



Ajuntament
de Barcelona

BARCELONA RING ROADS LOW EMISSION ZONE

Annual monitoring report 2023



BARCELONA RING ROADS LOW EMISSION ZONE

Annual monitoring report 2023

Coordination and author:

Manager's Office for Urban Services and Maintenance of Public Spaces

Directorate for Energy Services and Environmental Quality

Department of Environmental Assessment and Management



The contents of this publication are subject to an Attribution-ShareAlike (by) licence. This allows any use of the work, including for commercial purposes, as well as the creation of derived works, which may also be distributed without any restrictions, provided the source is cited.

The full licence may be consulted at

<https://creativecommons.org/licenses/by/4.0/deed.ca>

Barcelona, August 2024



Table of contents

Glossary of terms	1
1. Introduction	2
2. Context.....	3
3. Health impact.....	8
4. Regulatory Framework.....	9
4.1 European regulations	10
4.2 National regulations.....	10
4.3 Autonomous community regulations	11
4.4 Special regime for Barcelona.....	12
5. Barcelona Ring Roads LEZ	14
6. Monitoring of the Ring Roads LEZ.....	19
6.1 Air quality associated with road traffic	21
6.1.1 Average immissions recorded by the XVPCA stations	21
6.1.2 Emissions inventory.....	24
6.1.3 Analysis of the contribution	25
6.2 Climate change mitigation	27
6.2.1 Evolution of energy consumption	27
6.2.2 Evolution of GHG emissions by sector	28
6.3 Promoting a modal shift.....	29
6.3.1 Evolution of annual mobility	29
6.3.2 Modal share.....	30
6.3.3 Vehicle fleet characteristics: Evolution of annual emission factors.....	31
6.3.4 Evolution of road traffic emissions.....	32
6.3.5 Analysis of the vehicle fleet by environmental label	33
6.3.6 Analysis of vehicles without a label.....	34
6.3.7 Registered vehicle fleet data.....	35
6.4 Noise quality.....	35
6.5 LEZ register	37
6.5.1 Evolution of the number of applications.....	37
6.5.2 Evolution of the number of applications by type.....	37



6.5.3 Average number of daily authorisations requested per vehicle.....	38
6.5.4 New authorisations	40
6.5.5 Evolution of the number of green cards	42
6.6 Fine procedures.....	43
6.6.1 Number of closed fines	43
7. Conclusions	45



Glossary of terms

"NO_x" or "Nitrogen oxides": A group of highly reactive gases containing nitrogen and oxygen in various proportions that are formed when fuels are burned. The main sources of these pollutants would be cars (road traffic), industry, commerce and domestic activities where fuel is burned.

"NO₂" or "Nitrogen Dioxide": Brownish gas with an irritating odour, toxic at high concentrations, involved in the formation of photochemical smog and emitted mainly by road traffic in large cities, although it can also be produced by industrial activities, commerce or certain domestic activities.

"PM_{2.5}": Particulate matter passing through the selective size head, defined by the reference method for the sampling and measuring PM_{2.5} of the UNE-EN 12341 standard, for an aerodynamic diameter of 2.5 µm.

"PM₁₀": Particulate matter passing through the selective size head, defined by the reference method for the sampling and measuring PM₁₀ of the UNE-EN 12341 standard, for an aerodynamic diameter of 10 µm.

"BC" or "Black Carbon": Air pollutant formed from the incomplete combustion of organic materials, such as fossil fuels, biomass or wood. In large cities it becomes a major tracer of traffic's contribution to air pollution.

"CO₂": An insipid, colourless and odourless gas. It is not toxic and so is not considered to be directly harmful to health. However, it is a greenhouse gas and it does have a direct effect on global warming and climate change. It is produced by combustion in engines, heating, etc.

"Limit value": Pollution level set based on scientific knowledge aimed at preventing or reducing harmful effects on human health, the environment as a whole, and other goods of any kind, to be achieved within a specified period and not to be exceeded once achieved.

"µg" or "microgram": A unit of mass in the International System of Units which is equivalent to one billionth of a kilogram (10⁻⁹ kg) or one millionth of a gram (10⁻⁶ g).

"GHG": Greenhouse gases.

"Emission": Emissions are related with the release of pollutant substances into the atmosphere from an emission source (traffic, industry, homes, natural sources, etc.).

"Immission": Immission refers to the air we breathe. It is also known as air quality and can affect people, animals, vegetation or materials depending on the type and concentration of different pollutants.

1. Introduction

On 27 December 2022, Royal Decree 1052/2022 of 27 December was approved, regulating low emission zones in implementing Article 14 of Act 7/2021 of 20 May, on climate change and energy transition. This law mandates the establishment of low emission zones (referred to as LEZ) in Spanish municipalities with more than 50,000 inhabitants by 2023.

Barcelona City Council had previously approved an LEZ before the entry into force of Royal Decree 1052/2022. *This was done through the Byelaw restricting the circulation of certain vehicles in the city of Barcelona, with the aim of preserving and improving air quality, dated December 20, 2019.*

With the purpose of aligning the regulatory text with the aforementioned reference regulation, on 27 January 2023, a new *Byelaw establishing the criteria for access, circulation, and parking of vehicles in Barcelona's low emission zone, while promoting emissions-free mobility* was approved, replacing and repealing the previous regulatory text.

This new byelaw establishes the objective and purpose of the LEZ beyond strict compliance with air quality limit values, aligning the measure with the fight against climate change and the reduction of CO₂ emissions. It also aims to improve other environmental indicators and enhance quality of life in the city of Barcelona.

The new regulatory text maintains the essence of the LEZ intact but incorporates social improvements to mitigate possible negative externalities for very specific and vulnerable groups, which in no case jeopardises the overall benefit obtained by the measure.

As determined in Article 12 of Royal Decree 1052/2022, of 27 December, which regulates low emission zones, and in Article 18 of the *Byelaw establishing the criteria for access, circulation and parking of vehicles in Barcelona's low emission zone while promoting emissions-free mobility*, local authorities must establish a continuous monitoring and tracking system. This system aims to assess the effectiveness of measures adopted and ensure compliance with objectives related to air quality, mitigation of climate change impacts, public health, the modal shift towards more sustainable transport modes, and other aspects of urban life.

The aim of this report is to monitor the LEZ in the Barcelona for the year 2023, detailing the main regulatory changes and providing the set of indicators used for monitoring, thereby fulfilling the provisions of Article 18 of the Byelaw regulating the LEZ.

2. Context

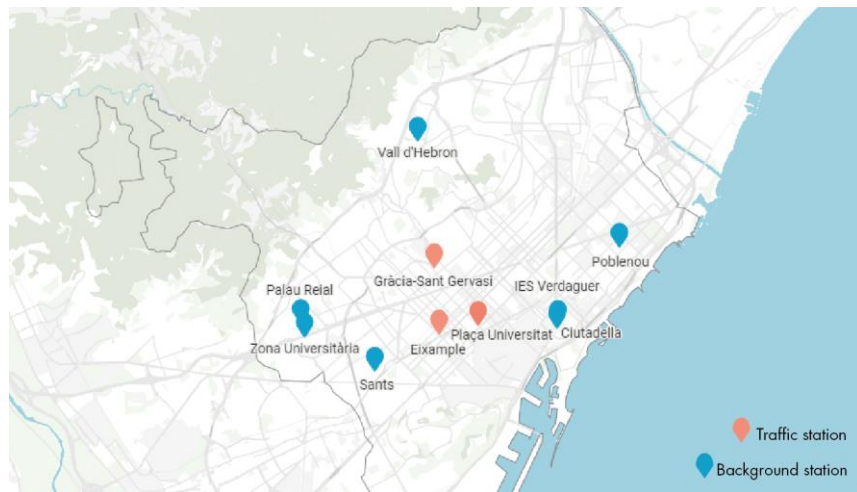
Air quality levels for NO₂ had consistently been exceeding both the limit values established by regulatory standards¹ ²and the recommended guideline values set by the World Health Organization (WHO)³ in Barcelona since 2005. This persistent non-compliance prompted implementation of decisive measures aimed at reversing the situation and improving the air quality that residents breathe in the city.

According to the data collected by the Air Pollution Monitoring and Forecasting Network (hereinafter XVPCA) [Map 1], the annual average of NO₂ has been decreasing over the past decade especially at traffic stations. Fig. 1 shows the evolution of this pollutant since 2001. During the pre-pandemic period [2000-2019] the levels remained above the legal annual average limit (40 µg/m³) and well above the current WHO guideline value (10 µg/m³). However, during the pandemic years [2020-2021], values remained within legal compliance due to the restrictions associated with the health emergency and the establishment of measures such as the LEZ.

MAP 1

Location of the Barcelona Air Pollution Monitoring and Forecasting Network (XVPCA) stations.

Source: Barcelona City Council



	Location	Type
Ciutatella	Parc de la Ciutatella	Background
IES Verdaguier secondary school	Parc de la Ciutatella (IES Verdaguier)	Background
Eixample	Av. Roma - c/Comte Urgell	Traffic
Gràcia – Sant Gervasi	Plaça de Gal•la Placídia (Via Augusta – Travessera de Gràcia)	Traffic
Cemetery	Jardins de Josep Trueta (c/ Pujades – c/ Lope de Vega)	Background
Sants	Jardins de Can Mantega (c/ Joan Güell)	Background
Plaça de la Universitat	c/Balmes – Gran Via de les Corts Catalanes	Traffic
Zona Universitària	Av. Diagonal, 643– Facultat de Biologia	Background
Vall d’Hebron	Parc de la Vall d’Hebron (c/ Martí Codolar – c/ de la Granja Vella)	Background
Palau Reial	c/John Maynard Keynes – c/ Jordi Girona	Background

¹ Directive 2008/50/EC of the European Parliament and of the Council, of 21 May 2008

² RD 102/2011 of 28 January

³ <https://www.who.int/publications/i/item/9789240034228>

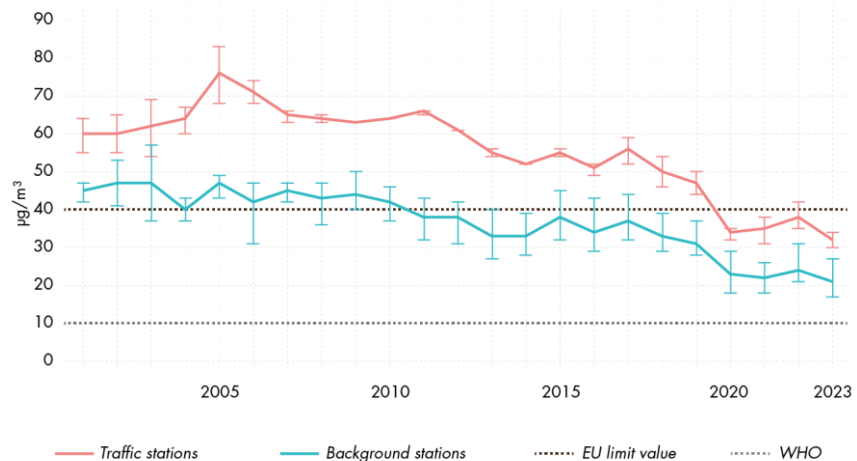
In 2022, the average NO₂ levels at the city's monitoring stations showed an increase compared to the years 2020 and 2021. However, the levels measured in 2023 have decreased again, returning to a situation where compliance is observed at all XVPCA stations. This trend is expected to become definitive in the following years.

In view of the above, it can be stated that NO₂ levels in Barcelona decreased across the city, on average, by more than 40% between 2015 and 2023. This positive trend in emission reduction is the result of accelerated vehicle fleet renewal and the benefits obtained from a comprehensive set of measures promoted by the City Council:

- The LEZ and the accelerated renewal of the vehicle fleet.
- Traffic calming measures, green hubs in the Eixample district, and in other districts of the city.
- The reduction of other local sources of emissions other than road traffic.

FIGURE 1

Evolution over time of the annual average aggregated by traffic and background NO₂ [µg/m³] stations for the period 2001-2023. The ranges indicate the maximum and minimum value measured at each type of station (traffic or background).



Source: Barcelona Public Health Agency (ASPB).

With regard to the vehicle fleet during 2023, it can be seen that the number of vehicles circulating in Barcelona in December of that year with an ECO label (20.51%) is now higher than those with a B label (16.64%). This fact greatly explains the pollution levels recorded in recent months.

TABLE 1

Historical evolution of the vehicle fleet circulating in the city of Barcelona according to the environmental label.

Note: To reach 100% of the total fleet, it is necessary to add a small portion of "unidentified" vehicles.

Source: Barcelona City Council

Label	May/21	May/22	Jan/23	Feb/23	Mar/23	Apr/23	May/23	Jun/23	Jul/23	Aug/23	Sept/23	Oct/23	Nov/23	Dec/23
SD	2,2%	1,6%	1,4%	1,3%	1,2%	1,5%	1,4%	1,3%	1,4%	1,3%	1,3%	1,2%	1,2%	1,3%
B	25,2%	22,1%	19,8%	19,6%	19,3%	19,4%	19,1%	18,8%	18,2%	17,6%	17,6%	17,4%	16,8%	16,6%
C	57,0%	57,2%	56,6%	56,0%	55,5%	54,1%	54,3%	55,9%	55,1%	53,1%	56,0%	56,3%	56,1%	54,6%
ECO	10,9%	13,8%	15,9%	16,2%	15,9%	16,0%	16,3%	18,0%	18,6%	19,6%	18,6%	18,5%	19,2%	20,5%
O	1,7%	2,4%	3,0%	2,9%	3,0%	2,8%	2,9%	3,2%	3,3%	3,1%	3,6%	3,7%	3,9%	3,7%
Foreigners	2,0%	2,0%	1,8%	1,7%	1,8%	2,1%	2,1%	1,9%	2,6%	4,4%	2,1%	2,0%	1,9%	2,2%

Finally, it should be noted that while the mobility recorded in 2023 has been stable, leaving aside the exceptional situation of the COVID-19 health emergency, and maintains annual values practically identical to those of the previous year 2022, the emission factor and the levels of NO₂ immission recorded show a downward trend, thanks mainly to the accelerated renewal of the vehicle fleet and the measures promoted by Barcelona City Council:

FIGURE 2

NO₂ immission levels at traffic stations vs. annual mobility

Source: Barcelona City Council

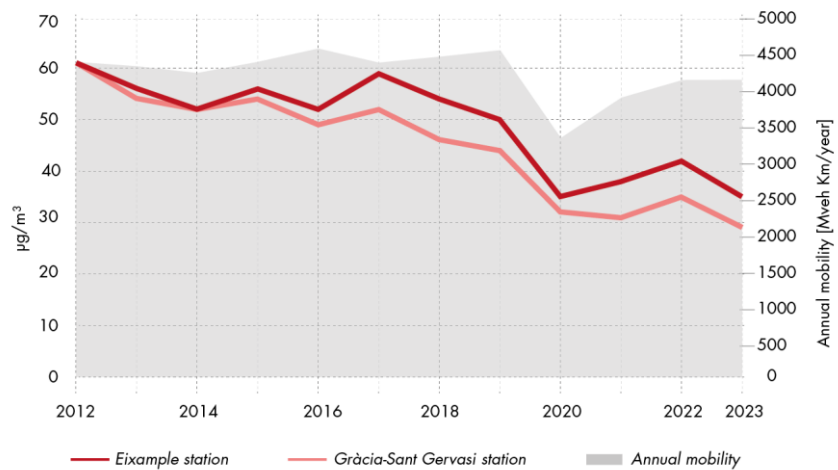
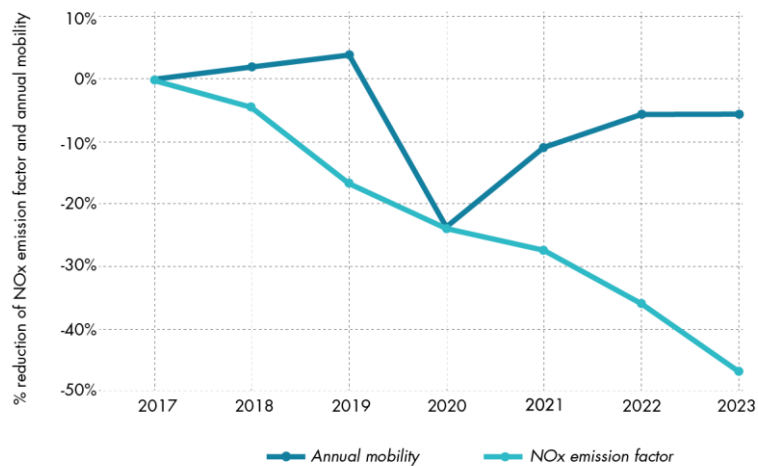


FIGURE 3

% decrease in NO_x emission factor vs. annual mobility

Source: Barcelona City Council

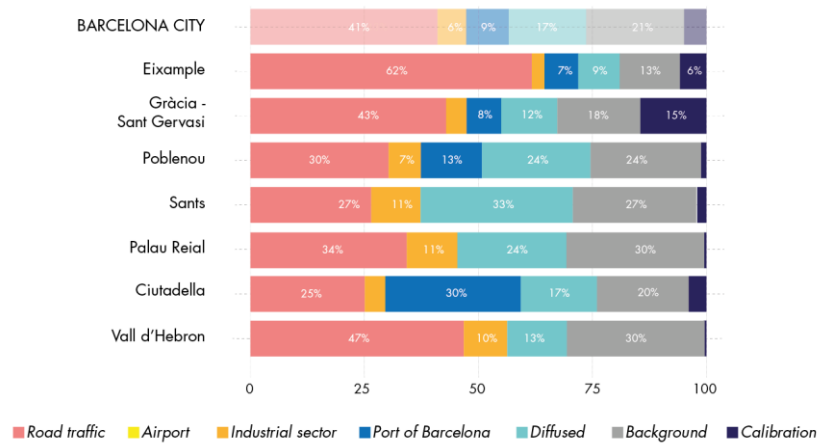


If we look in detail at the sources contributing to the levels of NO₂ recorded at the different XVPCA stations in Barcelona [Fig. 4] we can see that road traffic is the main contributor, accounting for more than 60% of the pollution recorded at the Eixample station, although its contribution has decreased compared to previous years. Nevertheless, the industrial, domestic, and service sectors, as well as major infrastructures like the Port of Barcelona and the Airport are also major contributing centres.

