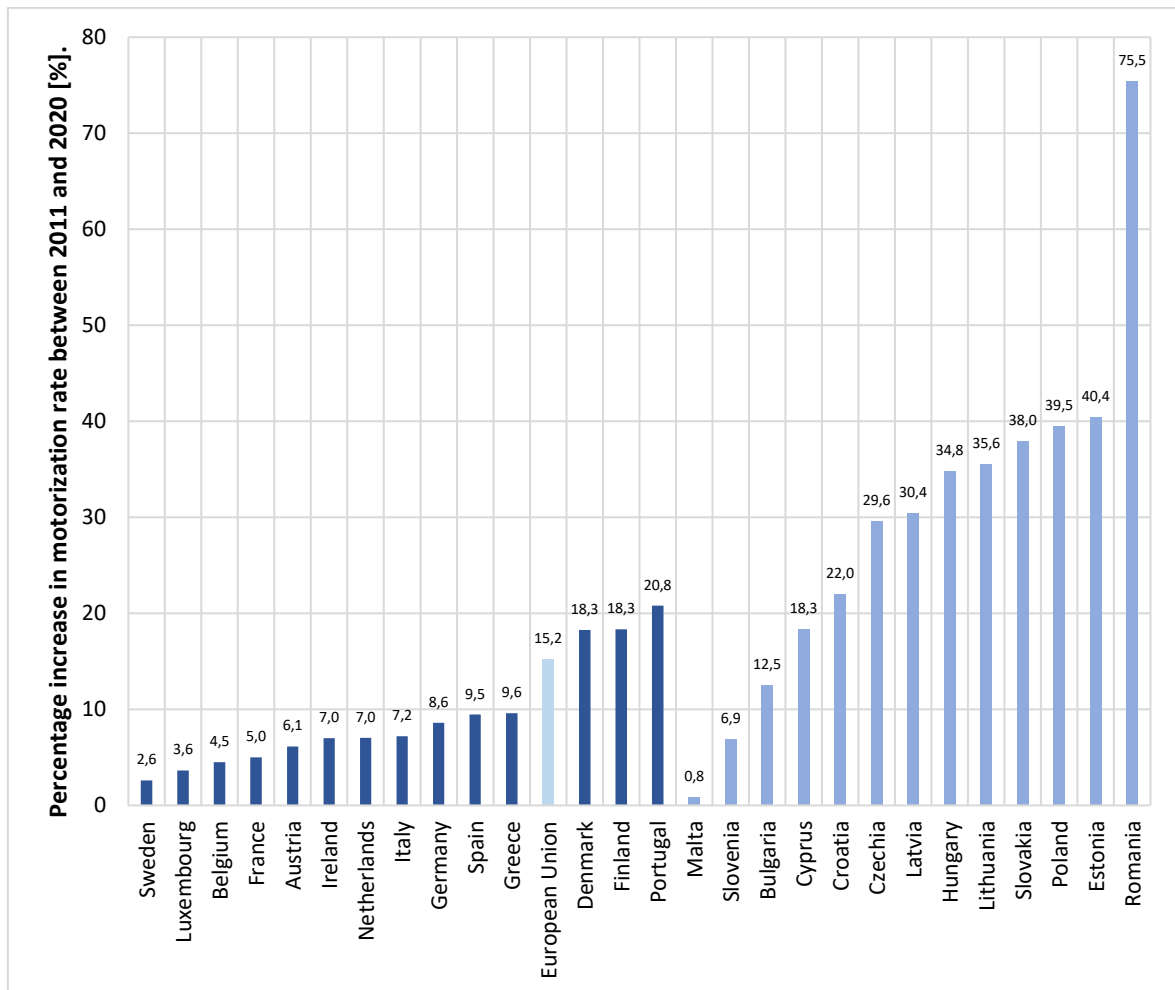


Figure 2.1: Increase in the rate of motorization (number of passenger cars per 1,000 inhabitants) in 27 EU countries from 2011 to 2020 – based on [5].

2.2. NEGATIVE SCENARIO OF TRANSPORT SYSTEM DEVELOPMENT IN CITIES

The foregoing effects associated with the development of motorization and the resulting problems are mostly compensated for by the expansion of urban transportation systems and roads outside cities. This is even becoming a hallmark of political efficiency and quality of governance in a large number of countries. Completing the layouts of the basic road network outside cities and streets in cities is mostly a priority activity. While the expansion of transportation systems outside cities generates numerous positive effects (such as economic development associated with improved transportation, reduced number of accidents, etc.), the over-intensive expansion of transportation systems aimed at motor vehicles mostly results in a further increase in the rate of motorization. This form of development with the omission or illusionistic development of public transportation and bikeways contradicts the principles of sustainable development, yet it is often carried out as a part of such actions. In these situations, as a rule, there are two principles of sustainability most strongly exposed, namely social needs (with the needs of car owners singled out) and economic needs, with environmental effects being marginalized. This creates a kind of closed circle of problems, which effectively forms a negative urban development scenario – Figure 3.1.

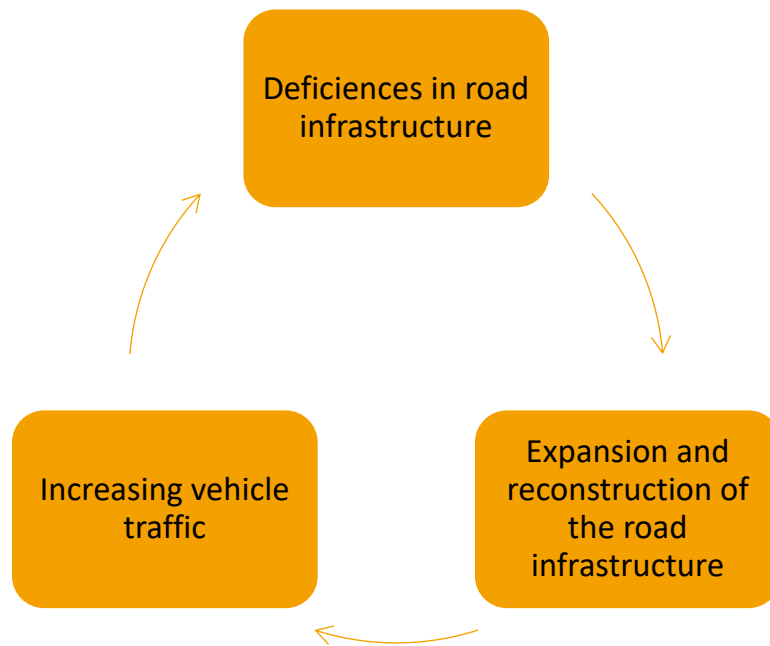


Figure 2.2: A negative scenario for the development of urban transportation systems (a vicious circle of infrastructure development).

