

Ban on coal-fired boilers: Madrid case study

This is one of four city case studies prepared by the Institute for European Environmental Policy for the Clean Air Fund. The study examines Madrid's policy to ban coal-fired boilers and reduce emissions from residential heating under the Madrid 360 Environmental Sustainability Strategy. In addition, this brief explores the social implications of this policy, with a particular focus on vulnerable groups and public health impacts. This case study is structured around Madrid's air quality challenges and policy response, followed by an assessment of the social dimensions of the transition away from coal-fired heating, including stakeholder perspectives, impacts and implementation challenges.

Madrid is Spain's capital and the country's largest city in terms of population and urban area (IQAir, 2026), functioning as one of Europe's largest metropolitan economies, with a GDP per capita well above the national average (see Annex 1). Madrid faces persistent air quality challenges resulting from a combination of transport emissions, residential heating, and, increasingly, the impacts of climate change. At the same time, the city's geographical setting can restrict air circulation and exacerbate pollution episodes. These climate-related pressures are expected to intensify in the coming decades, posing growing risks to public health. In response, Madrid has implemented a comprehensive package of air quality measures, including low-emission zones, cleaner public transport, and policies to reduce emissions from residential heating. Under the [Madrid 360 Environmental Sustainability Strategy](#), the city **introduced a ban on coal-fired boilers in 2022**. As the first Spanish city to introduce traffic restrictions specifically to improve air quality, Madrid is the national leader in integrating climate and air quality policies to reduce emissions and strengthen resilience to climate change (Sanchez, 2018)

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Madrid-specific air pollution challenges

Madrid has historically faced significant air quality challenges, primarily driven by road transport emissions. Traffic accounts for approximately 35% of PM_{2.5} emissions and remains the city's largest source of nitrogen dioxide (NO₂) (EEA, 2025). High traffic volumes, commuter flows, and urban density have contributed to persistent exceedances of the European Union (EU)'s air quality standards in the past.¹ This daily inflow of commuters increases traffic congestion during peak hours, leading to higher emissions of NO₂, particulate matter (PM_{2.5} and PM₁₀), and greenhouse gases (Gamarra, Lechon, Garcia vivanco, & Garrido, 2026) as well as ozone levels (Ecologistas en Acción, 2026). Unlike many other major European cities, Madrid has limited industrial emissions due to the relatively small contribution of the industrial sector within the municipality (Interviewee 1, Municipality of Madrid, 2026).² On the other hand, alongside traffic, **heating installations in buildings, which are mainly fuelled by gas, represent another major source of pollution** (Interviewee 3, Fundación Renovables, 2026). Neighbourhoods on the outskirts of the city, particularly in the Southern areas, are the most affected by pollution from residential heating, and also the most economically vulnerable, with inadequate infrastructure, exposed to energy poverty, and other social issues (Interviewee 3, Fundación Renovables, 2026).

In addition to local emissions, **Madrid experiences seasonal air pollution episodes linked to regional and climatic factors**. During summer, Saharan dust increases particulate matter concentrations, while smoke from large-scale wildfires in northwestern Spain and Portugal can be transported into the metropolitan area³ (IQAir, 2025). Spain's most severe wildfires took place in the past few years, with 2026 recording the largest wildfire in Spanish history (Madrid AFP, 2026). It occurred in the Madrid region, approximately 70 km west of the city (Carpio, 2026). This wildfire has been responsible for burning more than 50,000 hectares of forest, significantly increasing PM_{2.5} and PM₁₀ concentrations within the city (Casado, 2026). Climate change is likely to worsen this trend by increasing the frequency and severity of wildfires, leading to more frequent episodes of wildfire smoke-related pollution in Madrid. Rising temperatures and intense solar radiation as a consequence of climate change further contribute to the formation of ground-level ozone, creating additional air quality risks. Madrid's geographical location exacerbates these challenges. The city is partially surrounded by mountain ranges, which can restrict air circulation and limit the dispersion of pollutants during periods of low wind speeds and atmospheric stability (Eurocities, 2025). As a result, pollution can accumulate over the city, particularly during the summer months.

¹ In particular, Madrid experiences substantial daily suburban-to-urban commuting, with large numbers of residents travelling from surrounding municipalities into the city for work and other activities (Romero, Gomez, Rangel, & Vassallo, 2019).

² For the production of this policy brief, IEEP has conducted several interviews with relevant stakeholders and experts who significantly enrich the analysis. These include: the Clean technologies service of the Municipality of Madrid (Interviewee 1); Ecologistas en Acción (Interviewee 2), and Fundación Renovables (Interviewee 3).

³ Northwest Spain and Portugal represent 2% of European territory but accounted for more than 50% of the total area burned during wildfires across Europe in late august of 2025 (Pietroiusti & Cavitte, 2025).