FIGURE 4

*Origin of NO₂ contributions
by emission sector [2022].*

Source: Barcelona Regional



Although air pollution caused by high levels of NO₂ is caused by different sources, and it is necessary to address all of them, it is clear that road traffic is the main contributor in the city. For that reason, decisive actions must be implemented to reduce its emissions.

Thus, with the aim of promoting a reduction in NO₂ emissions caused by road traffic, an LEZ was implemented in Barcelona in 2020. An LEZ is understood as an area defined by a public administration within its jurisdiction, characterised by continuous application of access, circulation, and parking restrictions on vehicles to improve air quality and mitigate greenhouse gas emissions, in accordance with a vehicle classification based on their emission levels as established in the current General Regulation on Vehicles.

An LEZ is an air quality improvement measure already implemented in more than 200 cities across Europe with similar air pollution problems. It is a measure that enjoys the approval of the scientific community and achieves significant improvements in the reduction of pollutant emissions from traffic. [Map 2]

The LEZ operates by delineating a geographical area where restrictions are applied to the circulation of the most polluting vehicles, specifically those that emit higher levels of pollutants.

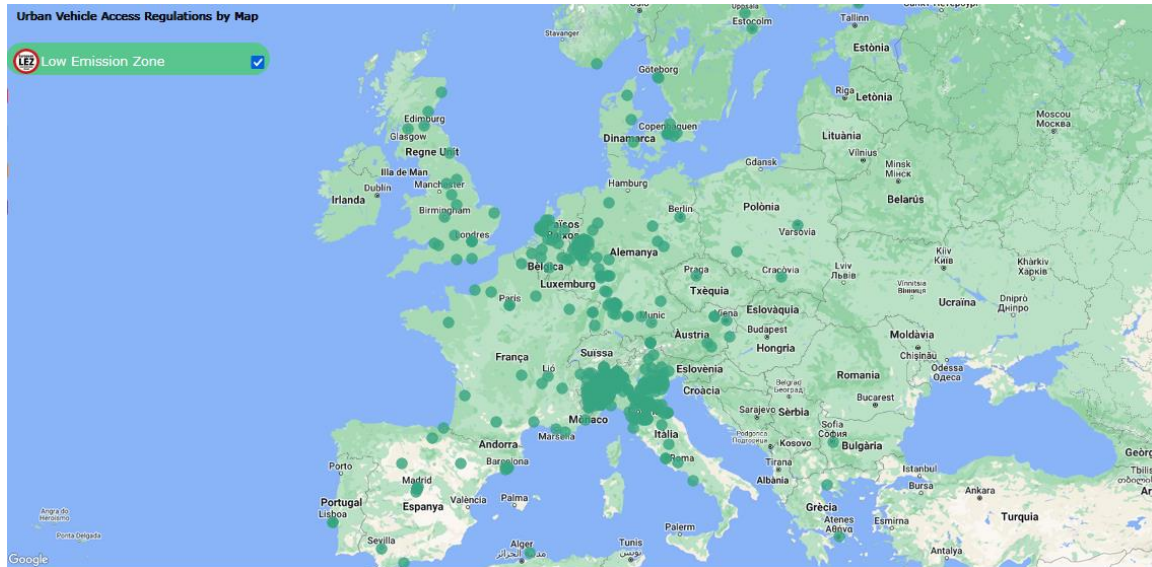
The measure takes advantage of the fact that vehicles registered in the European Union comply with specific criteria for emissions of pollutants, governed by the European emissions standards (EURO standards). Restricting circulation to vehicles compliant with the less permissive EURO standards (pre-EURO, EURO 1, and subsequent standards) allows vehicles that continue to operate to emit fewer pollutants, thereby contributing to cleaner air in the city.



MAP 2

Map of cities with Low Emission Zones

Source: <https://urbanaccessregulations.eu/userhome/map> [updated in 2023]



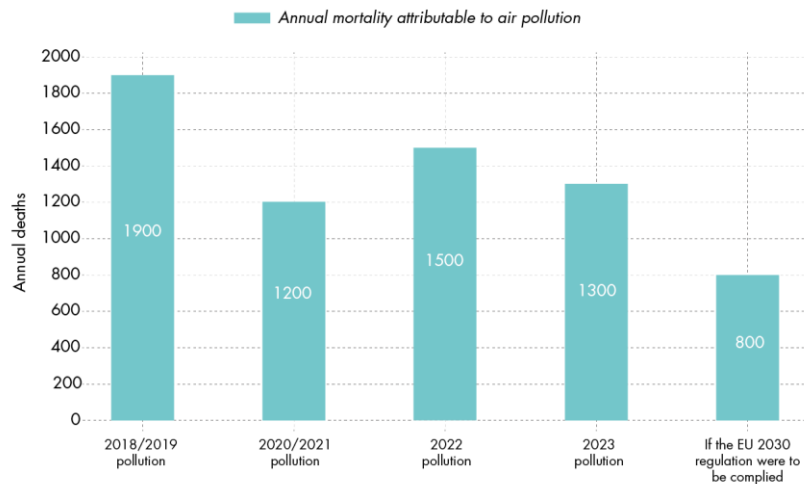
3. Health impact

Air pollution is the primary environmental risk that harms health, as it increases premature mortality and shortens life expectancy. Air pollution is particularly severe for the most vulnerable populations, including children, the elderly, pregnant women, and individuals with health problems.

In Barcelona, the Barcelona Public Health Agency (hereinafter, ASPB) estimates the health impact of air pollution in the city (exposure to annual levels of PM_{2.5} and NO₂).

Figure 5 shows how the variation in air pollution levels in recent years in the city affects the mortality attributable to this type of pollution. Long-term exposure to pollution levels in 2023 is estimated to be responsible for 1,300 deaths each year in the city. The social cost of this annual mortality is estimated at 891 million euros (95%CI=617-1.233) which represents 0.9% of the city’s GDP and around 537 euros per capita. The mortality attributable to pollution levels in 2023 is 32% lower than estimated for the years 2018-2019 (with 1,900 attributable deaths annually), and it would decrease by 38% if Barcelona were to comply with future legal limits for PM_{2.5} and NO₂ (resulting in around 800 attributable deaths annually).

FIGURE 5
Annual mortality attributable to air pollution (PM_{2.5} and NO₂) in the city of Barcelona
Source: Barcelona Public Health Agency



4. Regulatory Framework

The regulatory framework necessary for implementing a measure such as the LEZ includes EU, national, autonomous community and even local regulations. Understanding the entirety of the regulatory framework that needs to be complied with is an essential part of comprehending the implementation of the measure itself.

TABLE 2

Reference regulatory framework
 Source: Barcelona City Council

European regulations	
Directive 2008/50/EC , of the European Parliament and of the Council, of 21 May 2008, on ambient air quality and cleaner air for Europe	
National regulations	
Spanish Constitution (CE)	CE Art. 43 and 45 - The right to health protection
National sectoral legislation	Act 7/2021 , of 20 May, on Climate Change and Energy Transition
	Royal Decree 1052/2022 , of 27 December, regulating low emission zones
	Act 34/2007 , of 15 November, concerning air quality and atmospheric protection
	Royal Decree 102/2011 , of 28 January, concerning the improvement of air quality
	General Public Health Act 33/2011 , of 4 October
	Royal Legislative Decree 6/2015 , of 30 October
Autonomous Community Regulations	
Statute of Autonomy of Catalonia (EAC)	EAC – Art. 27 – Concerning the right to live in a balanced, sustainable and health-friendly environment
	EAC – Art. 46 – Concerning the obligation for environmental policies to be particularly aimed at reducing the different forms of pollution
Sectoral legislation of the Government of Catalonia	Act 22/1983 , of 21 November, concerning protection of the atmospheric environment
	Decree 226/2006 , of 23 May, on the declaration of special atmospheric protection zones
	Act 18/2009 , of 22 October, on public health in Catalonia
Local regulations	
Special regime for Barcelona	The Municipal Charter of Barcelona , approved by Act 22/1998, of 30 December
	Act 1/2006 , of 13 March, regulating the special regime for the municipality of Barcelona



LEZ municipal regulation	Bylaw that sets the criteria for access, circulation and parking of vehicles in the low-emission zone and promotes zero-emission mobility
--------------------------	---

4.1 European regulations

Directive 2008/50/EC, of the European Parliament and of the Council, of 21 May 2008, on ambient air quality and cleaner air for Europe.

This Directive is aimed at the following:

- Defining and establishing objectives for ambient air quality designed to avoid, prevent or reduce harmful effects on human health and the environment as a whole.
- Assessing the ambient air quality in Member States on the basis of common methods and criteria.
- Ensuring that information on ambient air quality is made available to the public and promoting increased cooperation between the Member States in reducing air pollution.

4.2 National regulations

Spanish Constitution:

CE, Articles 43 and 45 – The right to health protection establishes the obligation of public authorities to safeguard public health through the adoption of preventive measures and necessary services. It proclaims the right to enjoy an environment suitable for personal development, as well as the duty to conserve it. Public authorities are obligated to ensure the rational use of natural resources to protect and improve quality of life, and to defend and restore the environment. Penalties, both criminal and administrative, are provided for by law for violations, along with the obligation to compensate for any damage caused.

National sectoral legislation:

Act 7/2021, of 20 May, on climate change and energy transition, which aims to ensure Spain's compliance with the objectives of the Paris Agreement, signed by Spain on 22 April 2016, and to promote adaptation to the impacts of climate change and the implementation of a sustainable development model, among other aspects. Article 14.3 of this law establishes the obligation for certain local entities – including Barcelona – to adopt, before 2023, sustainable urban mobility plans that introduce mitigation measures to reduce emissions derived from mobility itself, including, among others, the establishment of low emission zones.

The obligation emanating from article 14.3 of Law 7/2021 included municipalities with more than 50,000 inhabitants, as well as those with more than 20,000 inhabitants when air quality limit values are exceeded. For its part, the Generalitat de Catalunya agreed, within the framework of the 3rd Summit on Air Quality of March 18, 2022, to take a step forward and assume the commitment to work for the implementation of the LEZ to all municipalities in Catalonia with more than 20,000 inhabitants before the end of 2025.



Royal Decree 1052/2022, of 27 December, which regulates low emission zones, implementing Article 14 of Act 7/2021 of 20 May, on climate change and energy transition.

Act 34/2007, of 15 November, on air quality and atmospheric protection, Article 5 of which establishes that local authorities are responsible for exercising those competences in matters of air quality and atmospheric protection that are attributed to them within the scope of their specific legislation, as well as those others that are attributed to them within the framework of basic National legislation and the legislation of the Autonomous Communities in this matter.

Royal Decree 102/2011, of 28 January, on the improvement of air quality, which implements Law 34/2007, and, inter alia, defines and establishes air quality objectives and regulates the assessment, maintenance and improvement of air quality in relation to certain harmful substances, in order to avoid, prevent and reduce harmful effects on human health, the environment as a whole and other goods of any nature.

General Public Health Act 33/2011 of 4 October, Article 19 of which provides that the public administrations, within the scope of their powers, must direct preventive actions and policies on the determinants of health, these being understood to be the social, economic, occupational, cultural, food, biological and environmental factors that influence people's health.

Royal Legislative Decree 6/2015, of 30 October, approving the revised text of the Law on traffic, circulation of motor vehicles and road safety, which, among other things, specifically allows the competent authority to order the total or partial prohibition of access to roads, both for all purposes and for certain vehicles, or the closure of certain roads for environmental reasons.

4.3 Autonomous community regulations

Statute of Autonomy of Catalonia (EAC):

EAC – Art. 27 – Establishes that everyone has the right to live in a balanced, sustainable and health-friendly environment, in accordance with standards and levels of protection determined by law. They also have the right to equal enjoyment of natural resources and the landscape, and the duty to use them responsibly and avoid waste. Likewise, this same article establishes the right of all people to protection against different forms of pollution, in accordance with the standards and levels determined by law, as well as the duty to collaborate in conservation of the natural heritage and in actions designed to eliminate different forms of pollution, with the aim of maintaining and conserving it for future generations. And finally, it guarantees the right of all individuals to access environmental information held by public authorities.

EAC – Art. 46 – Establishes that public authorities must ensure protection of the environment by adopting public policies based on sustainable development and collective and intergenerational solidarity. It requires that environmental policies focus particularly on



reducing various forms of pollution, establishing standards and minimum levels of protection, and implementing corrective measures for environmental impact, among other objectives.

Sectoral legislation of the Government of Catalonia:

Act 22/1983, of 21 November, on protection of the atmospheric environment, which aims to establish and regulate the instruments and procedure considered necessary for effective action by the public administrations of Catalonia in the field of prevention, monitoring and correction of atmospheric pollution and which attributes to the local authorities their own powers in the matter (Art. 11). Possible measures envisaged are those necessary to reduce the polluting effects of urban and intercity traffic in the affected area (Art. 10.5 d).

Decree 226/2006 of 23 May, declared several municipalities in the counties of Barcelonès, Vallès Oriental, Vallès Occidental and Baix Llobregat special protection zones for the pollutant nitrogen dioxide (NO₂) and for suspended particles, specifically those with a diameter of less than 10 microns (extended by Decree 203/2009 of 22 December 2009). This Decree has been repealed by the current Decree 152/2007 of 10 July, approving the Action Plan for the improvement of air quality in areas declared as special atmospheric protection zones.

Act 18/2009, of 22 October, on public health in Catalonia, aims to coordinate actions, services, and provisions in health matters to ensure the monitoring of public health, promote individual and collective health, prevent disease, and protect health. It defines, among the provisions in public health, the promotion and protection of health, and the prevention of risk factors related to air and water, as well as environmental aspects that may impact human health (Art. 7. 3 e).

4.4 Special regime for Barcelona

The Municipal Charter of Barcelona (hereinafter, the CmB), approved by Act 22/1998, of 30 December: The preamble states that the Act aims to “prioritise environmental concerns in the actions of municipal government”, a commitment later specified in its provisions (Article 103, first, letter a). According to Article 42 of the CmB, all citizens have the right to be informed about the data held by the City Council concerning environmental conditions within the municipal area, particularly regarding air, soil, and water pollution levels, as well as noise pollution. Within the framework of the Charter of Environmental Rights and general environmental legislation, the City Council is obligated to develop its environmental policy and exercise all its competencies with regard to their impact on environmental quality. It also stipulates that the City Council must encourage the use of non-polluting vehicles as opposed to those that may cause pollution. The specific measures for the application of this regulation must be established in the municipal byelaws.

Act 1/2006, of 13 March, which establishes the special regime of the municipality of Barcelona, gives primary importance to competences in the area of mobility. In its preamble, several paragraphs are dedicated to discussing the problems caused by traffic in Barcelona, stemming from the city's centralisation effects, particularly concerning neighbouring municipalities



within the metropolitan area. Given the high population density in this area, there is a direct consequence of constant influx and outflux of a large number of vehicles from other municipalities.

5. Barcelona Ring Roads LEZ

On 27 December 2022, *Royal Decree 1052/2022 of 27 December* was approved, regulating low emission zones, implementing Article 14 of *Act 7/2021 of 20 May, on climate change and energy transition*. This law mandates the establishment of LEZ in Spanish municipalities with more than 50,000 inhabitants by 2023.