For the most part, the negative scenario is interrupted by the actions of political or community groups campaigning against the excessive freedom of car use. Stopping such activities also requires the introduction of appropriate regulations, both national and local.

Using one type of restriction or ban on motor vehicles is one way to interrupt or reverse negative scenarios of urban development. Problems associated with the quality of life of residents become the main focus of urban planning activities.

2.3. THE IDEA AND TYPES OF AREAS WITH RESTRICTION FOR CARS

The problems of excessive vehicle accessibility and traffic nuisance have prompted a number of measures and solutions to rebalance urban street users or to restrict or ban vehicle traffic. It is estimated that there are more than several hundred areas with car restrictions in Europe. The following can be distinguished among all types of activities [6]:

- a. Low Emission Zones (LEZ);
- b. Urban Toll Schemes or Congestion Charging (CS);
- c. Emergency Air Pollution Schemes;
- d. Zero Emission Zones (ZEZ).
- e. Other Access Regulations;
- f. Combined Schemes;
- g. Smaller Regulations or Restrictions.

The foregoing methods and approaches can also include linear traffic reduction (in the lines of streets) or area-based traffic reduction (in larger areas, such as city districts). Traffic reduction can also be combined with the foregoing measures.

The methods and measures mentioned above are related to improving the quality of life of people and cause:

- Improving air quality;
- Reducing road noise;
- Increased traffic safety;
- Mitigating climate change;
- Landscape protection mainly in urban centers;
- Reducing traffic congestion;
- Increasing revenue.

It should be noted that air pollution and noise reduction can be affected by reducing traffic or changing modes of transportation, depending on the course of action. Figure 2.3 summarizes selected types of areas with restrictions for vehicles and their characteristic elements and features.

	Low Emission Zones	Urban Toll Schemes or Congestion Charging	Emergency Air Pollution Schemes	Zero Emission Zones	Other Access Regulations
Method of interaction	Bans on of vehicles with a specific emission limit	Entry fees	Administrative restrictions depending on air condition	Administrative restrictions on vehicle traffic	Administrative restrictions as required
Locations involved	Area, selected streets, sometimes highways	Area, some streets, roads, bridges	Area, municipality, region	Area, streets	Area, streets
Regulated vehicles	Different vehicle categories, different types of travel	Different vehicle categories, different types of travel	Different categories of vehicles depending on the pollution present	Various categories of vehicles excluding electric and hydrogen powered vehicles, bicycles and equipment without internal combustion engines	Different categories of vehicles and different vehicle weights, different modes of travel
Area information method	Vehicle sticker, vehicle recognition camera, zone signage	Vehicle recognition camera, online toll, street toll, toll via vehicle cab	Announcements about bans in the media, on the Internet, social media	Zone signage	Marked zones with restrictions for certain vehicles, total and temporary entry permits, marked parking zones with payment, one-way traffic system and other traffic-reducing solutions

Figure 2.3 Types of areas with restrictions for vehicles.

3. CASE STUDY: KRAKOW, POLAND

3.1. EXAMPLE OF SOLUTIONS IN POLAND

3.1.1. Vehicle characteristics in Poland

In 2020, the average age of a passenger car in Poland was 14.3 years (with median of 15 years) [2]. It is characteristic for the passenger car fleet that the oldest vehicles, more than 20 years old, account for 19.6% of the car fleet. These cars outnumber 4-year-old and younger cars, which account for 12.6%. More than 50% of used cars – with more than 10 years of age – are imported from other countries, a number that has not dropped below 650 000 cars since 2011. Gasoline cars account for 45% of the passenger car stream, 40% are diesel cars, while 14% are natural-gas-powered passenger cars, and only 1% of cars are hybrid. Nearly 45% of light commercial vehicles at the end of 2020 were between 11 and 20 years old, vehicles older than 20 years constituted 19% and only 14% were up to 4 years old. Among these cars, as many as 88% were equipped with diesel engines. In case of heavy commercial vehicles, 36% were 11 to 20 years old, 24% were 5 to 10 years old, and trucks younger than 4 years and older than 20 years accounted for 20% of the heavy commercial vehicle fleet.

The figures presented above are a good illustration of the problems faced by Polish motorization, which have a direct bearing on adverse effects, mainly air and noise pollution.

3.1.2. Krakow's problems with vehicle transport and air pollution

Currently in Krakow, it is estimated that 75% of NO_x comes from the exhaust fumes of vehicles traveling through the city. In May 2019, specialized measurements of exhaust emissions from cars were made in Krakow [3]. The results of these studies have shown the sources of air pollution problems from vehicle exhaust.