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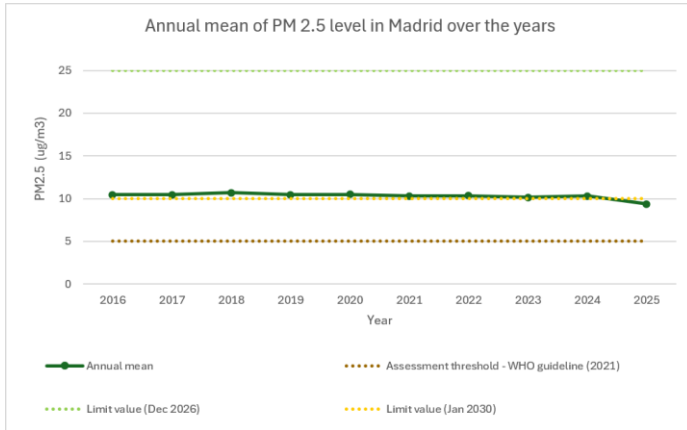


Figure 1. Annual mean of PM_{2.5} levels in Madrid between 2016 and 2025, assessment threshold and limit values from the Air Quality Directive 2024/2881. From IEEP, 2026. Based on data from (EEA, 2025) (EEA, 2026).

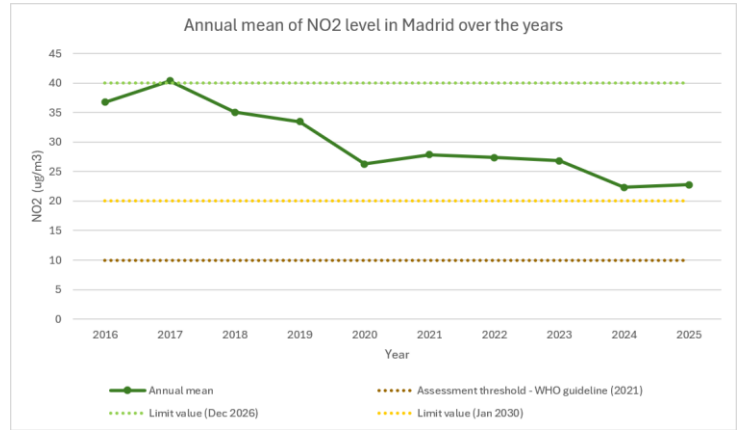


Figure 2. Annual mean of NO₂ levels in Madrid between 2016 and 2025, assessment threshold and limit values from the Air Quality Directive 2024/2881. From IEEP, 2026. Based on data from (EEA, 2025) (EEA, 2026).

Figure 1 illustrates that the annual mean for PM_{2.5} concentration in Madrid has remained relatively stable at around 10 µg/m³ over the past decade. Despite the implementation of the LEZ, no significant reduction is evident, suggesting that decreases in transport-related emissions may have been offset by other sources of particulate matter. Although PM_{2.5} concentrations in Madrid are elevated during winter due to stable atmospheric conditions that limit pollutant dispersion, summer peaks are particularly concerning because higher temperatures enhance the formation and accumulation of particulate matter, suggesting that climate-change-driven warming could further worsen summertime air pollution (Wei & Sobrino, 2025). On the other hand, **Figure 2** shows that the annual mean for all NO₂-related emissions significantly dropped in 2020, which can most likely be attributed to the outbreak of the COVID-19 pandemic, and thereafter thanks to the implementation of the Low-Emission Zone (LEZ) for vehicles⁴. Up until the implementation of a LEZ, NO₂ from urban traffic ranged from a lowest annual mean of 51.33 µg/m³ up to 61.87 µg/m³ in Madrid (EEA, 2025). Nevertheless, the value lies above the 2030 limit value and is more than double the WHO 2021 limit. The PM_{2.5} value measured at the network stations during 2025 was 9.36 µg/m³ and the average NO₂ value across all stations (traffic and background stations) in 2025 was 22.75 µg/m³ (Interviewee 1, Municipality of Madrid, 2026).

⁴ In September 2021, Madrid introduced the [Sustainable Mobility Regulation](#), restricting the circulation of the heavily polluting cars within the M-30 ring, which covers the entire territory of the municipality. From 1 July 2024, polluting vehicles that were not registered in Madrid before 1 January 2022, or do not appear in the list for the city's Motor Vehicle Tax (IVTM), were restricted from driving anywhere in the city. However, implementation has been happening gradually, allowing citizens to adapt until 2025.