Barcelona City Council approved an LEZ before the entry into force of the Royal Decree. *This was done through the Byelaw restricting the circulation of certain vehicles in the city of Barcelona, with the aim of preserving and improving air quality*, dated December 20, 2019. The measure came into force on 1 January 2020, as planned.

The approval process of the measure required an extensive participatory process, with sessions held in all city districts – and information distributed throughout the city – where citizens could give their opinion and propose changes to the initial text of the Byelaw. The public consultation process concluded with approximately 2,000 objections submitted, which helped adapt the text to the needs of different population groups, resulting in a significant number of exemptions and access authorisations granted for the LEZ.

In addition, on 27 January 2023, Barcelona City Council approved *the Byelaw establishing the criteria for access, circulation and parking of vehicles in the Barcelona low emission zone and promoting emission-free mobility*. This regulates the Barcelona LEZ and updates the provisions of the previous Byelaw to adapt it to *Act 7/2021, of 20 May, on climate change and energy transition* and the Royal Decree that implements it, establishing the objective and purpose of the LEZ beyond strict compliance with air quality limit values, and aligning the measure with the fight against climate change and the reduction of CO₂ emissions, as well as improving other environmental indicators and enhancing quality of life in the city.

In short, the Barcelona LEZ covers the entire municipal area of the city, except for the Vallvidrera, Tibidabo, and Les Planes neighbourhood, as well as the Zona Franca Industrial estate. It functions as an area where the circulation of highly polluting vehicles is restricted. The LEZ in the city alone covers an area of approximately 77 km² (76% of the municipal area) and includes nearly all its residents (1,636,193 inhabitants as of 2022).

Due to the cross-border nature of air pollution and the characteristics of the Barcelona conurbation, with different municipalities intertwined in the same urban fabric, the Barcelona LEZ took into account from the outset other municipalities in the Barcelona Metropolitan Area (such as L'Hospitalet de Llobregat, Cornellà de Llobregat, Esplugues de Llobregat, and Sant Adrià de Besòs), expanding its coverage to over 95 km² and affecting a population of over 2 million people.

The purpose of the LEZ is to reduce emissions from road traffic, thereby improving the air quality in the city, bringing pollutant levels closer to those recommended by the World Health


Organization (WHO), and complying with air quality limits established in current legislation. Additionally, it aims to promote better acoustic quality, making the city more pleasant and liveable.

Since the adoption of the LEZ [Map 3] on 1 January 2020, the most polluting vehicles have not been allowed to circulate, namely those vehicles that do not have the corresponding DGT environmental label (Zero, Eco, C and B).

TABLE 3

Vehicle classification table according to the DGT environmental label

Source: Barcelona City Council

	
Without environmental label	<p>Petrol-driven passenger cars (M1) and vans (N1) before Euro 3 and diesel-driven passenger cars before Euro 4.</p> <p>Motorcycles and mopeds (L) before Euro 2.</p> <p>Petrol- and diesel-driven buses (M2 and M3) and lorries (N2 and N3) before Euro 4.</p>
B	<p>Petrol-driven passenger cars and vans must comply with Euro 3 and diesel-driven passenger cars and vans must comply with Euro 4 or 5. Lorries and buses must comply with Euro 4 or 5.</p> <p>Motorcycles and mopeds: Euro 2.</p>
C	<p>Petrol-driven passenger cars and vans must comply with Euro 4, 5 or 6, and diesel-driven passenger cars and vans must comply with Euro 6. Lorries and buses must comply with Euro 6.</p> <p>Motorcycles and mopeds: Euro 3 or Euro 4.</p>
Eco	<p>Mopeds, motorcycles, passenger cars, light vans, vehicles with more than 8 seats and goods vehicles classified in the Vehicle Register as plug-in hybrid vehicles with a range of less than 40 km, non-plug-in hybrid vehicles (HEV and PHEV), vehicles powered by natural gas (CNG and LNG) or liquefied petroleum gas (LPG). In any event, they must comply with the criteria of the C label.</p>
Zero	<p>Motorcycles, tricycles, quadricycles, passenger cars, light vans, vehicles with more than 8 seats, and goods vehicles classified in the DGT Vehicle Register as battery electric vehicles (BEV), range extended electric vehicles (REEV), plug-in hybrid electric vehicles (PHEV) with a minimum range of 40 kilometres, or fuel cell vehicles.</p>

The LEZ is accompanied at all times by a set of exemptions and access authorisations that allow the vehicle to continue to be used sporadically, with a focus on the most vulnerable sectors of the population. Therefore, vehicles for people with reduced mobility (VPRM), emergency services (police, fire brigades, ambulances) and essential services (doctors, funeral services) are permanently exempt for driving in the LEZ, regardless of whether they have a DGT environmental label or not. Furthermore, authorisations are offered for low-income individuals, for individuals nearing retirement age who still need the vehicle for work, among many others.

To strengthen the new regulatory text and provide more support to these more vulnerable population sectors, the new Byelaw has added some authorisations primarily to support citizens with fewer resources and professionals nearing retirement age who use the vehicle as a tool for work.

FIGURE 6

List of current authorisations and exemptions. New authorisations are outlined with a box.

Source: Barcelona Metropolitan Area (AMB)



The following are the changes introduced in the new Byelaw on authorisations and exemptions:

- *Vehicles accessing or driving sporadically through the LEZ: daily authorisations, from 10 days/year and vehicle to 24 days/year and vehicle. This category includes sporadic access and circulation of classic and historic vehicles.*

This change is motivated by the need to ensure occasional use of the vehicle (considering use every 15 days), even though according to official statistics, the average number of days requested per affected vehicle was 3.3 days per vehicle in 2022.

- *Unique vehicles, according to classification by criteria of use, defined in accordance with Annex II of the General Regulation on Vehicles, approved by Royal Decree 2822/1998, of 23 December. Some categories have been added to the initial list, mainly special purpose vehicles intended exclusively for construction work.*
- *Vehicles that constitute a necessary tool for carrying out professional activities, whose owner can prove they have, at most, 5 years left until retirement under the Special*

Scheme for Self-Employed Workers (RETA), the General Social Security Scheme, or another alternative scheme, according to current legislation.

- *Vehicles whose owners can prove their total annual financial income (pensions, aid, income, rent, capital interest etc.,) is less than twice the public indicator of income for multiple effects (IPREM), increased according to number of household unit members, where appropriate, and calculated on the basis of that household unit's income.*
- *Vehicles whose owners can prove the purchase of a new motor vehicle that meets the technological and emission requirements equivalent to environmental labels. The inclusion of this type of authorisation is justified by the current situation in the automotive sector regarding electronic components and extended delivery times for purchased vehicles.*

In order to apply for any authorisation or exemption, it is necessary to be registered in the Metropolitan Register of foreign and other authorised vehicles:

<https://zberegistre.ambmobilitat.cat/>

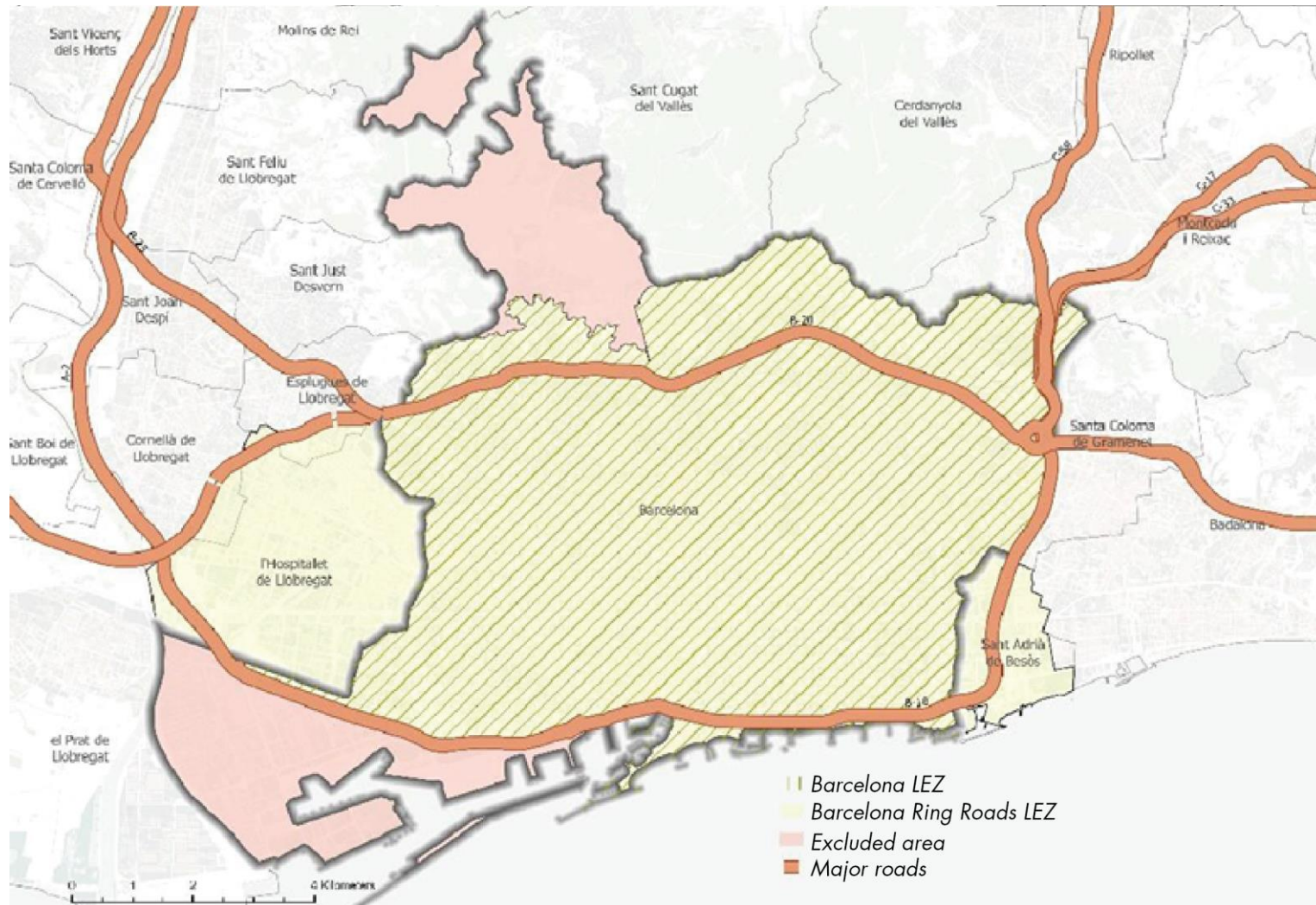
Compliance with the measure is monitored through cameras, which cross-check the licence plates with the corresponding DGT environmental label and with the Register. The automated control system, which currently has more than 100 number plate reading cameras at various points in the metropolitan area (access points to the LEZ and interior areas), provides local authorities with a list of vehicles identified in their territory that may be subject to fines. This system also allows for the periodic monitoring and updating of the fleet of vehicles circulating in the city, enabling an assessment of the benefits obtained from the set of measures implemented.

At the end of 2023, 42 new control points were implemented in Barcelona's LEZ, equipped with number plate reading cameras, thanks to funds from the Next Generation programme. The installation of the equipment took place during October 2023, and it was put into operation during the first quarter of 2024.

MAP 4

Scope of application of the Barcelona LEZ (striped area): The municipal boundary of Barcelona, except for the neighbourhoods of Vallvidrera, Tibidabo, and Les Planes, as well as the Zona Franca Industrial Estate. It covers 77 km² (76% of the municipal area), which expands to more than 95 km² when including the other municipalities of the Barcelona Ring Roads LEZ (L'Hospitalet de Llobregat, Cornellà de Llobregat, Esplugues de Llobregat, and Sant Adrià de Besòs).

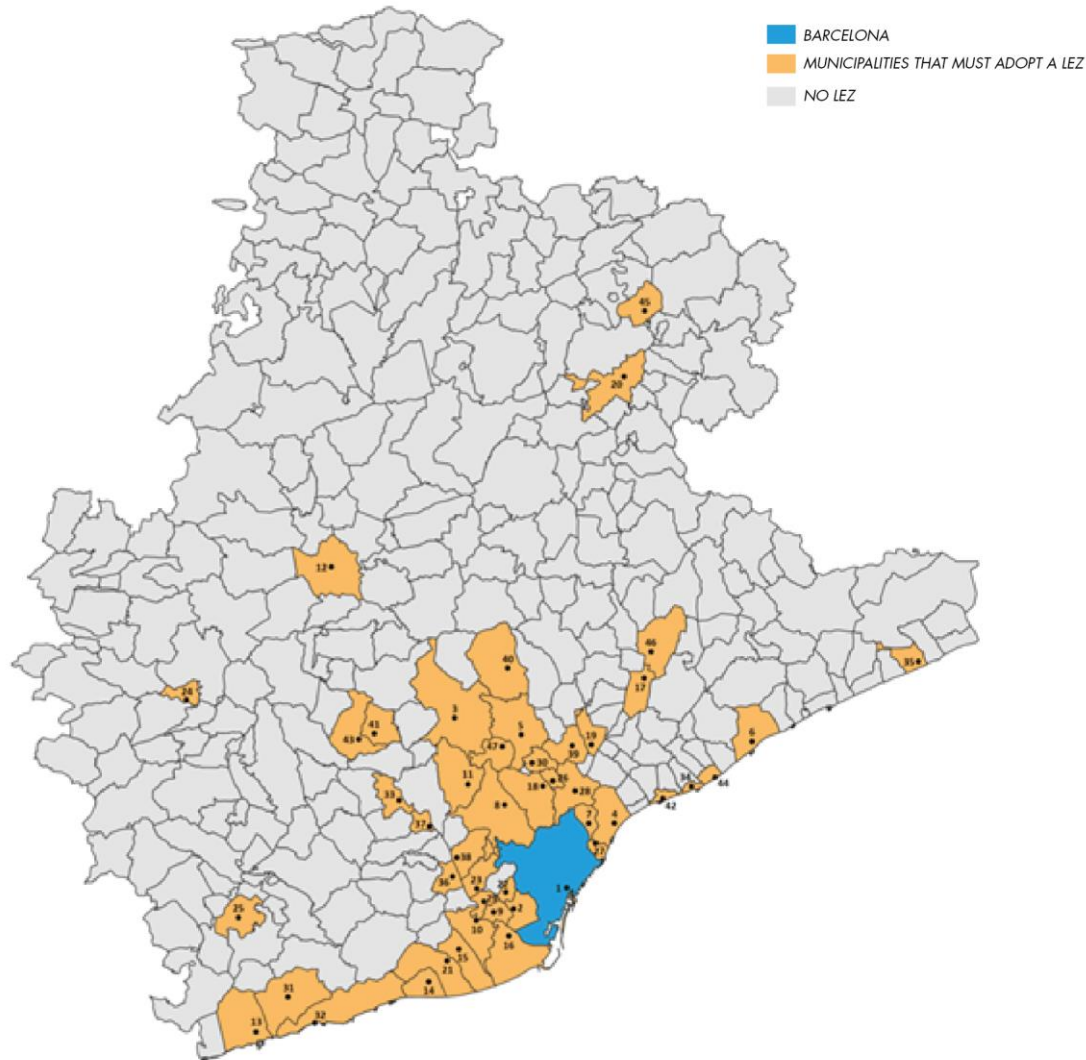
Source: Barcelona Regional



MAP 5

Municipalities with more than 20,000 inhabitants in the province of Barcelona, with the obligation to establish an LEZ.

Source: Barcelona City Council



	Municipality	Population (2022)
1	Barcelona	1.636.193
2	l'Hospitalet de Llobregat	265.444
3	Terrassa	224.114
4	Badalona	223.506
5	Sabadell	215.760
6	Mataró	128.956
7	Santa Coloma de Gramenet	117.981
8	Sant Cugat del Vallès	95.725
9	Cornellà de Llobregat	89.039
10	Sant Boi de Llobregat	83.371
11	Rubí	79.007
12	Manresa	77.452
13	Vilanova i la Geltrú	68.152
14	Castelldefels	67.307
15	Viladecans	66.720
16	el Prat de Llobregat	65.030
17	Granollers	61.983
18	Cerdanyola del Vallès	57.291
19	Mollet del Vallès	51.294
20	Vic	47.545
21	Gavà	46.974
22	Esplugues de Llobregat	46.414
23	Sant Feliu de Llobregat	45.642
24	Igualada	40.767
25	Vilafranca del Penedès	40.056
26	Ripollet	39.031
27	Sant Adrià de Besòs	36.918
28	Montcada i Reixac	36.666
29	Sant Joan Despi	34.039
30	Barberà del Vallès	33.082
31	Sant Pere de Ribes	31.688
32	Sitges	31.222
33	Martorell	28.684
34	Premià de Mar	28.518
35	Pineda de Mar	28.083
36	Sant Vicenç dels Horts	28.079
37	Sant Andreu de la Barca	26.965
38	Molins de Rei	26.242
39	Santa Perpètua de Mogoda	25.930
40	Castellar del Vallès	24.933
41	Olesa de Montserrat	24.272
42	el Masnou	23.829
43	Esparreguera	22.365
44	Vilassar de Mar	21.067
45	Manlleu	20.883
46	Les Franqueses del Vallès	20.332
47	Sant Quirze del Vallès	20.180

6. Monitoring of the Ring Roads LEZ

As determined in Article 12 of *Royal Decree 1052/2022, of 27 December, which regulates the low emission zones*, and in Article 18 of the *Byelaw establishing the criteria for access, circulation and parking of vehicles in Barcelona's low emission zone while promoting emissions-free mobility*, local authorities must establish a continuous monitoring and tracking system. This system aims to assess the effectiveness of measures adopted and ensure compliance with objectives related to air quality, mitigation of climate change impacts, public health, modal shift towards more sustainable transport modes, and other aspects of urban life.