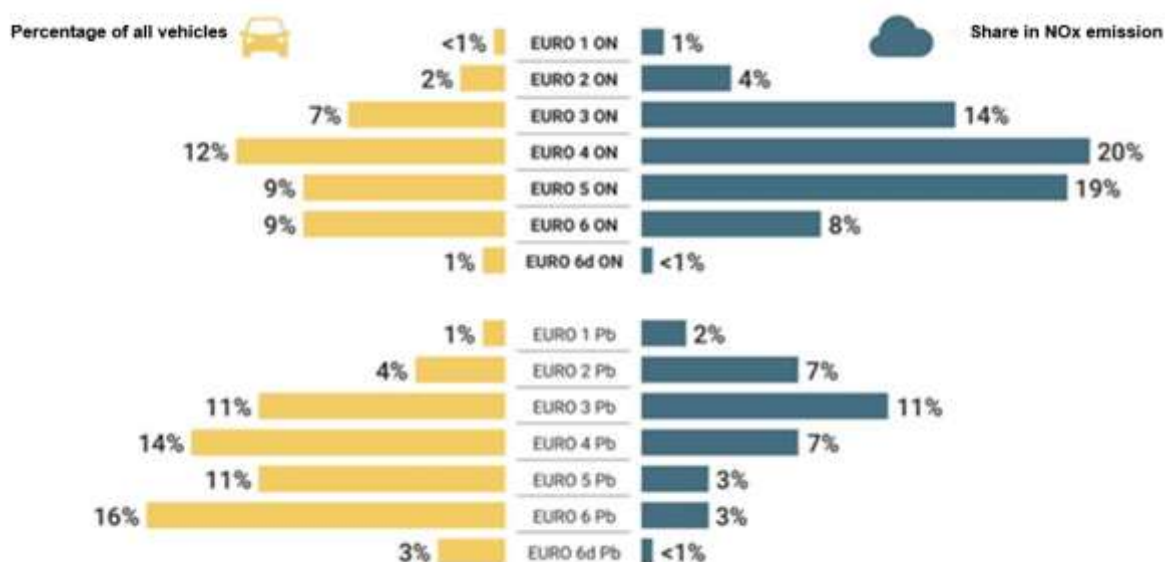


Figure 3.1: Percentage of vehicles meeting each EURO standard that travel in Krakow and their share of NO_x emissions [7].



Figure 3.2 Share of diesel or gasoline vehicles in traffic and their effect on NOx emissions [7].

3.1.3. Kraków's experience in creating an LEZ

Krakow has been trying to introduce the LEZ for many years. Initial activities have indicated that public consultation and public acceptance are extremely important elements.

Historically, in November 2018, the Polish Parliament adopted the Law on Electromobility and Alternative Fuels. This provision provides for the possibility of creating LEZs. In September 2020, the authorities of the Małopolska Voivodeship adopted a resolution "Air protection programme for the Małopolska Voivodeship", which obliged Kraków to create an LEZ. In December 2021, the Polish Parliament adopted an amendment to the 2018 Act, which gave cities the opportunity to set their own local rules for petrol and diesel cars.

In Krakow, traffic and exhaust gas pollution measurements were made on the streets in 2019. These measurements were repeated during the winter in December 2021. Public consultations were carried out twice in 2022. During that time, a special website was launched, along with the use of social media, 7 open meetings with residents, 3 meetings with entrepreneurs, and 5 telephone duties were provided. Residents submitted 600 comments and opinions in a special form. The city has formed a working group with other cities and the Minister of Climate, and also involved experts in the fields of medicine and internal combustion engines. There are three main conclusions from the public consultation:

- The LEZ should be introduced based on a gentle phasing of restrictions, allowing residents of the zone and those entering it to adjust to the new regulations;
- The LEZ should fulfill its main function of improving air quality, while taking into account the necessary exemptions that include individual and legitimate needs of residents;
- The LEZ must be enforced effectively.

The developers of the LEZ in Krakow eventually proposed the following after public consultation:

- Introduction of LEZ rules – June 1, 2024. The rules will apply to vehicles registered after January 1, 2023;
- Instead of the original six stages of implementation – fewer stages and initially more lenient treatment of vehicles already moving through the city;
- Phase I will apply only to vehicles newly registered from 2023. The assumption is that the rules will take effect from 2026 for vehicles currently on the streets of Krakow;
- Vehicles meeting at least "Euro 4" standard for gasoline engines and "Euro 6" standard for diesel engines will be allowed to enter the LEZ;
- Covering the elderly – aged 70+ – with an indefinite exemption for vehicles.

- Vehicles with the appropriate signage, which are used by people with disabilities, will be exempt from LEZ restrictions.
- Unlimited entry for historic vehicles and special vehicles (including motorhomes, bank armored vehicles, food trucks or hearses) to the zone.
- Use of a digital entry registration and control system – it is planned to prepare a database of vehicles allowed to enter beforehand, so that it will be used by law enforcement.

Finally, the Resolution of the Krakow City Council of 23 November 2022 adopted:

- The LEZ will be established from 1 July 2024 in the area of the administrative borders of Krakow (the whole of Krakow);
- The boundaries of the LEZ will be marked with road signs - Fig. 3. In addition, the boundaries of the LEZ may be additionally marked in accordance with the rules of the City Information System;
- The following vehicles will be allowed to enter the LEZ in accordance with the Act of Parliament: electric, hydrogen or natural gas-powered vehicles as well as vehicles for the disabled (with special marking), zero-emission buses, school buses as well as state, law and order and emergency services;
- In addition, Krakow has set out its conditions for the approval of vehicles. These conditions offer the possibility of gradually exempting vehicles with internal combustion engines from the LEZ, depending on the age of these vehicles and the Euro standards according to the table below;

Table tightening access conditions

	Until 30 June 2026, vehicles last registered before 1 March 2023	Until 30 June 2026, vehicles last registered after 1 March 2023.	From 1 July 2026, all vehicles, irrespective of the date of last registration
Diesel	Euro 2/Euro II	Euro 5/Euro V	Euro 5/Euro V
Gasoline, natural gas, LPG	Euro 1/Euro I	Euro 3/Euro III	Euro 3/Euro 3

- Vehicles that are entitled to enter the LEZ will be marked with an appropriate sticker (affixed to the windscreen of the car) issued by Krakow or another city in which the LEZ has been established;
- Control of vehicles entering the LEZ will be carried out by the Police and the Krakow Municipal Police. The control of vehicles may also be conducted by means of an electronic vehicle identification system.