Local pressure and policy response

Growing public concern over persistent air pollution and the effects of climate change, combined with legal pressure from the EU, has driven Madrid to adopt its air quality policies. This pressure is expected to intensify following the entry into force of [Directive \(EU\) 2024/2881](#) on ambient air quality and cleaner air for Europe, which introduces significantly stricter pollutant concentration thresholds, particularly for nitrogen oxides (NO_x), requiring municipalities to achieve further emission reductions. In 2022, the [Court of Justice of the European Union](#) ruled that Spain had failed to comply with EU air quality legislation by repeatedly exceeding nitrogen dioxide (NO₂) limit values in Madrid between 2010 and 2018.⁵ Local pressure was also exerted by citizens when, in 2019, following the opposition's victory in the municipal elections, the new conservative administration suspended the LEZ. Such mass protests and spikes in air pollution levels forced the administration to reinstate it.

Subsequently, the city took a step further and embedded emission reduction in the **Madrid 360 Environmental Sustainability Strategy (2019)**⁶, expanding the core principles of Madrid Central, which established the LEZ, while addressing some legal shortcomings (Hillen & Madrid City Council, 2025).⁷ The strategy combined the expansion of the LEZ across the entire municipal area by January 2025 with complementary investments in cleaner public transport, electric and hybrid buses, and cycling and pedestrian infrastructure, amounting to more than €350 million (EEA, 2025) (Eurocities, 2025). These measures enabled Madrid to comply with the existing EU air quality limit values for key pollutants in 2022 after more than a decade of non-compliance (Hillen & Madrid City Council, 2025). However, many argue that the objectives and actions of Madrid Central were more ambitious than the current Madrid 360 plan (Interviewee 3, Fundación Renovables, 2026), suggesting that the former strategy could have brought more suitable results for the needs of the city.

Creating the legal framework for Madrid 360, in 2021 the municipality introduced the **Air Quality and Climate Change Ordinance (OCAS)**⁸. The ordinance, whose drafting began in 2019, **established a ban on coal-fired boilers starting from 1 January 2022**, alongside energy-efficiency standards for new buildings, the mandatory installation of charging points for electric vehicles in new buildings, and other emission reduction measures. The ordinance also aimed to halve the city's estimated 4,500 oil-fired boiler rooms by 2027 (Madrid City

⁵ See more on EU legal issues in Annex 3.

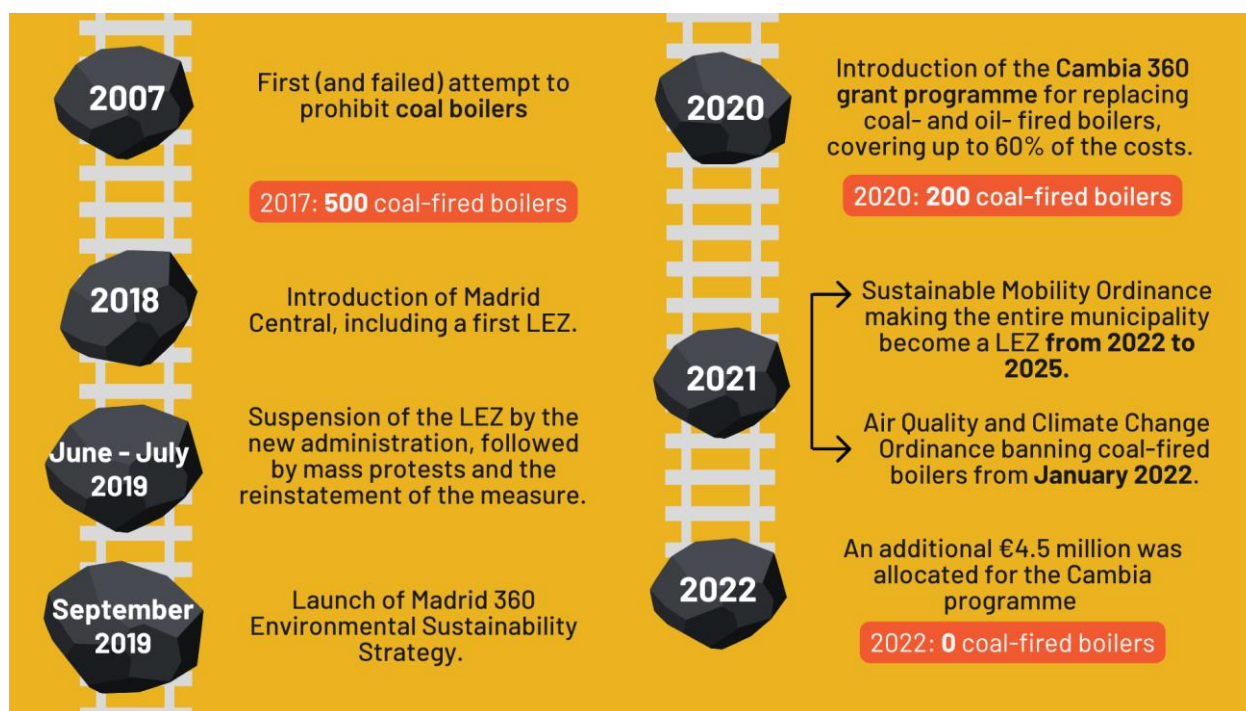
⁶ The legal basis for the ban was provided by Article 16.4 of [Law 34/2007 on Air Quality and Atmospheric Protection](#) and Article 25.b of [Law 7/1985 Regulating the Foundations of Local Government](#), which grant municipalities with more than 100,000 inhabitants the authority to adopt measures to improve urban air quality (Interviewee 1, Municipality of Madrid, 2026).