In that regard, a new set of monitoring indicators has been established and is updated periodically.

TABLE 4

Barcelona Low Emission Zone Monitoring Indicators

Source: Barcelona City Council

INDICATOR	FREQUENCY	SOURCE OF DATA
Air quality associated with road traffic		
Monthly immission levels at traffic stations for the pollutants NO ₂ , PM ₁₀ , PM _{2.5} .	Monthly	Atmospheric Pollution Monitoring and Forecasting Network
Monthly immission levels at background stations for the pollutants PM _{2.5} , PM ₁₀ , NO ₂ .	Monthly	
Evolution of the annual average value for the pollutants PM _{2.5} , PM ₁₀ , NO ₂ .	Annual	
Evolution of limit value (LV) exceedances for the pollutants PM _{2.5} , PM ₁₀ , NO ₂ .	Annual	
Annual average per station for the pollutants PM _{2.5} , PM ₁₀ , NO ₂ .	Annual	
Emissions inventory for the pollutants PM _{2.5} , PM ₁₀ , NO ₂ .	Annual	Barcelona local pollution model
Analysis of contribution by the pollutants PM _{2.5} , PM ₁₀ , NO ₂ .	Annual	
Climate change mitigation		
Evolution of energy consumption by sector	Annual	Barcelona Energy Agency
Structure of automotive energy consumption	Annual	
Evolution of GHG emissions by sector	Annual	
CO ₂ emissions by type of vehicle	Annual	

Promoting a modal shift		
Evolution of mobility		
Evolution of annual mobility (Mveh-km/year)	Annual	Mobility Directorate Barcelona City Council
Modal share		
Modal share (internal and connecting)	Annual	Working Day Mobility Survey (EMEF)
Variation in the number of journeys by private car	Annual	
Variation in the number of journeys by active modes: walking	Annual	
Variation in the number of journeys by active modes: cycling	Annual	
Variation in the number of journeys by public transport	Annual	
Vehicle fleet characteristics: road traffic emissions		
Evolution of annual emission factors for the pollutants PM _{2.5} , PM ₁₀ , NO ₂ and Black Carbon	Annual	Analysis of data from LEZ cameras
Evolution of annual road traffic emissions for the pollutants PM _{2.5} , PM ₁₀ , NO ₂ and Black Carbon	Annual	
Vehicle fleet characteristics: environmental labels		
Analysis of the vehicle fleet by environmental label	Monthly	Mobility Directorate Barcelona City Council
Average % vehicles without a label	Monthly	
Average % vehicles with label B	Monthly	
Average % vehicles with label C	Monthly	
Average % of vehicles with ECO label	Monthly	
Average % of vehicles with a 0 label	Monthly	
Age of registered passenger cars		
Average age of registered passenger cars in Spain	Annual	Directorate General of Traffic (DGT)
Average age of registered passenger cars in Barcelona	Annual	Municipal Institute of Statistics (Barcelona City Council)
Noise quality		
Sound pressure level LAeq 7-20h per year of 4 monitoring points	Monthly	Barcelona Noise Monitoring Network (Barcelona City Council)
Sound pressure level LAeq Pre-LEZ	Monthly	



Sound pressure level LAeq Post-LEZ	Monthly	
LEZ register		
No. of vehicles requesting daily authorisation	Monthly	AMB Information
Total number of daily authorisations requested	Monthly	
Evolution of the number of applications by type	Monthly	
No. of green card applications	Monthly	
No. green card applications accepted	Monthly	
Evolution of the number of green cards	Monthly	
Fine procedures		
No. open fines procedures	Weekly	Municipal Tax Office (Barcelona City Council)
No. of fine procedures paid	Weekly	
Amount paid	Weekly	
Evolution of fine procedures by type	Weekly	
No. of monthly fine procedures opened/paid	Weekly	

Below is an analysis of the key data for 2023. The previous monitoring reports can be consulted at the following link:

<https://ajuntament.barcelona.cat/qualitataire/ca/actualitat-i-recursos/estudis-i-informes>

6.1 Air quality associated with road traffic

6.1.1 Average immissions recorded by the XVPCA stations

As shown in the following figure [Fig. 7], over the past decade, annual NO₂ emission levels in the city have followed a downward trend, particularly at traffic stations, moving towards consistent compliance with the limit value set by European reference standards and approaching the recommended levels by the World Health Organization (WHO).

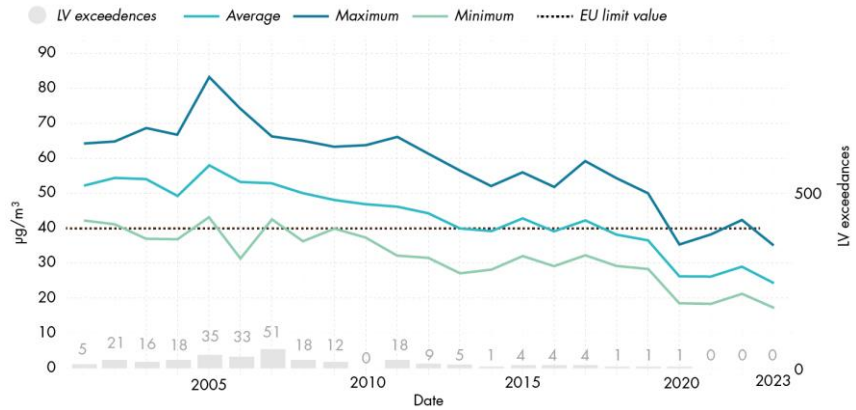
In 2022, the average NO₂ levels at the city's monitoring stations showed an increase compared to the years 2020 and 2021. However, the levels measured in 2023 have decreased again,

returning to a situation where compliance is observed at all XVPCA stations. This trend is expected to become definitive in the following years.

FIGURE 7

Annual average for immissions of NO_2 recorded by the XVPCA stations [2001-2023]

Source: Barcelona City Council with data from the Barcelona Public Health Agency

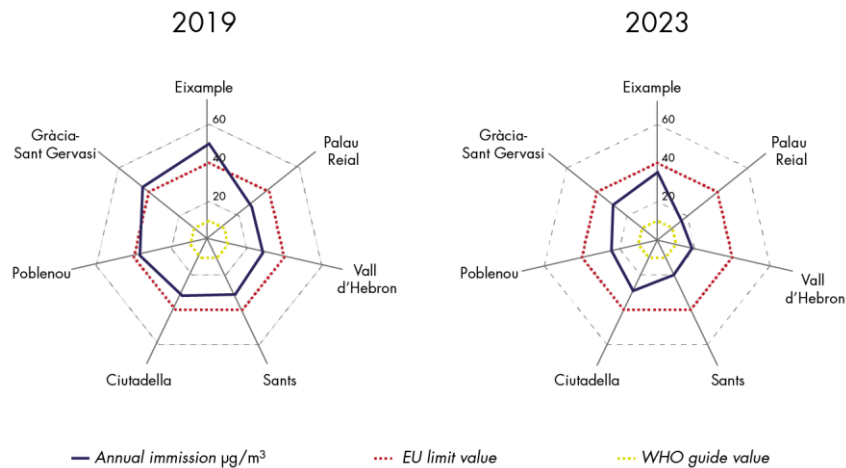


This shows that, during 2023, compliance was recorded at all XVPCA stations in Barcelona. Specifically, the annual average at the traffic stations is $35 \mu\text{g}/\text{m}^3$ and $29 \mu\text{g}/\text{m}^3$, for the Eixample and Gràcia – San Gervasi stations, respectively, without exceeding the current legal limit value ($40 \mu\text{g}/\text{m}^3$) in either case. On the other hand, the WHO’s annual average guideline value ($10 \mu\text{g}/\text{m}^3$) is exceeded at all the city’s stations.

FIGURE 8

Annual average by station of NO_2

Source: Barcelona City Council with data from the Barcelona Public Health Agency



As for PM_{10} particles, unlike NO_2 , the contribution of particulate matter from natural sources (Saharan dust, sea salt, etc.) also adds to emissions related to human activities such as traffic. This diversity of sources and secondary particles means that the decreases observed in recent years have been smaller compared to NO_2 , which is much more influenced by changes in traffic emissions. Over the last decade, PM_{10} levels have remained stable in the city, both at traffic stations and urban background stations, staying within legal limit compliance while consistently exceeding the WHO guideline value.

FIGURE 9

Annual average for immissions of PM_{10} recorded by the XVPCA stations [2002-2023]

Source: Barcelona City Council with data from the Barcelona Public Health Agency

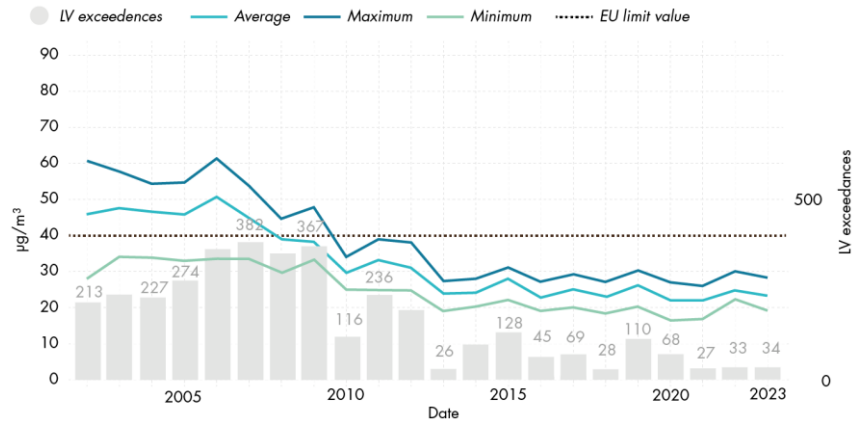
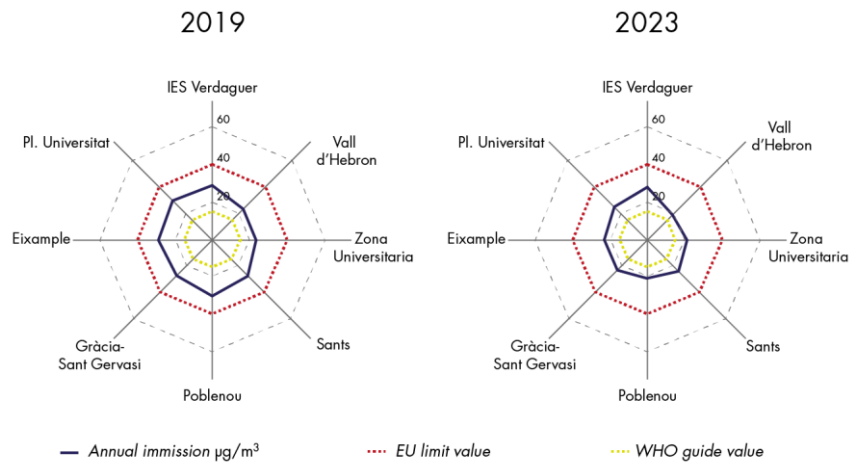


FIGURE 10

Annual average by station of PM_{10}

Source: Barcelona City Council with data from the Barcelona Public Health Agency

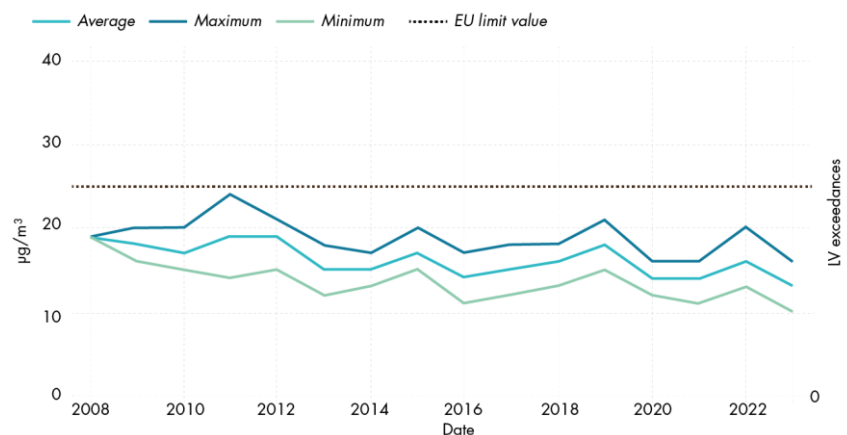


Finally, with regard to $PM_{2.5}$ particles, the annual average remained above the WHO guideline value ($5 \mu\text{g}/\text{m}^3$) during the period 2008-2023, while complying with the current legal limit ($25 \mu\text{g}/\text{m}^3$), which is the least stringent among European regulations. The general trend shows stability in levels since 2013, both at traffic and urban background stations.

FIGURE 11

Annual average for immissions of $PM_{2.5}$ recorded by the XVPCA stations [2008-2023]

Source: Barcelona City Council with data from the Barcelona Public Health Agency

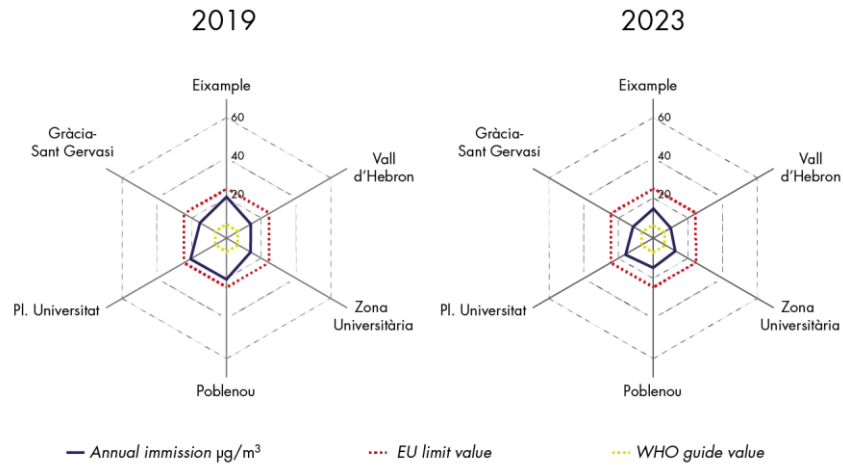


However, it should be noted that PM_{2.5} concentrations in 2023 have decreased compared to 2022 at all XVPCA stations.

FIGURE 12

Annual average by station of PM_{2.5}

Source: Barcelona City Council with data from the Barcelona Public Health Agency



6.1.2 Emissions inventory

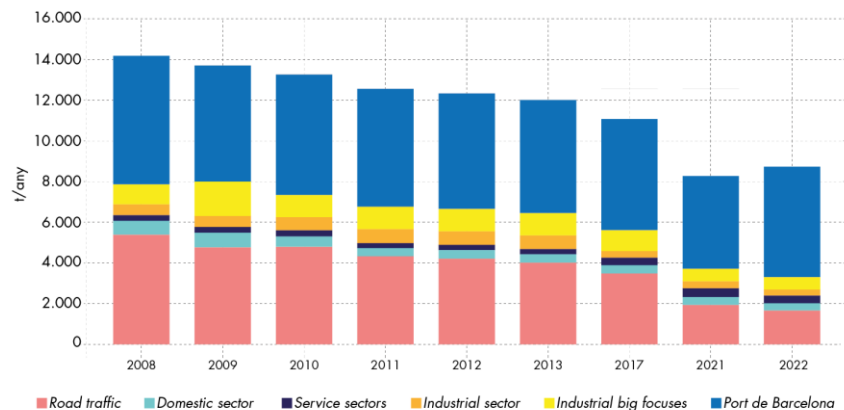
Below are the total NO_x emissions in the city of Barcelona broken down by sectors of activity.

As can be seen in Fig. 13, since 2008, the trend has been one of a progressive reduction in NO_x emissions. The data from 2021, which shows a sharp decline compared to the values in 2017, is affected by the impact of the COVID-19 pandemic. However, the data from 2022 shows that traffic-related emissions continue to decrease compared to previous years, while emissions from the Port of Barcelona have returned to pre-pandemic levels, and emissions from other sectors remain relatively stable.