Figure 3.3: Traffic signs at the beginning and end of the LEZ in Krakow

However, ZFEs are not unanimously supported, even among residents who are supposed to be the main beneficiaries of the measures. The introduction of this type of measure poses delicate problems of social acceptability, not to mention the assessment of their benefits when they are implemented outside the confines of the urban environment for which they are intended. Thus, numerous interventions by opponents of the LSEZ and an analysis by the Małopolska Voivode resulted in the Voivode filing a complaint to the Provincial Administrative Court on April 18, 2023 for a review of the resolution on the establishment of the LEZ. The complaint concerns the lack of precise definition of the LEZ boundaries. The provincial governor also accuses the resolution of interfering too far into the sphere of constitutional rights and freedoms, such as human freedom, freedom of movement, equality before the law or property - violating the principle of proportionality, as the intended effects generate too great a burden for citizens. The restriction of individual rights must be equivalent to the purpose served by the regulation and done only to the extent necessary. The last argument is criticised by proponents of the creation of the LEZ because of the constitutional right of people to live in a clean environment that is not polluted by vehicle exhaust.

4. CASE STUDY: ANTWERP, BELGIUM

4.1. LEGISLATIVE FRAMEWORK

The European Union makes member states responsible for taking the necessary measures in accordance with European regulations on improving air quality. Each member state can draw up its own plan to structurally improve air quality.

4.2. LEGISLATION AT THE FEDERAL LEVEL

A new traffic sign was included at the federal level. More information under 2.2 Announcement.

4.3. LEGISLATION AT THE FLEMISH LEVEL

To implement the European policy, the Flemish Government elaborated the framework for the introduction of low-emission zones (LEZ) on the Flemish territory. All Flemish cities and municipalities wishing to introduce an LEZ do so on the basis of the Decree of 27/11/2015 [8], amended by the Decree of 3/05/2019, and the Flemish Government Decision on Low Emission Zones of 26/02/2016 [9], amended by the Decision of 31/03/2017 and the Decision of 6/09/2019.

This Flemish overarching regulatory framework defines:

- Which vehicles the LEZ applies to (vehicle category, Euronorm);
- Under what conditions may be deviated from these access conditions at the local level;
- How enforcement will be regulated.

In addition, a database was made available from the Flemish administration containing the vehicle data of Belgian vehicles needed to monitor compliance with LEZ conditions. A common Flemish LEZ database was also established, to which all Flemish LEZs have access. This contains vehicle data that are not known in the Crossroads Bank for Vehicles and that are transmitted to a Flemish LEZ via voluntary and free registration, for example. An example is foreign vehicles. Exceptions to the LEZ regulations are also registered in the Flemish LEZ database, such as exceptions for vehicles for persons with disabilities.

4.4. LEGISLATION AT THE LOCAL LEVEL

Based on this overarching Flemish legislative framework, each Flemish city can introduce an LEZ. The introduction, management and enforcement of the LEZ itself is done by the local government. In concrete terms, this means that:

- A city itself decides when and if it introduces an LEZ;
- An LEZ has an effect only on local and regional roads (not highways);
- A city can grant access to cars other than those allowed by the Flemish decree, but only under conditions determined at the Flemish level;
- A city conducts its own enforcement and collects revenue from paid access and fine amounts.

4.5. FEASIBILITY STUDY

The local feasibility of introducing an LEZ in Antwerp was investigated in a feasibility study commissioned by the city of Antwerp during 2012 ².

4.5.1. Area delineation, access conditions and environmental impacts

First, the appropriate location, size and demarcation of one or more LEZs, differentiated or not, in the city of Antwerp was sought. Based on examples in other European cities, a contiguous zone around the city center was chosen, delimited by the Scheldt River and recognizable (ring) roads and characterized by a high population density.

For each of the area delineations studied, the expected effects were determined for nitrogen and particulate matter emissions. Consideration was also given to clarity and simplicity, enforceability, potential for through traffic, possibility of flanking policies and complementarity with the city's mobility policy.

4.5.2. Practical implementation

4.5.2.1. Regulation

The legal options available for implementing an LEZ were examined. Options examined included: through a municipal police regulation, through a supplementary traffic regulation, through a new supra-local regulatory framework, and through a modification of parking regulations.

The recommended option appeared to be the creation of a new supra-local regulatory framework specifically for the implementation of an LEZ.

The Flemish government is responsible for the regulatory framework because environment is a regional competence.

4.5.2.2. Announcement

To indicate this access restriction, there were a number of options. The best option appeared to be the creation of a new zonal sign indicating the access conditions and cumulative with other zonal regulations.

The federal government is responsible for creating a new zonal sign. In the Royal Decree of December 1, 1975 on general regulations on the police of road traffic and the use of public roads, Article 2, 2.63, a definition for low-emission zones was added and traffic signs F117 and F118 were chosen to indicate the boundaries of the low-emission zone [10].



² "Feasibility study for introduction and management of low emission zone(s) in the city of Antwerp" conducted by Transport & Mobility Leuven, in collaboration with PricewaterhouseCoopers (PwC) and the Netherlands Organization for Applied Scientific Research (TNO)

4.5.2.3. Recognition and waiver

The following options were explored for the recognition of vehicles admitted into the LEZ:

- using the existing Crossroads Bank of Vehicles without additional registration;
- a central database based on the existing DIV database with additional registration for foreign vehicles, retrofitted vehicles (retrofitted particulate filter) ... to arrive at a complete dataset of authorized vehicles;
- A vignette system without central registration;
- Link the right to a resident card to vehicle emission standards.

A central registration system, linked to existing databases and with additional registration for vehicles not included therein, was chosen to achieve full recognition of authorized vehicles.

Exemptions have been introduced for target groups disproportionately burdened by the introduction of LEZ. For vehicles with a waiver (exemption), the LEZ is free. For passenger cars, for example, exemptions can be linked to the owner's specific situation (e.g. income). Exemptions are included in the Flemish regulatory framework and include exemptions for persons with disabilities entitled to increased allowances or with an adapted car.

Waivers are crucial to create support and acceptance, but the number of waivers issued must be limited so as not to undermine the environmental effects too much. Therefore, the choice was also made to limit the duration of a waiver over time.

4.5.2.4. Enforcement and collection

The practical application of enforcement depends on the choices previously made regarding regulation and recognition of vehicles. The analysis indicated that full enforcement of the LEZ cannot take place without central registration of vehicles.