⁷ See more in Annex 4.

⁸ An earlier attempt by the Spanish national government to prohibit the use of coal in building heating installations was made in 2007 through the Regulation on Thermal Installations in Buildings (Royal Decree 1027/2007 of 20 July). However, the measure proved ineffective because the relevant provision did not apply to buildings that existed before the regulation entered into force and the energy-efficiency legislation underpinning the regulation did not provide a legal basis for imposing requirements on existing heating installations (Interviewee 1, Municipality of Madrid, 2026).

Council, n.d.). In support of the transition, the City Council launched the [Cambia 360 grant programme](#), allocating €12.5 million in 2020 and €13.3 million in 2021 for the replacement of coal- and oil-fired heating systems with cleaner and more efficient alternatives (Madrid City Council, n.d.), which contributed to the achievement of the objective of eliminating coal-fired boilers. An additional €4.5 million was allocated for the programme in 2022 to continue accelerating the transition to low-emission heating systems (Madrid City Council, n.d.).

Timeline



Social Aspects – Investigations and Stakeholder Consultations

Stakeholder engagement and public participation

As per standard municipal legislative procedure, the Air Quality and Sustainability Ordinance was subject to public consultation through the [Decide Madrid portal](#), where citizens and organisations had the opportunity to express their views. Certain organisations were also directly consulted and participated in discussions on urban sustainability with Madrid's Air Quality Commission (Interviewee 1, Municipality of Madrid, 2026). Information sessions were held, particularly for the affected residents, to explain the implications of the ban and the support schemes available. Contact was maintained for the two years following the ban's entry into force to monitor implementation, inspect the replacement works, and ensure that people were satisfied and familiar with the operation of the new devices (Interviewee 1, Municipality of Madrid, 2026).

Public acceptance, resistance and perceptions

In contrast with the LEZ and other restrictive measures targeting highly polluting sources, the number of citizens directly affected by this measure was small, and it targeted a specific heating fuel (coal) that had already become outdated in much of the city. Thus, the public debate around it was much more limited than that surrounding the LEZ, which, on the other hand, affected the broader public (especially average and above-average income citizens) and, therefore, faced considerable public resistance (Interviewee 1, Municipality of Madrid, 2026; Interviewee 2, Ecologistas en Acción, 2026; Interviewee 3, Fundación Renovables, 2026). Among the small number of directly affected citizens, however, the measure was initially met with resistance; yet no significant complaints were recorded once installations had been renovated, and many affected users even expressed satisfaction with the improved comfort (Interviewee 1, Municipality of Madrid, 2026). Beyond this group, the broader public was generally indifferent to the measure. Support came mainly from environmental organisations, while opposition came from political groups and critics who viewed the measure as interventionist and an interference with individual freedom, as well as from coal marketing companies, which challenged its legality. Overall, the relatively limited public controversy the ban received has not substantially changed since implementation; rather, the measure has simply ceased to attract media attention, because of the relatively small number of buildings affected (Interviewee 1, Municipality of Madrid, 2026).

On a general note, the wider **Madrid 360 strategy has highlighted the importance of ensuring that environmental measures are perceived as fair and proportionate**. Through participatory initiatives such as *Decide Madrid*, the municipality has sought to involve residents in shaping the city's environmental policies (Madrid City Council, n.d.).

Impacts of the ban

The most immediate impact of Madrid's ban on coal-fired boilers is the **elimination of one of the city's most polluting residential heating technologies**. In 2008, it was estimated that around 600 buildings had centralised heating systems using coal as fuel (Interviewee 1, Municipality of Madrid, 2026). Through subsidy schemes, which covered up to 70% of renovation costs, approximately 300 installations were converted between 2008 and 2019. The Cambia 360 grant programme (2020), covering 60% of the costs and supplemented by personal income tax deductions for energy-efficiency renovation works in the residential sector, has enabled the replacement of the remaining boilers.⁹ In theory, no coal-fired installation has remained in operation after 1 January 2022 (Interviewee 1, Municipality of Madrid, 2026).