FIGURE 13

Evolution of NO_x emissions between 2008 and 2022 in the city of Barcelona

Source: Barcelona Regional

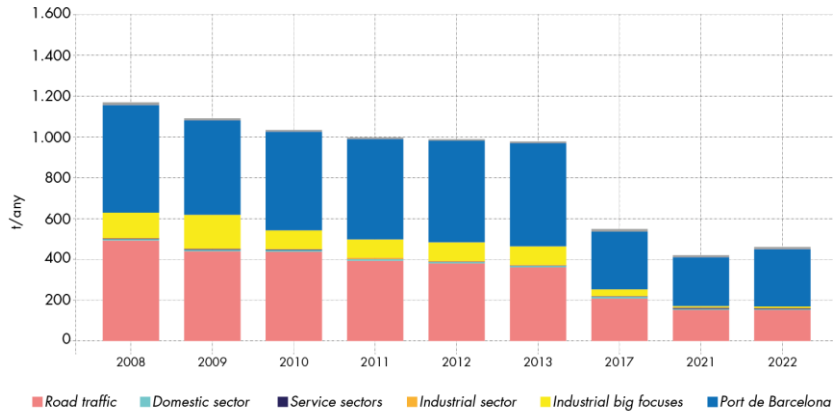


In the case of PM₁₀ particles, emissions from all sectors, including road traffic, remain steady except for emissions from the Port of Barcelona, which have slightly increased compared to the previous year, reaching levels similar to those of 2017.

FIGURE 14

Evolution of PM_{10} emissions between 2008 and 2022 in the city of Barcelona

Source: Barcelona Regional

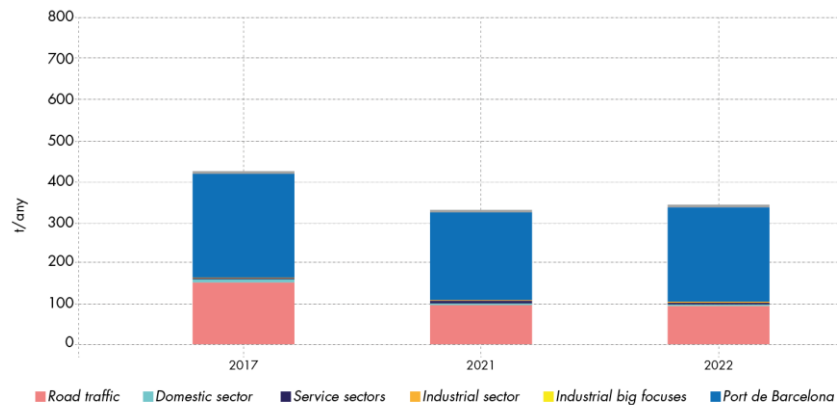


With regard to $PM_{2.5}$ emissions, the situation is similar to PM_{10} particles, with emissions from all sectors remaining nearly constant. Only a small increase has been detected in emissions from the Port of Barcelona, but they remain lower than the emissions in 2017.

FIGURE 15

Evolution of $PM_{2.5}$ emissions between 2017 and 2021 in the city of Barcelona

Source: Barcelona Regional



6.1.3 Analysis of the contribution

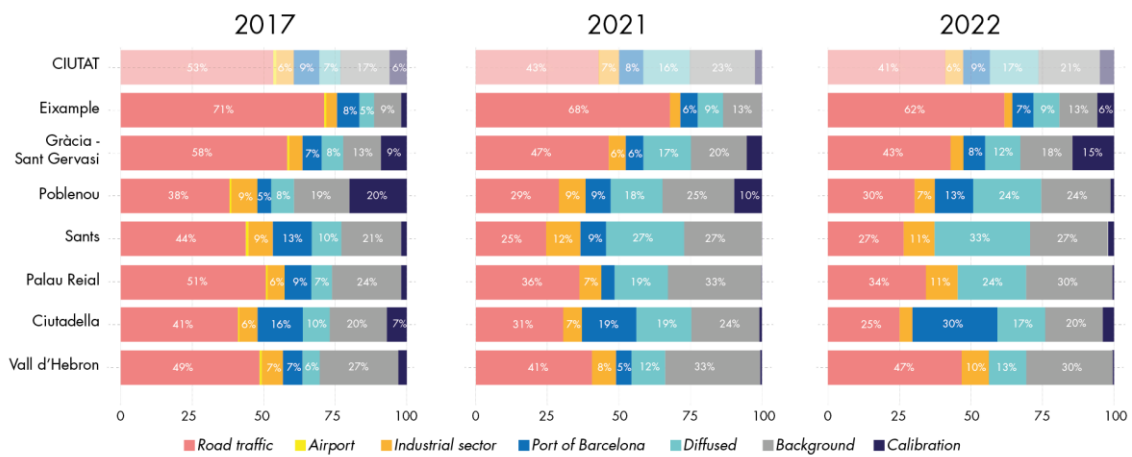
The analysis of the contribution of sources to the main atmospheric pollutants analysed (NO_2 , PM_{10} and $PM_{2.5}$) reports the primary emitting source contributing to the pollution levels recorded at each measurement point in the XVPCA in the city of Barcelona.

If we study the comparison of contributing sources to the levels of NO_x recorded between the years 2017, 2021, and 2022, we can observe that the contribution from road traffic has decreased at all stations. In fact, since 2017, the trend has been one of a progressive reduction in road traffic's contribution to NO_x pollution levels, primarily driven by the accelerated renewal of the vehicle fleet. This renewal has resulted in a circulating fleet with lower pollution potential (significantly lower emission factors).

At the city-wide average level, the contribution of traffic decreased from 43% in 2021 to 41% in 2022 (compared to 53% in 2017). This trend is expected to continue in subsequent years due to the gradual phasing out of internal combustion vehicles, particularly EURO 4 and EURO 5 (which include diesel vehicles with high emission factors), and their replacement with EURO 6 vehicles, hybrids, or electric vehicles with much lower pollution potential.

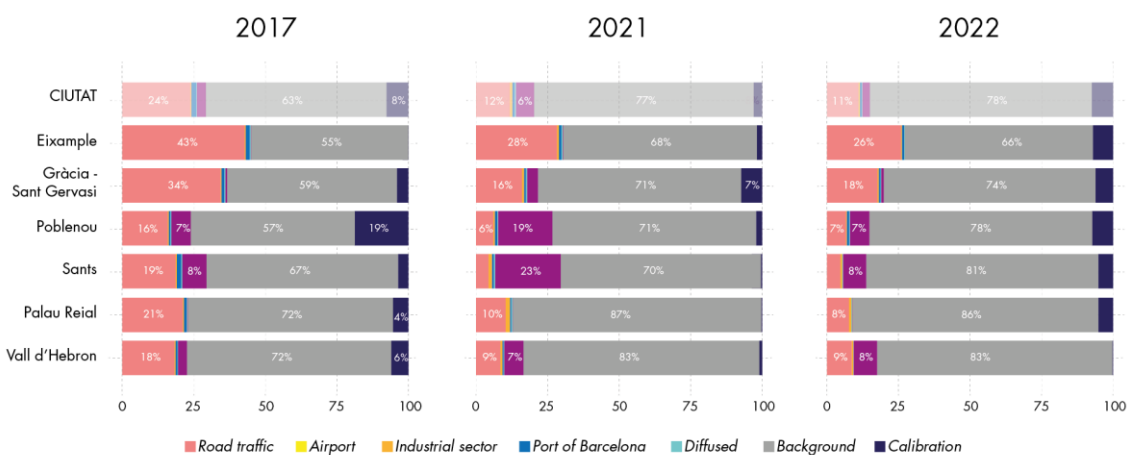
It is worth noting that within the XVPCA for the city of Barcelona, the Eixample station continues to have the highest contribution from road traffic, but it decreased from 68% to 62% in just one year. [Fig. 16]

FIGURE 16
Contribution of NO_x recorded by the XVPCA stations
Source: Barcelona Regional



In the case of PM₁₀, although road traffic was no longer the main contributor, the situation is similar, and the contribution of road traffic at the city level declined by 50% between 2017 and 2022. [Fig. 17]

FIGURE 17
Contribution of PM₁₀ recorded by the XVPCA stations
Source: Barcelona Regional



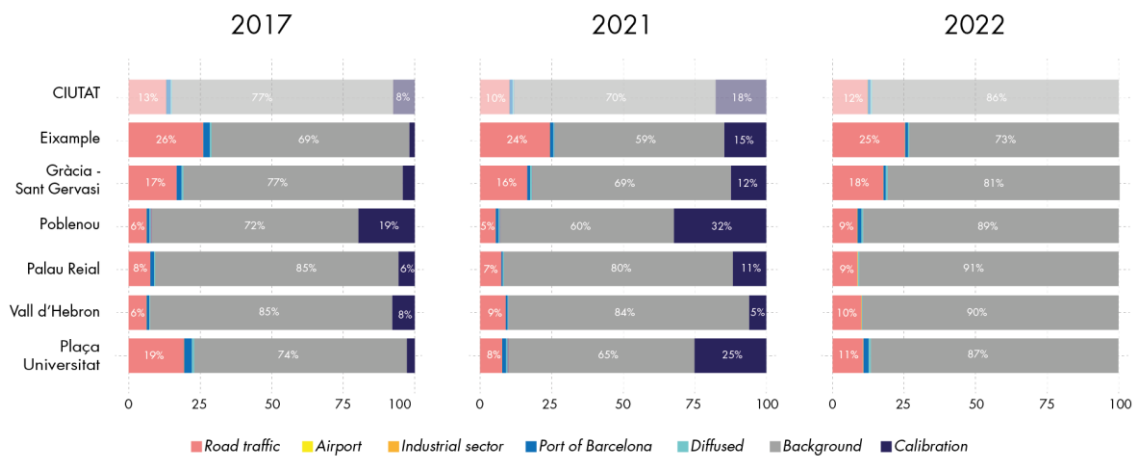
In the case of PM_{2.5} the contribution from road traffic is much lower, so the reduction over the years is also much smaller, although there has been a slight decrease as well. In this case, background sources continue to be the main contributing source to PM_{2.5}. [Fig. 18]

It is worth highlighting the performance of the model used to represent PM_{2.5} concentrations for 2022, which eliminates the need for calibration adjustments to achieve the levels recorded by the XVPCA stations.

FIGURE 18

Contribution of PM_{2.5} recorded by the XVPCA stations

Source: Barcelona Regional



6.2 Climate change mitigation

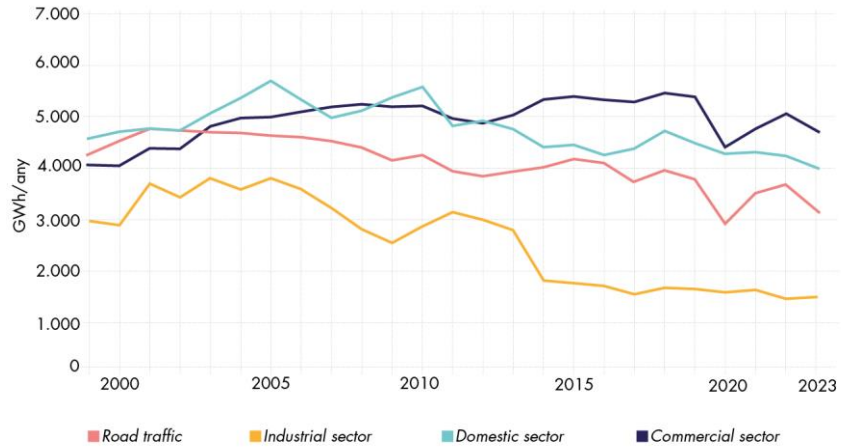
To analyse the impact that introducing the low emission zone has had on climate change mitigation, periodic monitoring indicators of energy consumption and greenhouse gas (GHG) emissions have been incorporated.

6.2.1 Evolution of energy consumption

Analysing energy consumption by sector, it can be observed that in the transport sector, consumption has been progressively decreasing mainly due to improvements in vehicle efficiency and the resulting lower fuel consumption. In 2020, a significant decline was detected, primarily due to the effects of the COVID-19 pandemic. In 2021 and 2022, there was a slight increase in energy consumption in this sector, although it did not reach pre-pandemic levels. Finally, in 2023, there was once again a slight decrease in energy consumption, particularly in the transport sector.

FIGURE 19

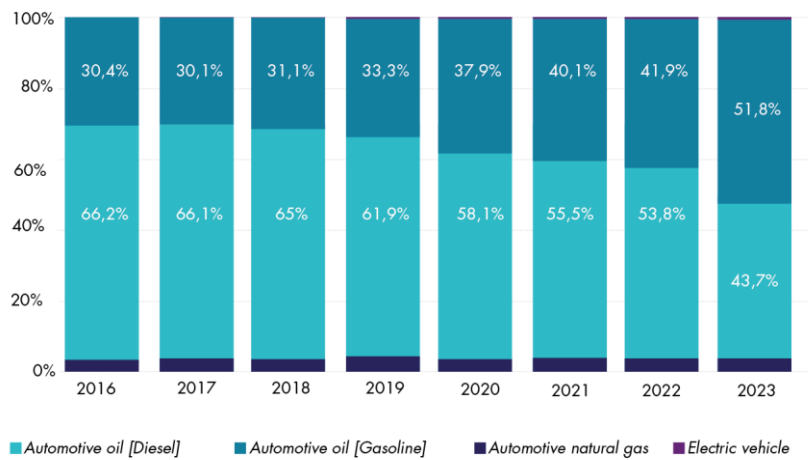
Evolution of energy consumption by sector
Source: Barcelona Energy Agency



Analysing automotive energy consumption before and after the implementation of the LEZ, it can be seen that diesel consumption has decreased, with a significant increase in petrol consumption. The data for 2023 shows that for the first time, petrol consumption in automotive use exceeds diesel consumption.

FIGURE 20

Structure of automotive energy consumption
Source: Barcelona Energy Agency



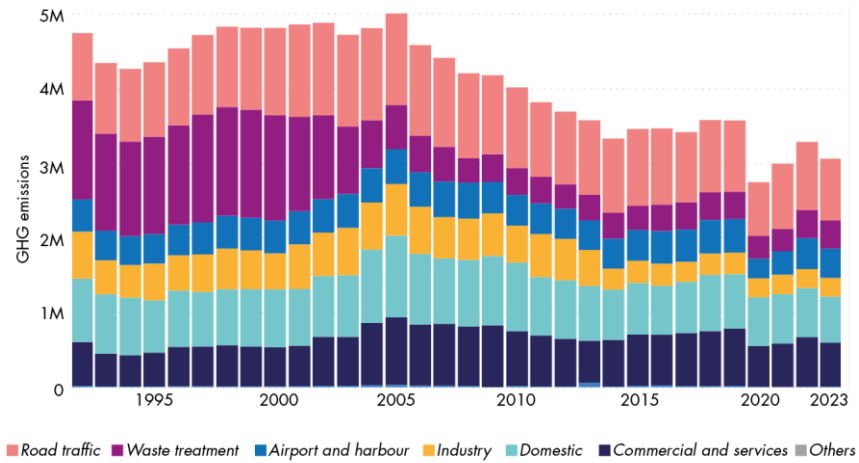
6.2.2 Evolution of GHG emissions by sector

The conclusions regarding greenhouse gas emissions (GEH) are similar to those obtained from energy consumption since they are directly related. Therefore, there has been a continuous decrease since 2005, stabilising from 2015 onwards, with a slight increase in 2018 and 2019 due to mobility increases. The figures from 2022 are higher than the values recorded during the years affected by COVID but greenhouse gas emissions (GEH) are still lower compared to the pre-COVID years. The data for 2023 continue the downward trend with values similar to those obtained in 2021.

FIGURE 21

Evolution of greenhouse gas emissions by sector

Source: Barcelona Energy Agency

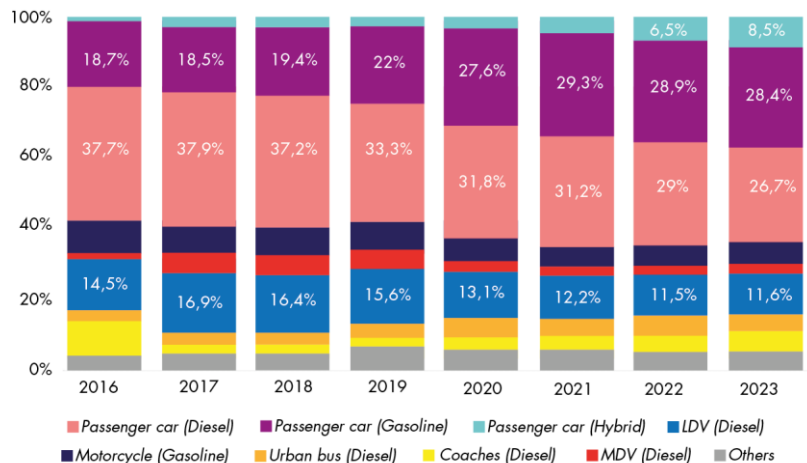


If we analyse CO₂ emissions according to vehicle type, we can see that passenger cars are the highest emitters of CO₂. Within this type, it is worth noting that emissions from diesel vehicles have decreased and those from petrol and hybrid vehicles have increased.