It was therefore opted for an entry ban with a central database where all license plates of approved vehicles are stored so that an automatic check with ANPR (automatic number plate recognition) cameras can be made on incoming and outgoing traffic.

4.5.2.5. Conclusions for practical implementation

Eventually the following scenario was chosen: Access prohibition indicated by new zonal traffic sign - Central registration - Control with ANPR. However, this scenario required a higher legislative framework which came in the form of the previously mentioned Flemish LEZ decree of 27/11/2015.

The study also mentions a number of flanking measures to increase social acceptability and support the effectiveness of the LEZ.

- Choose a clear and logical area delineation, consistent with local mobility policies;
- Establish reasonable and acceptable access conditions; phased implementation of these access conditions has a positive impact on social acceptance;
- Provide qualitative mobility alternatives.

Solid enforcement, firm legal anchorage and an adequate communication strategy are also necessary.

4.5.2.6. Cost-benefit analysis

Finally, a cost-benefit analysis was conducted. The start-up, management and enforcement costs to the government, financial revenues to the government, costs to users and health benefits to society were estimated. The feasibility study concludes that the net present value (NPV) of the benefits is greater than the NPV of the costs.

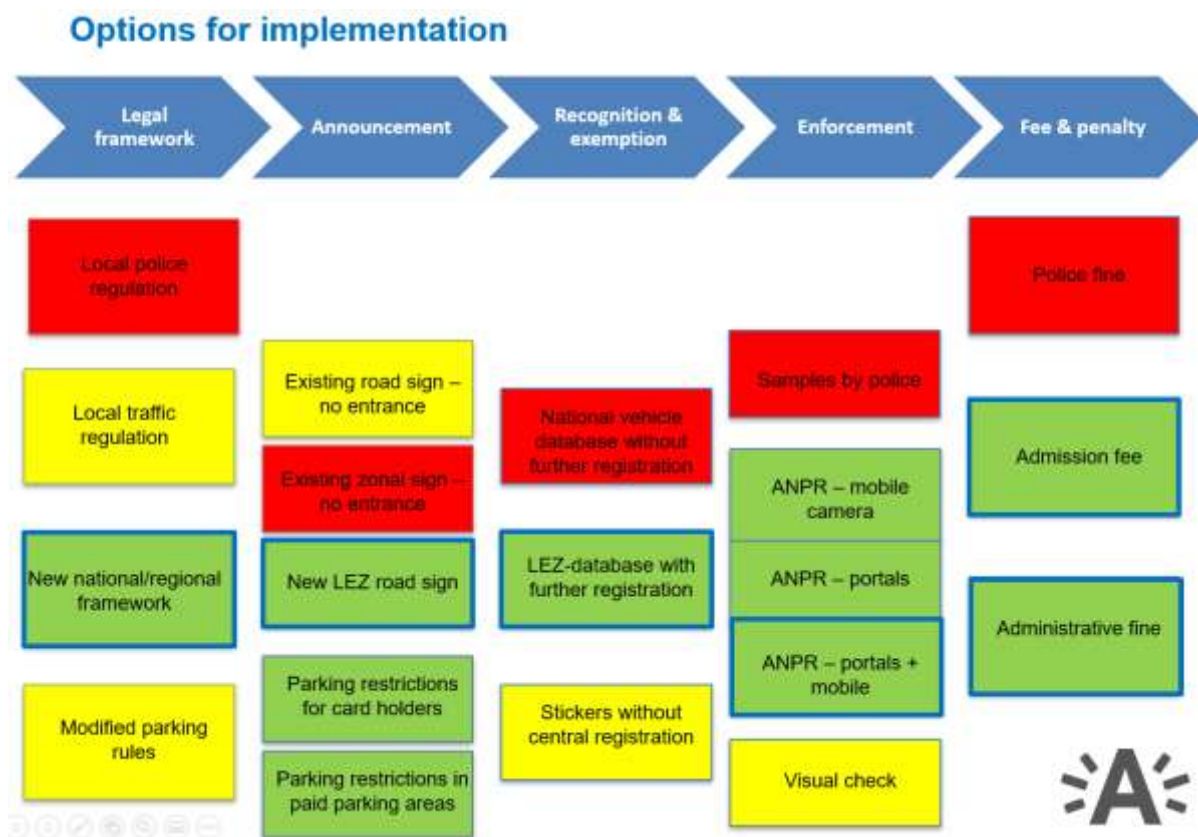


Figure 4.1: This is a schematic overview of the options considered. Framed in green are the options that were eventually chosen.

4.5.2.7. Current admission requirements³

The LEZ in Antwerp started in February 2017. The LEZ area covers 20 km² and includes about 200,000 inhabitants.

Entry requirements based on the vehicle's Euronorm are stricter for diesel cars than for cars running on gasoline, natural gas or LPG. This is because diesel cars emit more soot and particulate matter.

The LEZ applies seven days out of seven throughout the day and to the following vehicles: passenger cars, campers, vans and trucks, agricultural vehicles, buses (this includes tourist coaches).

4.5.2.8. Automatically admitted

The admission requirements will be tightened in stages, as determined at the Flemish level. If no euronorm is known, the date of first registration is taken as the basis for determining the euronorm.

³ The information included in this document is a brief overview. For a complete and up-to-date overview, please visit www.sna.be/lez.

Table tightening access conditions

	As of 2017	As of 2020	As of 2025	As of September 2027	As of 2028
Diesel	Euro 4 or higher	Euro 5 or higher	Euro 6 or higher	Euro 6d or higher	Euro 6d or higher
Gasoline, natural gas, LPG	Euro 1 or higher	Euro 2 or higher	Euro 3 or higher	Euro 3 or higher	Euro 4 or higher

Some vehicles are always allowed to enter the LEZ. These include vehicles with a specific function (army vehicles, priority vehicles, vehicles designed to transport people with disabilities, etc.). Other vehicles that have unlimited access are vehicles that emit very little soot and particulate matter such as electric vehicles and hydrogen-powered vehicles.