Voluntary programmes aimed at encouraging the renovation of thermal installations proved costly for citizens while delivering limited results. Over ten years, despite substantial subsidies, the number of installations renovated was roughly equivalent to that achieved in just two

⁹ See data for 2020 [here](#).

years following the introduction of the mandatory ban (Interviewee 1, Municipality of Madrid, 2026). While it is difficult to isolate the effects of the coal boiler ban from the broader Madrid 360 package, **the measure contributes to the city's overall strategy of reducing emissions from buildings alongside transport**. Based on the characteristics of the renovated installations, the estimated emission reductions due to the coal-firing ban were 9.7 tonnes/year of SO₂, 39.4 tonnes/year of NO₂ and 19.8 tonnes/year of PM_{2.5} (Interviewee 1, 2026; Interviewee 3, Fundación Renovables, 2026). The number of affected installations is very small compared to thermal installations and road traffic; thus, the estimated reduction in emissions is not particularly significant if assessed by itself (Interviewee 1, 2026; Interviewee 3, Fundación Renovables, 2026).

Public health impacts.

Exposure to particulate matter in Madrid is associated with higher rates of hospitalisation for respiratory illnesses, including acute respiratory infections and pneumonia (ISCIII, 2025). During the summer months, heat further increases the risk of hospital admissions for respiratory diseases (ISCIII, 2025), particularly among adults aged 65 years and older, with studies also reporting increased admissions for Parkinson's and Alzheimer's diseases (Culqui, Linares, Ortiz, Carmona, & Diaz, 2017) (Franco, Gordo, Marques da Costa, & Lopes, 2023). The mortality burden linked to annual PM_{2.5} exposure is sufficiently high to justify urgent public health action aimed at drastically reducing these pollution levels (Lopez-Encuentra, Cid, Abaira, & Pozo Coronado, 2025). These findings suggest that climate change, through rising temperatures and more frequent heatwaves, is likely to exacerbate the health impacts of air pollution in Madrid.

The ban has contributed to compliance with EU air quality standards by targeting pollutants that are particularly harmful to human health. Replacing the remaining coal-fired boilers removes a highly polluting source of emissions and delivers localised improvements in air quality, particularly during the winter heating season. No direct improvements in public health have been identified; however, atmospheric sulphur oxide concentrations declined substantially and had virtually disappeared by 2022 (Interviewee 1, Municipality of Madrid, 2026).

Socio-economic impacts.

Household income has been investigated as a potential determinant of air pollution exposure in Madrid, but **evidence does not support a simple city-wide relationship between lower household income and greater pollution exposure**, as affluent neighbourhoods also experience high traffic-related pollution due to their proximity to major transport hubs (Hewitt, Carames, & Borge, 2024). This pattern is also reflected in the distribution of residential heating systems. Historically, coal-fired boilers, and today many of the remaining centralised oil-fired heating systems, were located within the M-30 ring road, where many of Madrid's higher-income neighbourhoods are situated (Interviewee 1, Municipality of Madrid, 2026). By contrast, many lower-income neighbourhoods developed between the 1940s and 1970s on the urban periphery were built without centralised heating systems, as Madrid's relatively mild winters

meant heating systems were not needed to the same extent (Alonso, et al., 2023).¹⁰ Consequently, residential heating-related emissions have historically been more concentrated in parts of the city with relatively higher incomes, and much of the replacement work has taken place in the city centre. However, as shown in a [map compiled using data from Madrid City Council](#), in 2017, most of the 500 remaining coal-fired boilers were distributed across different areas that could be classified in two categories: central, high-income neighbourhoods, whose residents were able to afford allocating the high level of resources necessary to maintain these systems; and more peripheral, lower-income neighbourhoods, whose residents retained these systems due to difficulties to afford the renovations' investment costs (Interviewee 2, Ecologistas en Acción, 2026).

The availability of **municipal grants under the Cambia 360 programme reduced potential resistance by helping building owners finance the replacement of existing systems and minimise financial barriers for households and building owners** (Madrid City Council, n.d.). Although the municipality reimbursed the costs after the renovation works were completed, payments were processed relatively quickly, generally within nine to ten months (Interviewee 1, Municipality of Madrid, 2026). In practice, many projects were implemented through companies offering financial solutions, where the contractor initially covered the costs and building owners only paid the remaining amount once the municipal subsidy had been received (Interviewee 1, Municipality of Madrid, 2026). In addition, the replacement of coal- and oil-fired heating systems often resulted in lower energy consumption, meaning that households benefited from reduced energy bills rather than facing a significant additional financial burden. Despite renovated installations being equipped with significantly lower nominal thermal capacities than the coal-fired systems they replaced, heating demand during periods of peak winter temperatures was fully met (Interviewee 1, Municipality of Madrid, 2026)¹¹. Overall, no major complaints were received regarding the affordability of the transition. Nevertheless, some environmental and social justice organisations highlighted **the negative implications of the one-size-fits-all approach of the subsidy scheme**, claiming that it failed to genuinely include vulnerable groups, as quotas or conditions did not apply differently depending on income levels (Interviewee 2, Ecologistas en Acción, 2026). Others believe that social considerations were partially taken into account, as the funding scheme did not make an explicit distinction between owners and tenants; similarly, the penalties provided for by law were directed at homeowners, which in the majority of the cases are homeowners associations (Interviewee 3, Fundación Renovables, 2026).