FIGURE 22

CO₂ emissions by vehicle type.

Source: Barcelona Energy Agency



6.3 Promoting a modal shift

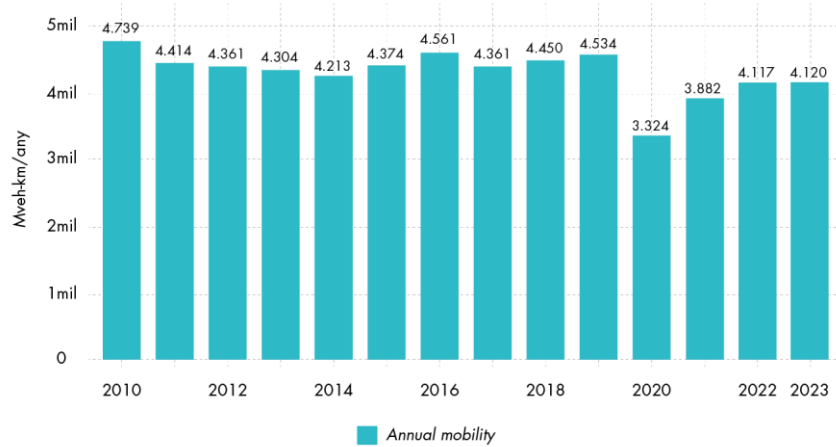
CO₂ and atmospheric pollutant emissions are closely linked to mobility and of the objectives of the LEZ is to encourage a modal shift towards more sustainable means of transport. For this reason, it is considered necessary to incorporate monitoring indicators in this area that allow us to monitor both the evolution of mobility and its characteristics.

6.3.1 Evolution of annual mobility

Mobility during the years 2020 and 2021 experienced a significant decline due to the restrictions stemming from COVID-19. The data for the year 2023 shows that mobility has stabilised, following a similar trend to 2022. However, it has not yet reached pre-pandemic levels.

FIGURE 23

Evolution of annual mobility (Mveh-km/year)
Source: Barcelona City Council



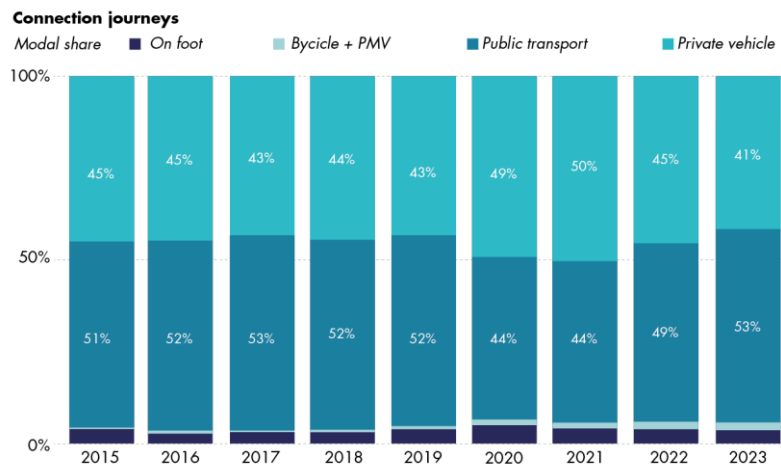
6.3.2 Modal share

The changes in modal share between 2016 and 2023 highlight the impact of mobility restrictions due to the COVID-19 pandemic and the modal changes driven by concerns about disease transmission.

In the case of connecting journeys, fear of using public transport led to an increase in private vehicle usage in 2020 and 2021, at the expense of public transportation [Fig. 24]. On the other hand, the data for 2022 and 2023 shows a change in trend, reaching pre-pandemic levels of public transport use and a slight drop in the use of private vehicles for this type of journey.

FIGURE 24

Modal share connecting journeys
Source: EMEF

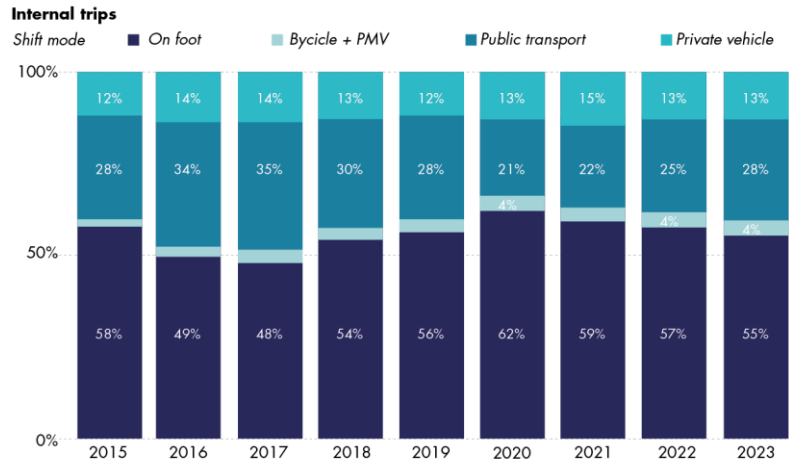


With regard to internal journeys, in 2023 the modal share has returned to pre-pandemic levels, surpassing the pandemic's impact on mobility. Public transport journeys have recovered, while the use of private vehicles remains stable at around 13%. [Fig. 25]

FIGURE 25

Modal share, internal journeys

Source: EMEF



6.3.3 Vehicle fleet characteristics: Evolution of annual emission factors

The evolution of the average emission factor [g/km] allows us to understand (excluding the influence of mobility levels) whether vehicles are better in terms of emissions, mainly due to technological improvements introduced in vehicles themselves.

Looking at the 2023 data, it can be seen that the emission factors for NOx and Black Carbon (hereafter BC) are still significantly down compared to the previous year, while for particulate matter the reduction is much smaller.

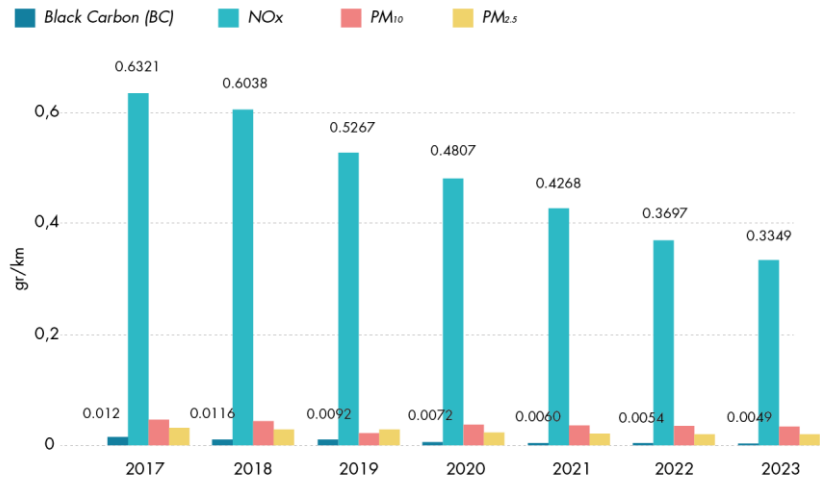
If the values for 2023 are compared to the year before the implementation of the measure (2019), the reduction in NOx emission factors stands at 36% and for BC it is 47%. If the calculation is made with respect to the year when the measure was announced (2017), the reduction in emission factors is even greater, with a 47% reduction for NOx and a 60% reduction for Black Carbon.

FIGURE 26

Evolution of annual emission factors

Source: Barcelona Regional with data from LEZ cameras





6.3.4 Evolution of road traffic emissions

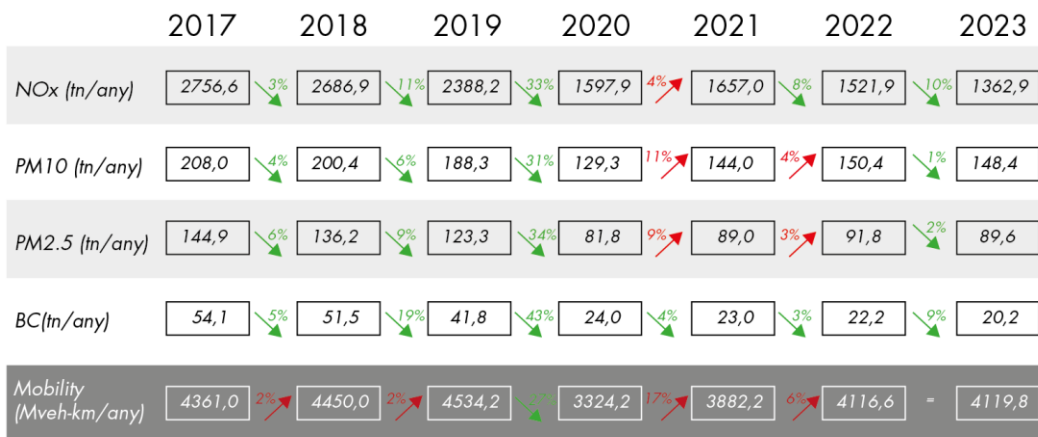
Emissions, however, depend on the characteristics of the vehicle fleet and also on the annual mobility value.

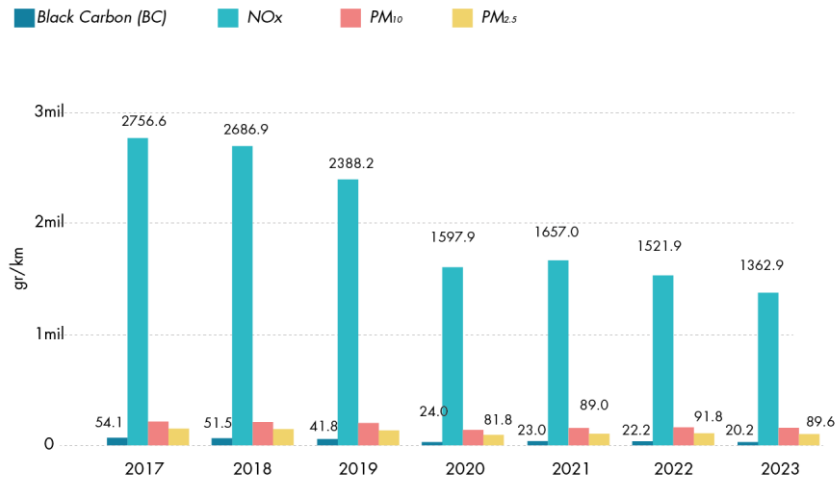
As shown in the following table [Fig. 27], mobility in 2023 has remained nearly stable compared to the previous year, while emissions have decreased.

If the values for 2023 are compared to the year before the implementation of the measure (2019), it can be seen that NOx emissions have decreased by 43% and BC emissions by nearly 52%. In the case of particles, the difference is smaller, and between 2019 and 2023, there was a reduction of 21% in PM₁₀ emissions and 27% in PM_{2.5} emissions.

FIGURE 27

Evolution of annual road traffic emissions
Source: Barcelona Regional with data from LEZ cameras





6.3.5 Analysis of the vehicle fleet by environmental label

The evolution of the vehicle fleet by environmental label during the year 2023 has followed the same trend as in the previous year.

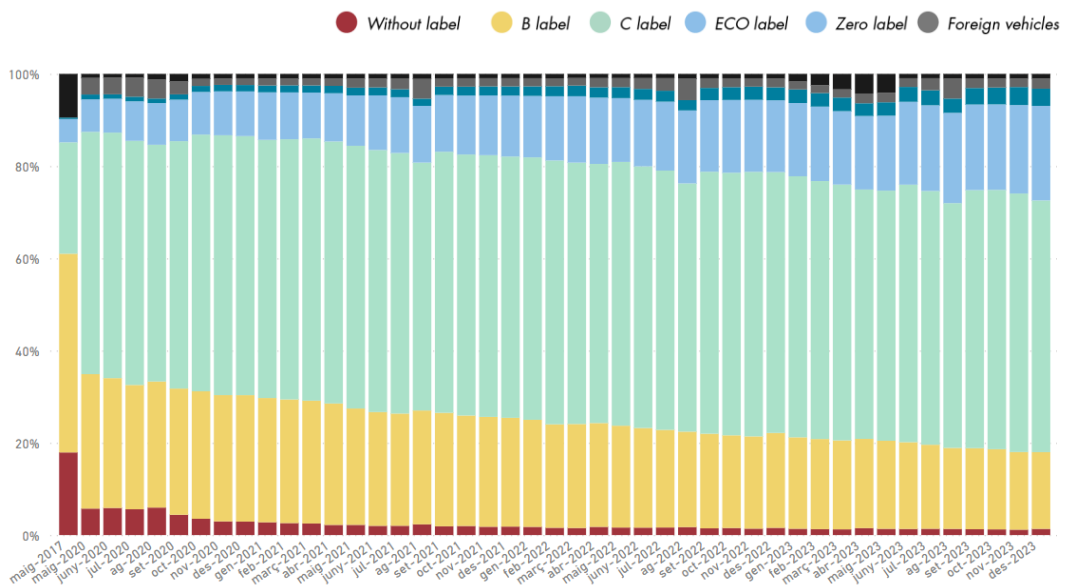
The percentage of vehicles without a label has stabilised, while the number of vehicles with a B label is on a downward trend. On the other hand, the number of vehicles with 0 and ECO labels is increasing slightly and the presence of foreign vehicles is concentrated in the summer months.

Likewise, during 2023 the number of vehicles circulating in Barcelona with an ECO label (20.51% in December 2023) is already higher than those with a B label (16.64% in December 2023).

FIGURE 28

Distribution of the fleet by environmental label

Source: Barcelona City Council



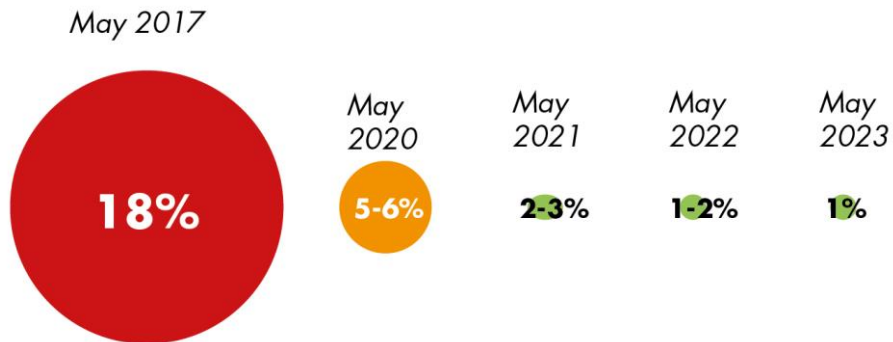
6.3.6 Analysis of vehicles without a label

The percentage of vehicles without a label has stabilised during 2023, and remained close to 1% throughout the year.

FIGURE 29

Evolution in the circulation of the most polluting vehicles from Monday to Friday

Source: Barcelona Regional

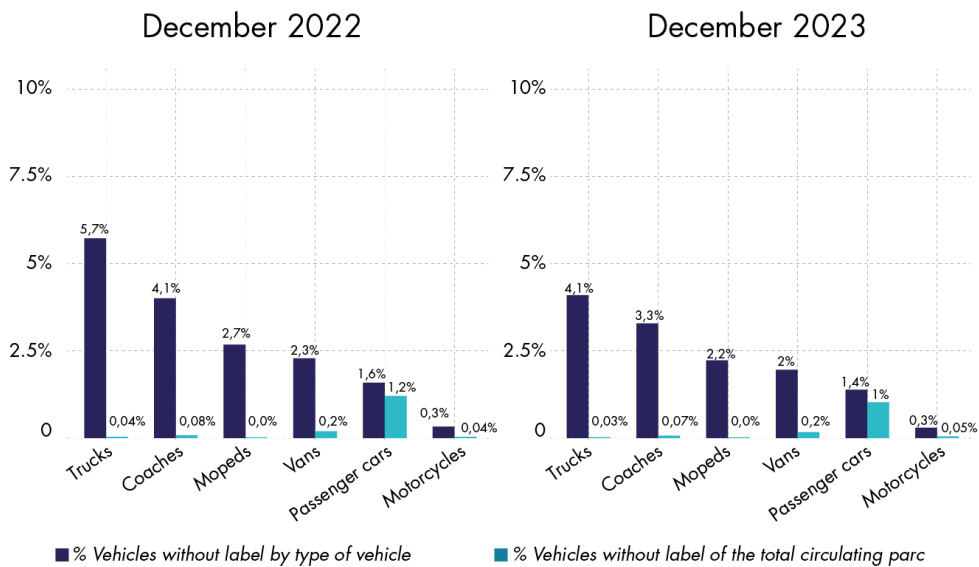


If we analyse by vehicle type, we can see a continued decline in the percentage of buses and lorries without a label compared to their respective vehicle types. The percentage of lorries without a label in 2023 is around 4% and for buses, it is approaching 3%. Passenger cars without a label make up only 1% of the total fleet.