4.5.2.9. Access after payment

If a vehicle does not meet the admission requirements, it can purchase an LEZ day pass up to eight times a year that is valid on the chosen day until 6 a.m. the following day.

For diesel vehicles that have just not been automatically authorized (euronorm 4 for the period 2020 - 2025), a temporary admission for a fee was introduced. The admission can be purchased for one week, one month, four months or one year. This transitional measure was introduced because the admission requirements for diesel vehicles are stricter than those for gasoline vehicles, which means that they are often relatively young diesel vehicles.

These products can both be purchased until the calendar day after entry. This allows vehicles that drove into the LEZ by accident or emergency to still regulate themselves.

4.5.2.10. Access after free registration

Some vehicles are required to register once and free of charge to access the LEZ. The vehicle data are included in the common Flemish LEZ database making the registration valid for all LEZs in Flanders.

These are primarily foreign vehicles with a permitted Euro standard. There is currently no exchange of vehicle data with other countries possible, which is why it was included in the Flemish LEZ legislation that these vehicles must be registered in the LEZ database. The registration is one-time and free of charge. The only exception are Dutch vehicles, whose data are included in RDW's freely consultable database.

Vehicles that do not meet the authorized euron standard but fall under specific exception conditions must also register once and free of charge. An example of this are cars intended to transport people with disabilities.

Several modalities are provided where a driver can complete the purchase of a day pass or admission, or register their vehicle. A convenient check tool was developed online that tells whether a vehicle has access and what action is required to gain access (no action, registration, day pass or admission). In addition, LEZ vending machines have been placed throughout the city and

access roads to the city where these actions are also possible. Finally, a day pass can be purchased at any parking machine in the city.

4.5.2.11. *Communication on the introduction of the low-emission zone in Antwerp*

The introduction of the LEZ in Antwerp involved an extensive communication campaign. Antwerp was the first city in Belgium to introduce an LEZ. It was therefore chosen to focus on three messages:

- An LEZ is being introduced in Antwerp
- Why is an LEZ needed?
- Check if your vehicle has access

This communication campaign was targeted at several interested audiences. The main target group to be reached was the vehicle owners who had to take action if their vehicle did not meet the access conditions. This was done in the form of spots on TV and radio, brochures, a mailing to the inhabitants of Antwerp, posters, articles in newspapers and magazines, stickers on garbage trucks and streetcars, information signs in parking lots, stickers at petrol stations just across the border with neighboring countries, etc. The message was also spread online, more specifically in the form of a website (www.sna.be/lez), social media campaigns and search engine advertising (SEA).

Information sessions were also provided for residents in and around Antwerp, which included a small exhibition and the chance to receive tailored advice on alternative means of transportation.

In addition, other interested parties were also addressed. Examples include the tourist board of Antwerp and other cities, garage owners, hotels, foreign embassies in Belgium, embassies of neighboring countries ...

The first communication was sent out a year before the LEZ was launched (spring 2016). Here the main focus was on the first two messages mentioned above. The follow-up communication in the fall of 2016 was to encourage vehicle owners to check their vehicles and possibly take action to regulate.

When it was introduced in February 2017, the decision was made not to send out fines in the first month, but rather a warning letter. In this way, drivers who had not been prompted to take the necessary action through previous campaigns still had a chance to regulate themselves before receiving a fine.

4.5.2.12. *Enforcement - Check*

Monitoring of vehicles traveling in the LEZ is done with ANPR cameras.

These are set up at each entrance and/or exit of the low-emission zone and in the city center. The use and cost of the ANPR cameras is shared with the local Antwerp police.

The license plates registered by the ANPR camera are compared with a list of all authorized vehicles after ten days. This list is, on the one hand, the local whitelist of vehicles for which a day pass or permit was purchased. On the other hand, there is a comparison with the data in the Flemish LEZ database, which includes all registered foreign vehicles and exemptions, and data of vehicles with Belgian license plates). There is a delay on the check because the maximum administrative processing time for applications for admission or registration is ten days and one can still submit an application up to and including the day after entering.

Vehicles that are not on the whitelist and yet have entered the LEZ enter the list of potential violators. An LEZ supervisor then checks that list (visual inspection of license plate and country) and makes the determination. The fining officer then sets the administrative fine for each violator. The fine is sent by registered mail to the suspected violator. Thus, the violator receives the fine for the violation an average of 20 to 30 days after entering the low-emission zone.

In order to maximize the deterrent effect and encourage people to adapt, the amount of the fine was increased from 125 euros to 150 euros from the second year. In addition, repeat offenders receive a higher fine each time.

Table of rates of violations (as of 2018)

First offense	€150
Second offense within 12 months of previous fine	€250
Third and subsequent offense within 12 months of previous fine	€350

4.5.2.13. Enforcement of vehicles with foreign license plates

- Bilateral agreement France and the Netherlands

Based on a bilateral agreement between Belgium and France, and Belgium and the Netherlands, respectively, it is possible to request the personal data of license plate holders of French and Dutch vehicles that are in violation. Thus, the team in Antwerp can also send fines to France and the Netherlands.

- Cooperation with bailiff

For foreign offenders from ten other countries, we work with a bailiff who first tries to retrieve the license plate holder's information in the respective countries. It will then follow up on the case once the fine has been imposed. In other words, the determination of the violation and the imposition of the fine is done locally in Antwerp. The bailiff then sends out the fine, deals with complaints and objections, and sends a reminder if payment is not made.

Some of the countries the judicial officer is currently writing to include Germany, Italy, Lithuania, Poland, Spain, and Switzerland.

- On-street enforcement

Finally, enforcement is also carried out on the streets in cooperation with the police. This enforcement occurs on average twice a month and aims to check vehicles from the remaining countries for which there is no record of the license plate holder. The vehicles are stopped and a check is made to see if there is an outstanding fine on that license plate. If a fine is outstanding, the driver can pay on the spot. The amount in case of immediate collection is less than the normal amount of the fine. If there is no outstanding fine, the LEZ team provides the necessary info about the LEZ so that the driver is alerted.