¹⁰ It is relevant to mention that these neighbourhoods are characterised as vulnerable urban areas, with high inefficiency due to bad insulation. This is becoming an increasing issue for the implementation of cooling systems in Madrid. See more on cooling in Box 1.

¹¹ According to the municipality, this reflects the fact that heating systems installed between 1960-1990 were generally oversized, while improvements in buildings, particularly window thermal performance, and milder winter temperatures have substantially reduced heating demand.

Implementation and current city challenges

The implementation of the coal boiler ban was followed by monitoring activities conducted together with the regional government of Madrid, which found that centralised systems had ceased operation (Interviewee 1, Municipality of Madrid, 2026). In case of continuous non-compliance, fines were issued; however, they would only apply as a last resort, after issuing warnings.¹² The municipality inspected the completed works and maintained contact with affected users up to three years following implementation to identify potential problems or concerns (Interviewee 1, Municipality of Madrid, 2026). This follow-up process provided information on users' experiences with the new heating systems and their perceptions of the transition. The main challenge for the implementation of Madrid's coal boiler ban concerns the lack of explicit legal authority to impose restrictions on existing installations, which is a recurrent problem for municipal administration when adopting similar measures (Interviewee 1, Municipality of Madrid, 2026).

Such an approach appears to have been reasonably effective for phasing out coal boilers, but evidence suggests a slow pace of replacement of oil boilers, the other major part of the Ordinance (Interviewee 3, Fundación Renovables, 2026). In addition, most boilers were substituted with gas, instead of promoting other cleaner devices, such as heat pumps. Around 23 coal-fired systems have been replaced by biomass or pellet-fired devices, most of which were supplied by a company that has itself transitioned from being a coal to a biomass supplier. (Interviewee 1, Municipality of Madrid, 2026). Today, natural gas is the predominant heating source in Madrid's residential sector, with over 950,000 dwellings using individual or centralised natural gas boilers, 75,000 using centralised oil-fired boiler systems, while only 2,500 use centralised biomass boilers. Heat pumps remain limited largely to newer and recently refurbished buildings (Interviewee 1, Municipality of Madrid, 2026). The remaining dwellings use electric heating systems, primarily direct-electric resistance heating or direct-expansion systems (split units). Speeding up the replacement of electrification of transportation and increasing the uptake of heat pumps are considered key actions for Madrid, with the latter contributing to fulfil heating and cooling needs without any direct pollution or other emissions (Interviewee 3, Fundación Renovables, 2026).

¹² The fines established for non-compliance, which ultimately did not need to be applied, are set out in Chapter IV of Title VII of Ordinance 4/2021, which refers to Law 34/2007 on Air Quality and Atmospheric Protection. Articles 30 and 31 of that law establish offences and penalties, with fines of up to €20,000 depending on the severity of the infringement (Interviewee 1, Municipality of Madrid, 2026).

Box 1. Cooling a warming city

Although this series of briefs focuses on heating systems, Madrid's climate and geographical location make it necessary to briefly address cooling as well. Rising temperatures and other climate change impacts are making **cooling** an increasingly urgent challenge for the city. Cooling needs are becoming increasingly critical as heating needs, or even more critical, due to the **significant inequalities in access to cooling** (Interviewee 2, Ecologistas en Acción, 2026). Many vulnerable households are unable to keep their homes cool during the hottest months because they live in poorly insulated and old buildings and cannot afford renovation works or air-conditioning systems. The lack of trees in poorer neighbourhoods further worsens the situation, contributing to the 'urban heat island' effect, with temperatures reported to be up to 8°C higher than in other parts of the city (Reuters, 2025). The Ministry of Health reported that in Spain, the impacts of heat on mortality are greater than those of cold. The municipality considers this one of its most pressing future challenges and is exploring mitigation measures, including geothermal systems where feasible and centralised cooling systems that do not expel hot air into the street (Interviewee 1, Municipality of Madrid, 2026). In anticipation of the transposition of the EU Energy Efficiency Directive (2023/1791), which requires cities with more than 45.000 inhabitants to prepare local Heating and Cooling plans, Madrid has been acting proactively and has conducted a preparatory study. This assesses the neighbourhood energy conditions, building characteristics and existing cooling systems, and identifies lower-impact alternatives and building interventions to improve energy efficiency.