FIGURE 30

Comparison of the breakdown of vehicles without a label

Source: Barcelona City Council



6.3.7 Registered vehicle fleet data

Analysing the evolution of the average age of the registered fleet can give us an idea of the pace at which the fleet is being renewed.

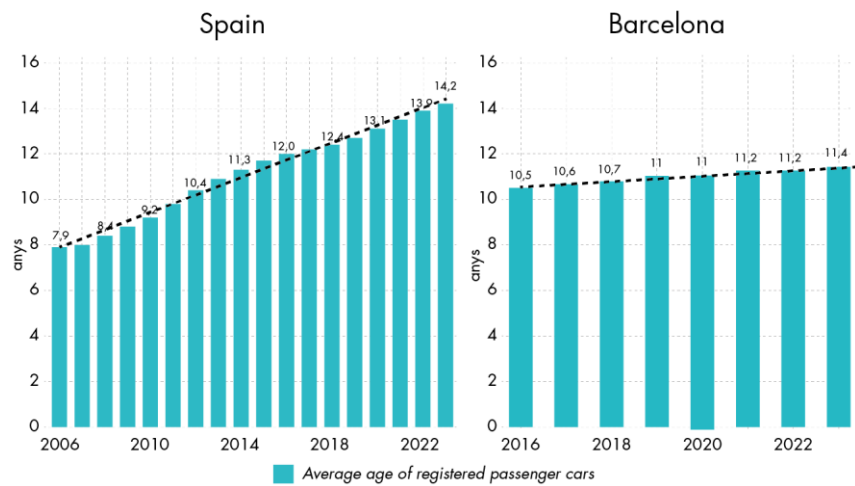
From the state statistics provided by the DGT, it can be seen that since 2006 the average age of registered cars in Spain has been rising, and in 2023 it exceeded 14 years. [Fig. 31]

If we refer instead to the average age of registered vehicles in the city of Barcelona [Fig. 31], we can see that this indicator does not follow the trend observed in the rest of Spain. The increase between 2016 and 2023 is 0.9 years in Barcelona and 2.2 in Spain.

FIGURE 31

Average age of registered passenger cars

Source: Barcelona City Council



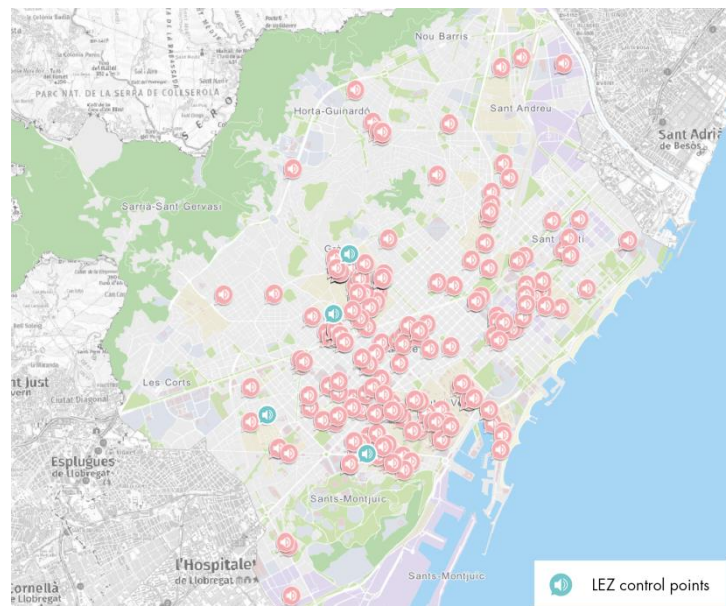
6.4 Noise quality

In order to analyse whether the implementation of the LEZ has any impact on the city's noise levels, 4 traffic noise measurement points from Barcelona's noise monitoring network have been selected as reference points. [Map 6]

MAP 6

Measurement points of Barcelona's noise monitoring network

Source: Barcelona City Council



The analysis compared the average levels before the implementation of the LEZ (2018-2019) and once the LEZ was in operation (2022-2023), without taking into account the years in which mobility was affected by the pandemic (2020 - 2021).

The levels recorded in 2023 show a slight downward trend [Fig. 32] , but the difference compared to the levels before the implementation of the LEZ remains minimal. [Table 5]

TABLE 5

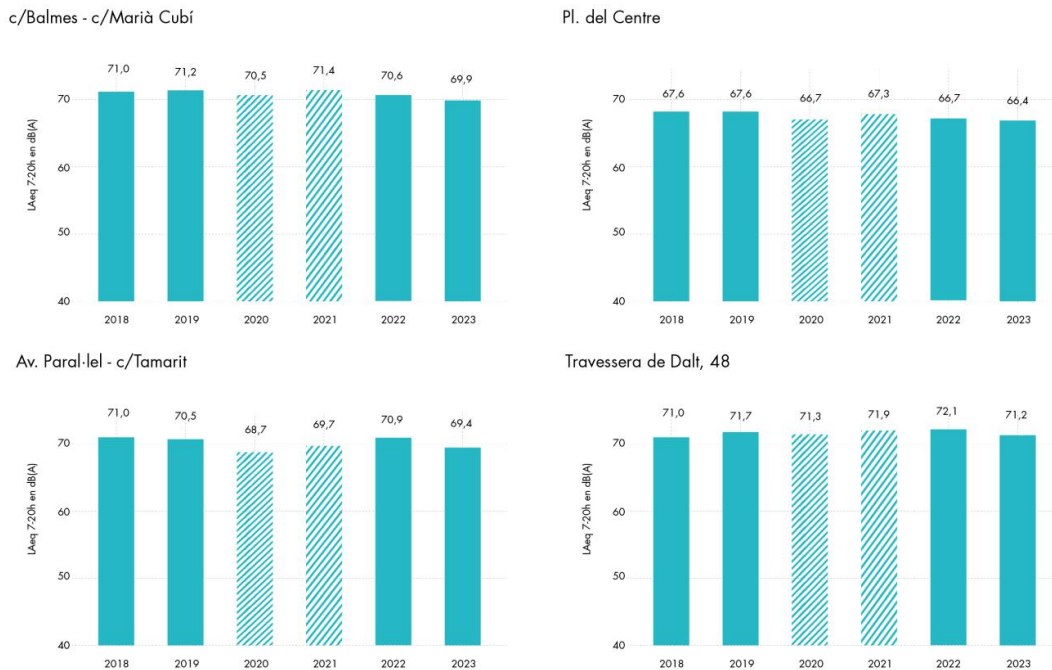
Comparison of sound levels before and after the implementation of the LEZ
Source: Barcelona City Council

Measuring point	Sound pressure level Pre-LEZ	Sound pressure level Post-LEZ	Difference
c/Balme - c/Marià Cubí	71.1dB(A)	70.3dB(A)	-0.8dB(A)
Av. Paral·lel - c/Tamarit	70.7dB(A)	70.2dB(A)	-0.5dB(A)
Plaça del Centre	67.6dB(A)	66.5dB(A)	-1.1dB(A)
Travessera de Dalt, 48	71.4dB(A)	71.7dB(A)	+0.3dB(A)

FIGURE 32

Annual evolution of the equivalent level LAeq7-20h

Source: Barcelona City Council



6.5 LEZ register

6.5.1 Evolution of the number of applications

Initially, the total number of authorisations requested in the Register skyrocketed with the implementation of the fining system in September 2020.

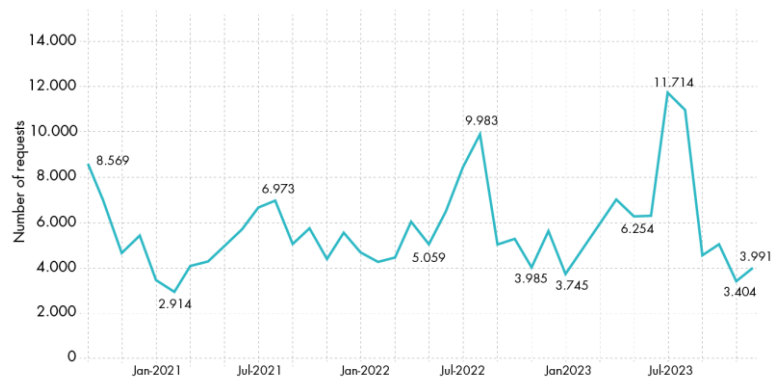
During the first quarter of 2021, requests decreased, likely due to mobility restrictions caused by COVID-19 and the measures to extend existing moratoriums implemented by the Barcelona City Council.

From the second quarter of 2021 onwards, the situation stabilised, with a peak in applications in the summer, coinciding with the peak in requests for authorisation for foreign vehicles. With regard to the data for the year 2023, it is worth highlighting the number of applications during the month of July, which reached nearly 12,000, almost 2,000 more requests than in the same month of the previous year.

FIGURE 33

Evolution of the number of applications

Source: AMB information



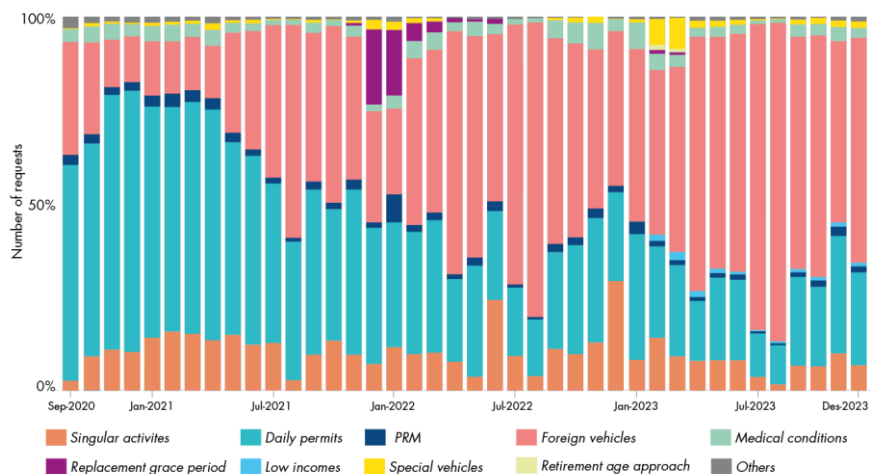
6.5.2 Evolution of the number of applications by type

Analysing the applications in the Register of authorisations by type, it can be seen that the most common procedure during the year 2023 is the application for the registration of foreign vehicles, which accounts for more than 75% of the applications during the month of August.

FIGURE 34

Evolution of the number of applications by type

Source: AMB information



6.5.3 Average number of daily authorisations requested per vehicle

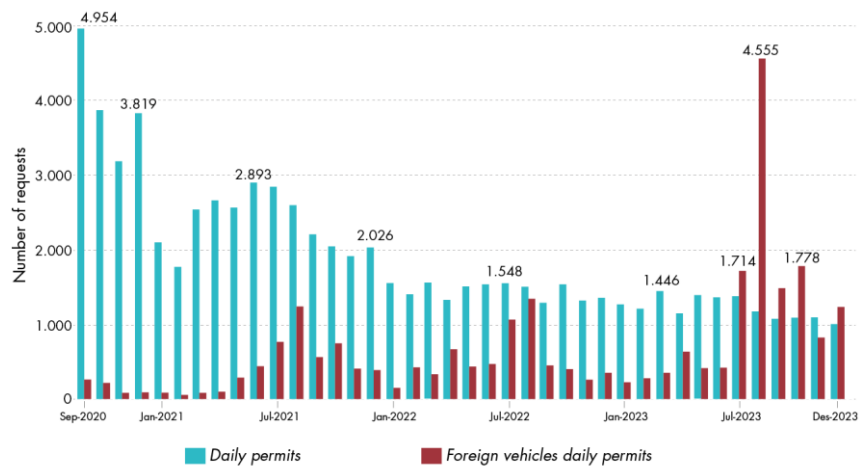
Vehicles without an environmental label from the DGT can request daily authorisations to access within the LEZ if they are previously registered in the *Metropolitan Register of Foreign Vehicles and other vehicles authorised in low emission zones*. Non-foreign vehicles applying for registration in order to obtain a daily authorisation to access and drive sporadically within the LEZ stabilised during 2022, but from mid-2023 onwards a slight downward trend can be detected.

With regard to the number of applications for registration of foreign vehicles, a significant increase was detected during the summer months of 2023 and the trend remains quite high until the end of the same year.

FIGURE 35

Evolution of the number of applications for registration in the daily authorisations register

Source: AMB information



In 2023, a total of 35,224 vehicles requested daily authorisations. Of these, 23,184 are vehicles without a label that sporadically access the LEZ and 12,040 are foreign vehicles [Table 6]. If we analyse the annual trends, we can see that the number of non-foreign vehicles without a label accessing the LEZ decreases very slightly. However, there is a very significant increase in the number of foreign vehicles using daily authorisations.

Regarding the number of daily authorisations requested by local vehicles accessing the LEZ, there has been an increase in the number of authorisations requested even though the number of vehicles has remained stable. This means that the average number of authorisations requested per vehicle has increased to 4, but remains far below the limit of 24 authorisations per year.

In the case of foreign vehicles, the average number of authorisations requested remains constant at around 2 applications per year.

TABLE 6

Annual data related to the number of vehicles applying for daily authorisations and the number of applications
Source: AMB Information

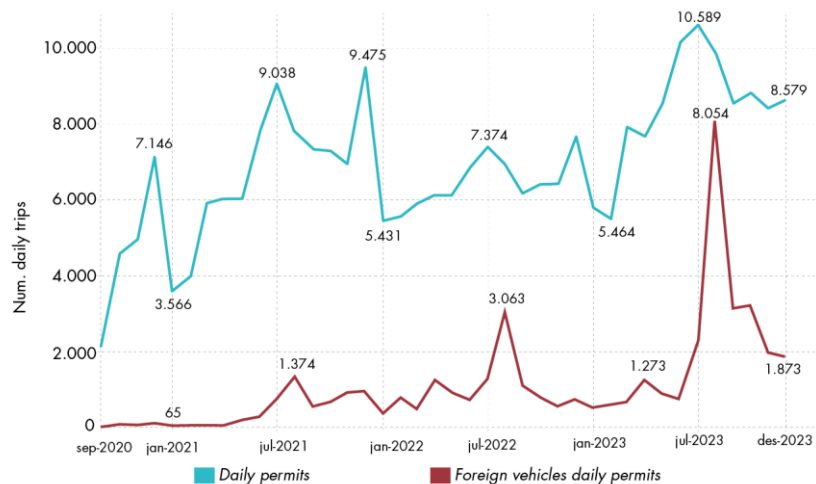
		2020	2021	2022	2023
Number of vehicles requesting daily authorisations	Vehicles without a label that sporadically access the LEZ	8,483	23,513	23,213	23,184
	Foreign vehicles requesting daily authorisations	176	3,188	5,235	12,040
Total authorisations requested	Vehicles without a label that sporadically access the LEZ	18,867	80,989	76,722	100,016
	Foreign vehicles requesting daily authorisations	338	6,171	12,272	25,391
Average authorisations requested per vehicle	Vehicles without a label that sporadically access the LEZ	2.22	3.4	3.3	4.3
	Foreign vehicles requesting daily authorisations	1.92	1.94	2.34	2.1

Analysing the distribution of days when daily authorisations were used by both local and foreign vehicles, it can be seen that the use of these authorisations is concentrated during the summer months. July is the month with the highest circulation of non-foreign vehicles, while August is the month when there is a peak in the use of daily authorisations by foreign vehicles.

FIGURE 36

Monthly evolution of the use of daily authorisations (circulations)

Source: AMB information



6.5.4 New authorisations

- **Vehicles accessing or circulating sporadically through the LEZ**

With the approval of the new Byelaw regulating Barcelona's low emission zone, starting 27 January 2023, vehicles that access or circulate sporadically in the LEZ have 24 daily authorisations per year, compared to the previous allowance of 10 daily authorisations per year.

In order to analyse whether there has been a change in behaviour among users with this modification, the number of daily authorisations used by each registered vehicle has been analysed for the years 2022 and 2023.