- Late registration

Despite extensive communication, it remains difficult to inform foreign visitors in a timely manner that they are required to register their vehicle. If they fail to do so, they will be fined. Since it is not known what euronorm and fuel these vehicles have, the fine is as high for a vehicle with high

euronorm as for a vehicle with an unauthorized euronorm. To still accommodate these drivers, the procedure of late registration was introduced from January 2020.

This allows the license plate holder, after receiving the fine, to still register his vehicle and pay an administrative cost of 75 euros for this instead of a 150 euros fine.

4.6. IMPACT OF LOW-EMISSION ZONE IN ANTWERP

4.6.1. Fleet conformity

Before the LEZ was implemented, a study was conducted to determine what percent of the fleet would be affected by it.

This showed that 20% percent of vehicles would no longer have access to the LEZ. 10% would still have access after purchasing an admission and 10% would only be able to access eight times a year after purchasing a day pass.

Figures from recent years show that the proportion of unauthorized vehicles still driving in the LEZ is declining. In 2020, 1.6% of Belgian vehicles were still fined for entering the LEZ with an unauthorized vehicle. In 2021, this figure dropped to 0.7%. The proportion of compliant cars in the low-emission zone is increasing every year.

4.6.2. Impact after three years of LEZ: vehicle fleet, air quality and social impact

An [evaluation](#) published by the Flemish Environment Agency (VMM) in November 2020 [11] on the LEZ in Flanders shows that:

- **the low-emission zones have effectively accelerated the greening of the vehicle fleet.** Most LEZ residents with old diesel vehicles sold them before or immediately after the introduction of the LEZ or the tightening of access conditions (from January 1, 2020). As a result, old diesel vehicles disappeared from the low-emission zones faster than in the rest of Flanders. Those who replaced an old vehicle more often chose a (used) petrol vehicle than a more recent diesel vehicle because a petrol vehicle is allowed in an LEZ for much longer.
- **the effects of the LEZ extend beyond the zone itself.** This is because more gasoline than diesel cars were also purchased in the rest of Flanders, due to the arrival of low-emission zones in several cities but also due to the adjustment of fuel taxes and the greening of traffic taxation. As a result, nitrogen dioxide concentrations have also fallen sharply in Flanders at all high-traffic locations.

4.6.3. Impact on air quality: soot

The introduction of the LEZ caused additional local decreases in black carbon concentrations. Black carbon is a measure of ambient air soot concentration – Fig. 4.2.

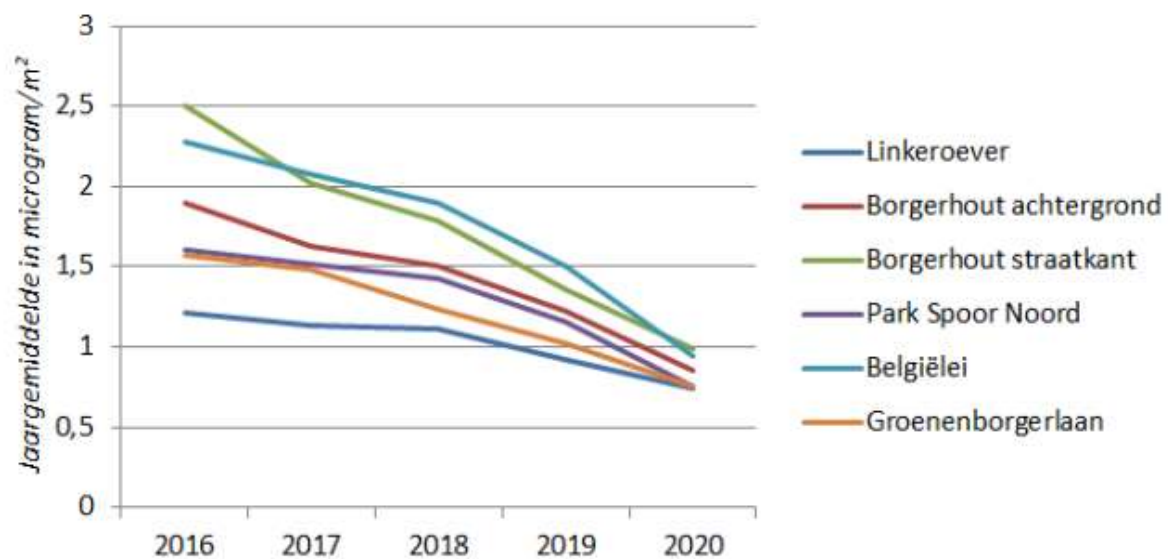


Figure 4.2: Air quality measurement of soot

The concentrations of black carbon dropped between 39 % and 60 % between 2016 and 2020 at the LEZ monitoring sites. For the other monitoring stations in Flanders (excluding the 8 monitoring stations in the Antwerp agglomeration), we see a relative decrease between 29 % and 55 % in 2020 compared to 2016. When looking at decreases in black carbon concentrations, we see that concentrations at the traffic-oriented measurement site at Plantin and Moretuslei (R802) and Belgiëlei (R805) and also at background measurement sites in and at the edge of the LEZ decrease overall more than elsewhere.

4.6.4. Impact on air quality: NO2

NO2 concentrations decreased between 28% and 40% at monitoring sites in the LEZ between 2016 and 2020 – Fi. 4.3.