Transferrable lessons and recommendations

Madrid's ban on coal-fired boilers offers an interesting case study for linking air pollution and climate change needs under a single comprehensive framework. Although the PM 2.5 levels did not see significant improvements in the past 10 years, there is an evident reduction in nitrogen caused by this package of measures. While the environmental, social and health impacts attributable to the ban remain difficult to isolate, owing to the limited scope and the relatively small number of households affected in comparison to other measures, some key lessons can be summarised as follows:

1. Treating air pollution and emission reduction as two sides of the same coin

Climate-related phenomena, such as the wildfires occurring with increased frequency and severity, have exposed the city's vulnerability, emphasising the need for increased climate efforts and a comprehensive approach. The Air Quality and Climate Change Ordinance, which implements the broader 360 Madrid Sustainability strategy, places air quality improvement and emission reduction on an equal footing as key objectives for enhancing urban sustainability and citizens' wellbeing. It recognises that steady and lasting progress, which mainly occurred in the past few years with a significant reduction in NO₂, requires a coordinated, cross-sectoral approach, bringing multiple objectives under a common framework rather than addressing them through fragmented and disconnected measures.

2. Maintaining close contact with citizens before and throughout implementation

Although the measure did not attract much media attention due to its limited scope, the increased general support from the citizens concerned indicates that the Municipality effectively communicated its benefits and implemented an effective reimbursement scheme to facilitate the transition, thereby minimising potential socio-economic impacts. In particular, monitoring its implementation and operation following the entry into force of the ban was crucial for assessing user satisfaction with the new devices. While the measure had a limited reach, the positive results confirmed the effectiveness of the approach, suggesting that the policy was well received.

3. Ensuring gradual and flexible implementation

While the legislation allows for significant penalties in cases of non-compliance, the municipality chose to implement the ban in a pragmatic and gradual manner. This approach prioritises engagement and support over strict enforcement. The apparent phase-out of all coal-fired boilers suggests that the strategy was effective, demonstrating that a measured and flexible implementation can successfully deliver ambitious environmental objectives.

4. Sustain momentum on clean heating

The ban on coal-fired boilers is symbolically important in supporting the decarbonisation of heating in Madrid. However, it represents only a small part of the broader transition required. Further action is needed to promote the adoption of clean technologies, including through financial incentives, the accelerated replacement of oil-fired boilers, gradually phasing out of all fossil fuel-based heating systems.

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Annex 1 Socio-demographic data for Madrid

Socio-demographic data for Madrid	
Area coverage	605.7 km ² (A) ¹³
Population density	5,713 inhabitants/km ² (B)
GDP per capita of Madrid:	EUR 52,386 (C)
GDP per capita of Spain:	EUR 30,812 (D)
Madrid's average annual wage	EUR 34,410.01 (E)
Spain's gross average annual wage	EUR 29,540.26 (F)
EU average annual wage	EUR 39,800 (G)

¹³ A. Additionally, the city of Madrid has a population of 3,460,491, with the average age being 44 years (Madrid City Council, 2025); B. (Madrid City Council, 2025); C. This value is for the city of Madrid. The GDP per capita in the region of Madrid is significantly lower at €39,387 (Madrid City Council, 2025); D. (Madrid City Council, 2025); E. (Instituto Nacional de Estadística, 2026) ; F. There are stark differences according to region, sector and occupational level (Instituto Nacional de Estadística, 2026) ; G. (Eurostat, 2025).

Annex 2 National air quality context and trends

In 2025, Spain's annual average PM_{2.5} was 9.1 µg/m³, making it the 13th cleanest European country (IQAir, 2026). The primary sources of PM_{2.5} emissions in Spain are waste management (41%), the energy sector (27%), primarily from non-industrial combustion, followed by industry (12%) and road transport (10%).¹⁴ In addition to direct emissions, fine particulate matter is also formed secondarily in the atmosphere through chemical reactions involving precursor gases and existing particles. Since 2011, national average PM_{2.5} concentrations have remained relatively stable (see Figure 3 below), while the highest concentrations at urban traffic and industrial monitoring stations have gradually declined. This improvement is largely attributed to stricter vehicle emission standards, cleaner industrial processes, and the implementation of air quality policies, including low-emission zones in major cities. The health burden associated with air pollution has also decreased, with the number of premature deaths attributable to PM_{2.5} exposure falling significantly over the past decade (EEA, 2025). Nevertheless, air pollution remains one of Spain's leading environmental health risks, leading to 22,000 premature deaths annually (SMC Spain, 2025). Although compliance with European air quality standards has improved, isolated exceedances of nitrogen dioxide (NO₂) and particulate matter limits continue to occur, particularly in large urban areas. Air pollution is estimated to cost Spain approximately 3.5% of its Gross Domestic Product each year,¹⁵ with projections suggesting these costs could rise to 4% by 2030. (Oficina de Ciencia y Tecnología del Congreso de los Diputados (Oficina C), 2023).