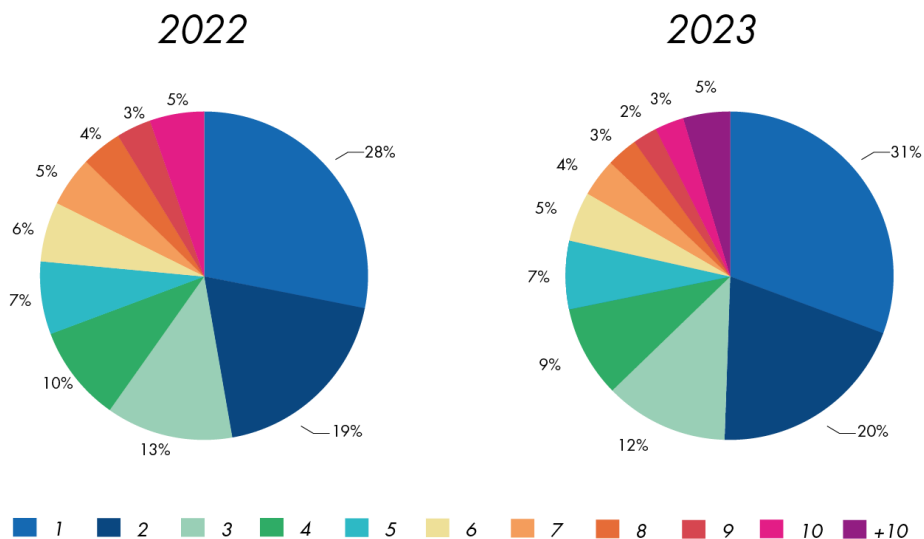
The data for 2023 shows that the number of vehicles requesting 1 or 2 daily authorisations has increased compared to the previous year, accounting for more than half of the requests. This fact may be related to the increase in the number of foreign vehicles detected in 2023.

The number of vehicles requesting 10 or more authorisations has indeed increased from 5% to 8%. However, the number of vehicles that have used all 24 daily authorisations annually is only 0.2%.

FIGURE 37

Histogram of the number of daily authorisation requests per vehicle

Source: AMB information



- **Unique vehicles**

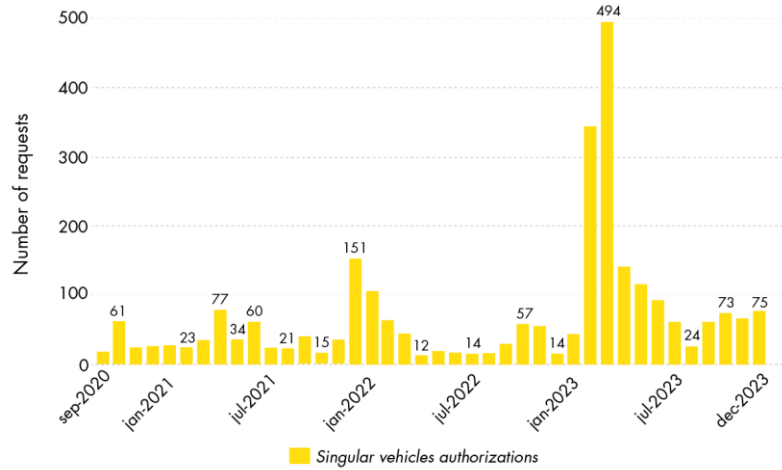
In the authorisations for *Unique vehicles*, according to classification by criteria of use, defined in accordance with Annex II of the General Regulation on Vehicles, approved by Royal Decree 2822/1998, of 23 December, additional categories have been added to the initial list in the new byelaw, primarily concerning unique vehicles exclusively used for construction work.

This change has led to an increase in the number of authorisations of this type requested from February 2023.

FIGURE 38

Evolution of the number of applications for authorisations for unique vehicles

Source: AMB information



- Professionals close to retirement age

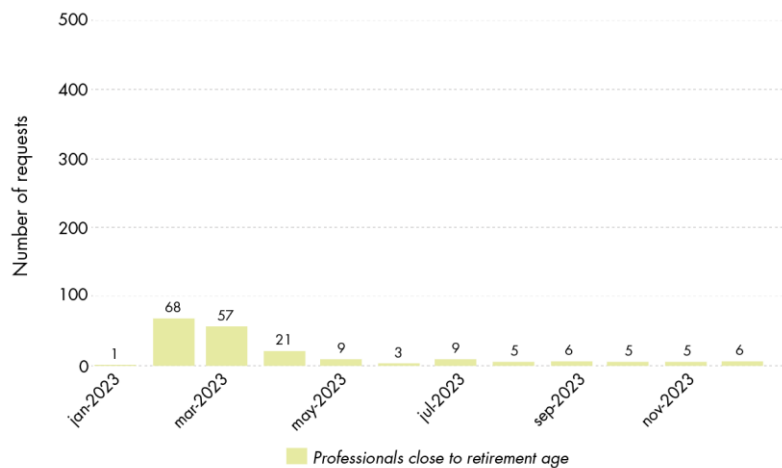
An authorisation introduced from 2023 is that for *Vehicles that constitute a necessary tool for carrying out professional activities, whose owner can prove they have, at most, 5 years left until retirement under the Special Scheme for Self-Employed Workers (RETA), the General Social Security Scheme, or another alternative scheme, according to current legislation.*

The number of authorisations granted in this category during 2023 was 195.

FIGURE 39

Evolution of the number of applications for authorisations for unique vehicles

Source: AMB information



- Low-income individuals

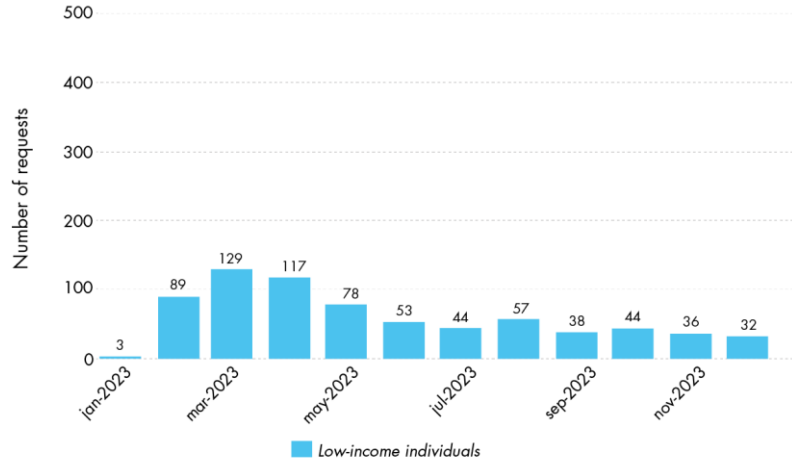
To provide support for individuals with low incomes, the Byelaw has incorporated an authorisation for *vehicles whose owners can prove their total annual financial income (pensions, aid, income, rent, capital interest etc.) is less than twice the public indicator of income for multiple effects (IPREM), increased according to number of household unit members, where appropriate, and calculated on the basis of that household unit's income.*

The annual number of applications in this category during 2023 was 720.

FIGURE 40

Evolution of the number of applications for authorisations for unique vehicles

Source: AMB information



- Moratorium for replacement

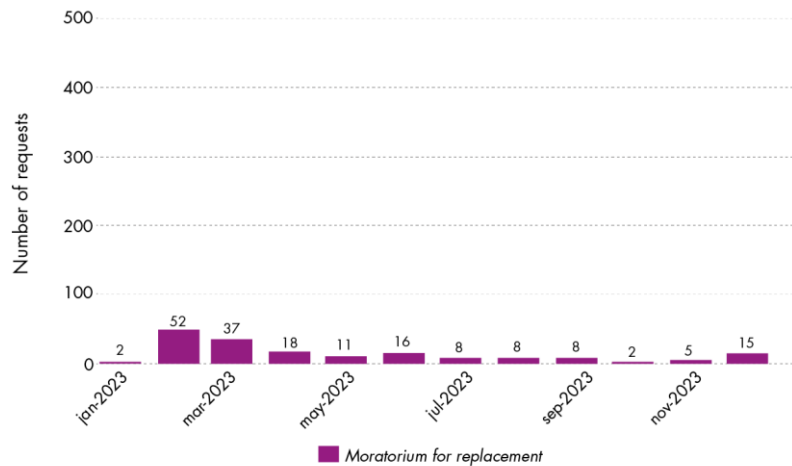
In response to the current situation in the automotive electronic components market, which has led to extended delivery times for new vehicles, a new authorisation has been introduced for *Vehicles whose owners can prove the purchase of a new motor vehicle that meets the technological and emission requirements equivalent to environmental labels.*

The annual number of applications in this category during 2023 was 182.

FIGURE 41

Evolution of the number of applications for authorisations for unique vehicles

Source: AMB information



6.5.5 Evolution of the number of green cards

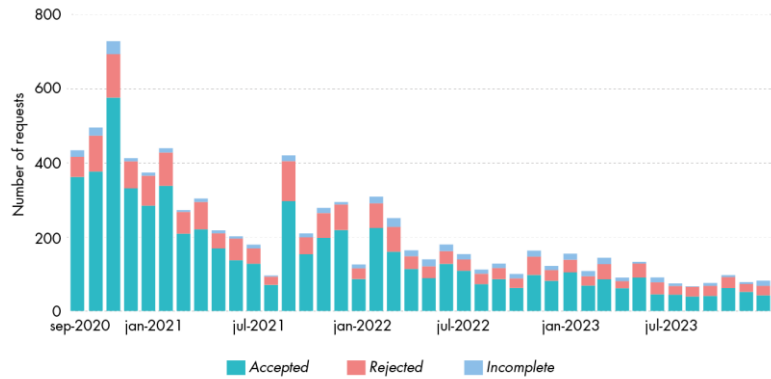
The green card is a free transport pass granted to residents of the metropolitan area when they deregister and scrap a vehicle without an environmental label.

The indicator of the number of green cards issued can give an indication of the number of vehicles without a label that have been scrapped.

As seen in the following graph, during 2023, the requests have decreased compared to previous years and the figure stands at around 50 accepted requests per month.

FIGURE 42

Evolution of the number of green card applications
Source: AMB information



The number of applications received from 21 August 2017 to 31 December 2023 was 19,797, of which 15,313 have been accepted. During 2023, 721 requests have been accepted.

TABLE 7

Annual data related to the number of vehicles applying for the green card.
Source: AMB Information

		2020	2021	2022	2023
Green card applications	Accepted	4,872	2,426	1,322	721
	Rejected	967	757	459	345
	Incomplete	184	97	166	114

6.6 Fine procedures

To assess the compliance with the measure, the Municipal Tax Office of Barcelona City Council provides weekly updates on the status of fine procedures.

6.6.1 Number of closed fines

The number of fine procedures closed on a monthly basis has followed the expected trajectory, taking into account previous experiences in other cities. Closed fines procedures are those for which payment has been completed.

The number of open procedures has been progressively decreasing since the implementation of the measure.

TABLE 8

Annual data related to the number of open and paid fine procedures
Source: Municipal Tax Office

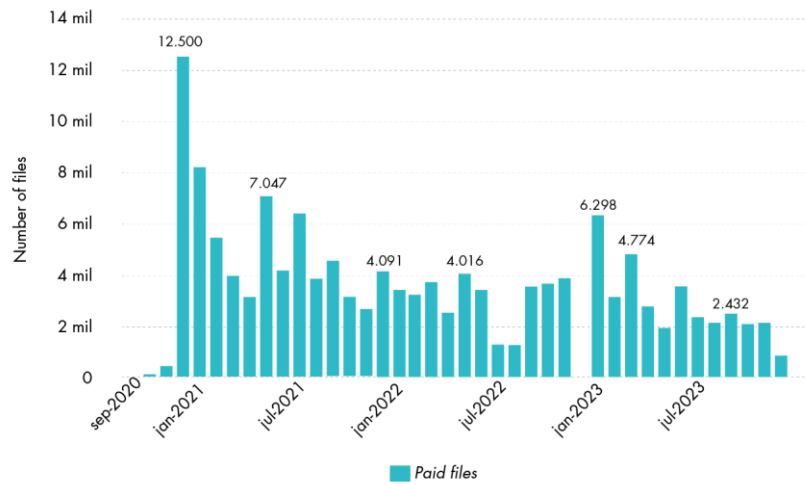
	2020*	2021	2022	2023
Number of open fines	68,231*	139,527	90,100	82,163
Number of paid fines	12,882*	56,263	33,498	33,977

*Data for the last quarter of 2020

The increase in the number of paid fines in 2023 compared to the previous year is due to a technical issue in December 2022 that prevented the fines from being paid until January 2023.

FIGURE 43

Evolution of the number of fines paid
Source: Municipal Tax Office Barcelona City Council



7. Conclusions

1. Act 7/2021, of 20 May, on Climate Change and Energy Transition, and Royal Decree 1052/2022, of 27 December, which implements its provisions regarding the establishment of low emission zones, allow for the establishment of a robust regulatory framework to provide legal certainty in the implementation of this type of measure by different municipalities.
2. On 27 January 2023, Barcelona City Council approved *the Byelaw establishing the criteria for access, circulation and parking of vehicles in the Barcelona low emission zone and promoting emission-free mobility*, which regulates the Barcelona LEZ and updates the provisions of the previous Byelaw to adapt it to Act 7/2021 and the Royal Decree that implements it, establishing the objective and purpose of the LEZ beyond strict compliance with air quality limit values, aligning the measure with the fight against climate change and the reduction of CO₂ emissions, as well as to improve other environmental indicators in order to enhance quality of life in the city.
3. To strengthen the new Byelaw and provide more support to these more vulnerable population sectors, new authorisations have been added primarily to support citizens with fewer resources and professionals nearing retirement age who use the vehicle as a tool for work.
4. In 2022, the average NO₂ levels at the city's monitoring stations showed an increase compared to the years 2020 and 2021. However, the levels measured in 2023 have decreased again, returning to a situation where compliance is observed at all XVPCA stations. This trend is expected to become definitive in the following years.

It can be stated that NO₂ levels, on average across the city, decreased by more than 40% between the years 2015 and 2023 in the city of Barcelona. This positive trend of emission reduction is the result of accelerated vehicle fleet renewal and the benefits obtained from a comprehensive set of measures promoted by the City Council itself.

5. During the year 2023, compliance was recorded at all XVPCA stations in Barcelona. Specifically, the annual average at the traffic stations is 35 µg/m³ and 29 µg/m³, for the Eixample and Gràcia - San Gervasi stations, respectively, without exceeding the current legal limit value (40 µg/m³) in any case. On the other hand, at all stations in the city, the WHO's annual average guideline value (10 µg/m³) is exceeded.
6. Regarding PM₁₀ and PM_{2.5} particles, over the last decade, levels have remained stable, both at traffic stations and urban background stations, staying within legal limit compliance while consistently exceeding the WHO guideline value.

7. With regard to the number of vehicles on the road, it is worth noting that in 2023 the number of vehicles circulating in Barcelona with an ECO label (20.51% in December 2023) is already higher than those with a B label (16.64% in December 2023). This fact greatly explains the pollution levels recorded throughout the year.
8. There has been a progressive reduction trend in NO_x emissions in Barcelona. Compared to 2017, emissions from road traffic have been reduced by more than 50%. Total NO_x emissions between 2022 and 2017 have been reduced by more than 21%.
9. While mobility recorded in 2023 has stabilised and is nearing pre-pandemic levels, the emission factor and levels of NO_x emissions recorded have not recovered to the same extent. Instead, they maintain a downward trend, primarily due to the accelerated renewal of the vehicle fleet and measures implemented by Barcelona City Council.
10. In Barcelona, according to studies conducted by the Barcelona Public Health Agency, long-term exposure to pollution levels in 2023 is estimated to be responsible for 1,300 deaths annually. The mortality attributable to pollution levels in 2023 is 32% lower than estimated for the years 2018-2019 (with 1,900 attributable deaths annually), and it would decrease by 38% if Barcelona were to comply with future legal limits for PM_{2.5} and NO₂ (resulting in around 800 attributable deaths annually).
11. CO₂ emissions are also experiencing a downward trend compared to pre-pandemic levels, largely due to the accelerated renewal of the vehicle fleet driven by measures such as the LEZ. In this regard, it should be noted that the percentage of diesel vehicles is declining, while the number of petrol vehicles is increasing.
12. With regard to the operation of the register of authorised vehicles, it is worth noting that the peak of requests is recorded during the summer months. In July 2023, almost 12,000 applications were registered, with an increase of almost 2,000 compared to the same period of the previous year, 2022. Analysing the applications in the Register of authorisations by type, it can be seen that the most common procedure during the year 2023 is the application for the registration of foreign vehicles, which accounts for more than 75% of the applications during the month of August.
13. With regard to new authorisations, the number of authorisations granted during the year 2023 for professionals close to retirement age was 195. Meanwhile, up to 720 applications for authorisations have been received from low-income individuals.
14. The number of fine procedures opened in 2023 was 82,163 (almost 8,000 less than the previous year), while the number of fines paid since the LEZ came into operation is 136,620, (33,977 in 2023).