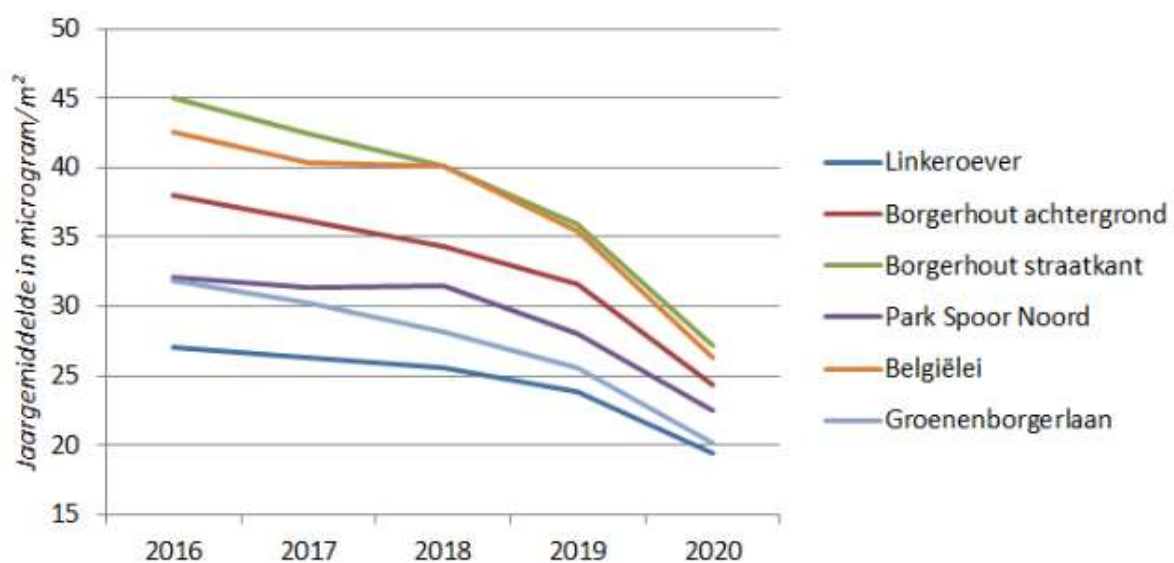


Figure 4.3: Measurement of air quality NO2

In 2020, NO2 concentrations decreased significantly at all sites compared to 2019.

However, it is important to bear in mind that general activity has been considerably reduced in 2020 due to administrative measures linked to the management of Covid19 and that emissions of all kinds have therefore fallen considerably in 2020.

5. CONCLUSIONS

One of the more difficult parts of introducing the LEZ will be finding a balance between environmental goals (mainly lowering emissions), social acceptability and also economic effects. Finding a consensus among these three factors should result in introducing a solution compliant with the rules of sustainable development.

According to Krakow's experience, LEZs should be implemented based on mild and phased restrictions. This is one of the major conclusions of the public consultations that are being conducted in Krakow. After many years of work towards the establishment of the LEZ, it has been proposed that the LEZ will become operational on July 1, 2024. However, it is unclear when the LEZ will actually be introduced. The position of the provincial governor and opponents of the LEZ indicate that the introduction of the LEZ may be delayed, despite the efforts of activists and extensive public consultation.

Concerning the impact of the LEZ in Antwerp the evaluation published in 2020 by the Flemish Environmental Agency (VMM) shows that the low-emission zones have effectley accelerated the greening of the vehicle fleet.

6. RECOMMENDATIONS

From the work carried out during this cycle, we can already predict that the major challenge for the implementation of LEZ will be finding a balance between environmental goals (mainly lowering emissions), social expectations and also economic effects. Finding a consensus among these three factors should result in introducing a solution compliant with the rules of sustainable development which has to be viable, liveable and fair.

Thus, for a European-type city where the inhabitants of the urban centres are more affluent than those in the suburbs, where, by assumption, the main activity is in the tertiary sector and the housing is low in pollutant emissions, the introduction of an EPZ in the city centre will be beneficial to its inhabitants. On the other hand, the pressure exerted on personal vehicles will be detrimental to outsiders forced to drive through the EPZ or to get to it. It is therefore not obvious that the apparent social acceptability (for example, by having only the residents of the EPZ vote) is real if all the people affected are included. The same applies to each of the criteria to be taken into account. These must be assessed on the scale of the changes brought about by the LEZs, not just in or around them.

It follows that assessing the performance of a LEZ cannot be limited to monitoring certain parameters (number or quality of vehicles, concentration of pollutants, etc.) in or around the LEZ. A global vision of the impacts and changes induced and their effects is required. One example is the greening of the fleet of vehicles circulating within the LEZ : The electrification of the vehicle fleet is not without consequences either, as it increases pressure on the minerals needed to build electric vehicles and their batteries, and worsens the social and environmental conditions under which they are extracted.

For all these reasons, it is not possible to unilaterally recommend the use of EPZs. On the contrary, engineers, researchers and decision-makers must be encouraged to take into account the overall impact of these measures in order to assess whether the benefits that can be expected for the inhabitants of the LEZ really outweigh the negative aspects, which must be identified both inside and outside the LEZ.

7. REFERENCES

- [1] Amundsen, A. H. and Sundvor I. (2018). Low Emission Zones in Europe. Requirements, enforcement and air quality. Institute of Transport Economics. Norwegian Centre for Transport Research. TØI report 1666/2018.
- [2] Automotive Industry Report 2021/2022. Polish Automotive Industry Association.
- [3] Bernard, Y., Titge, U., Pniewska, I. (2020). Teledetekcja emisji spalin pojazdów silnikowych w Krakowie (Remote sensing of motor vehicle emissions in Krakow). International Council on Clean Transportation na zlecenie Zarządu Transportu Publicznego w Krakowie.
- [4] <https://civitas-reveal.eu/>
- [5] <https://ec.europa.eu/eurostat/web/transport/>
- [6] <https://urbanaccessregulations.eu/>
- [7] <https://ztp.krakow.pl/sct/idea-sct>
- [8] <https://codex.vlaanderen.be/Zoeken/Document.aspx?DID=1026220¶m=inhoud>
- [9] <https://codex.vlaanderen.be/Zoeken/Document.aspx?DID=1026568¶m=inhoud&ref=search&AVIDS=1286750,1286751,1286758>
- [10] <https://www.wegcode.be/nl/regelgeving/1975120109~hra8v386pu>
- [11] <https://www.vmm.be/publicaties/impact-van-de-lage-emissiezones-op-het-wagenpark-de-luchtkwaliteit-en-sociaal-kwetsbare-groepen>
- [12] <https://www.vmm.be/publicaties/luchtkwaliteit-in-de-antwerpse-agglomeratie-jaarrapport-2020>



Copyright by the World Road Association. All rights reserved.

World Road Association (PIARC)

La Grande Arche, Paroi Sud, 5e étage, F-92055 La Défense cedex