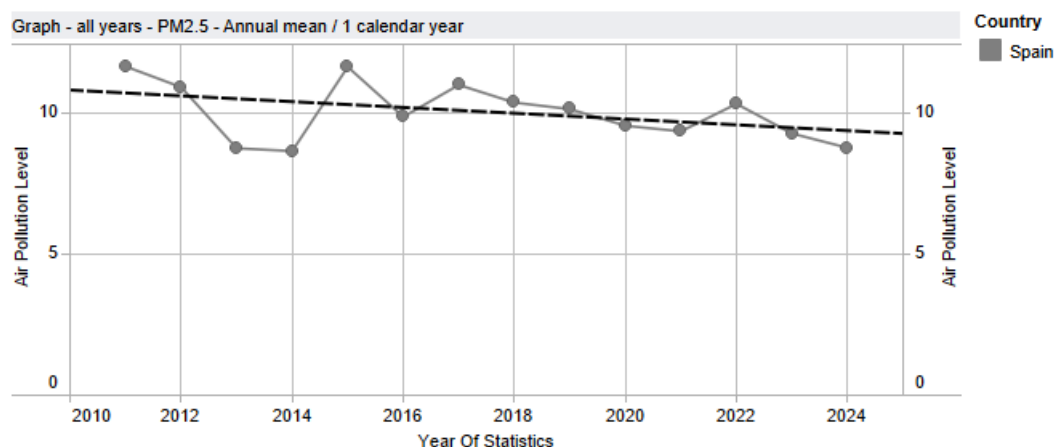


Figure 3. Annual mean of PM 2.5 in Spain from 2011 to 2024. (EEA, 2025)

¹⁴ Ministerio para la Transición Ecológica y el Reto Demográfico & Secretaría General Técnica. Centro de Publicaciones. Informative inventory report. Submission to the secretariat of the Geneva Convention and EMEP Programme. Reporting to the European Commission under Directive (EU) 2016/2284. NIPO: 665230213 (2023).

¹⁵ Greenpeace. *Tracking the cost of air pollution*. Greenpeace website, n.d.

Annex 3 Legal and policy context

Spain has faced long-running infringement proceedings for failing to comply with the EU Ambient Air Quality Directive ([Directive 2008/50/EC](#)), particularly due to persistent exceedances of annual NO₂ limit values in Madrid and the Barcelona metropolitan area. In 2019, the [Commission referred Spain to the European Court of Justice \(CJEU\)](#), citing systematic breaches of the Directive and inadequate air quality plans. In December 2022, the ECJ ruled in favour of the Commission ([Case C-125/20](#)), finding that Spain had systematically exceeded the annual NO₂ limit values between 2010 and 2018 and had failed to adopt appropriate measures to achieve compliance within the shortest possible time, despite improvements in air quality over the period. Following the judgment, Madrid strengthened its air quality policies, most notably through the expansion of its low-emission zone (Madrid 360). Furthermore, the European Commission has launched an [infringement procedure](#) for PM₁₀ against a number of Member States, including Spain.

A recent ruling by [the High Court of Justice of Galicia \(TSXG\) in 2025](#) found that Spanish authorities violated Galicia's residents' fundamental rights by failing to address pollution from intensive livestock farming. The case highlighted water contamination as well as air pollution impacts, including odour emissions and fine particulate matter linked to intensive agricultural activities. The court ordered urgent corrective measures, marking an important precedent in recognising PM-related air pollution as a potential human rights violation.

Annex 4 Low Emissions Zone for transport

In 2018, the city introduced **Madrid Central**, a Low Emission Zone (LEZ) restricting access for the most polluting vehicles in the city centre, although fines were only implemented the following year. Following the 2019 municipal elections, the new conservative administration suspended the LEZ zone, arguing that it imposed excessive restrictions on motorists and businesses (The Guardian, 2019), even though nitrogen dioxide emissions went down by 32% since the policy's introduction (IQAir, 2019). The LEZ was reinstated five days later due to a spike in pollution and mass protests (BBC, 2019). In 2020, Madrid's High Court annulled the original ordinance on procedural grounds (Moral-Carcedo, 2022). The city subsequently embedded emission reduction in the **Madrid 360 Environmental Sustainability Strategy (2019)**, which retained and expanded the core principles of Madrid Central while addressing the legal shortcomings (Hillen & Madrid City Council, 2025). The strategy combined the expansion of the LEZ across the entire municipal area by January 2025 with complementary investments in cleaner public transport, electric and hybrid buses, and cycling and pedestrian infrastructure, amounting to more than €350 million (EEA, 2025) (Eurocities, 2025).

Within the Madrid 360 Framework, in September 2021, the city introduced the [Sustainable Mobility Regulation](#), restricting the circulation of heavily polluting cars within the M-30 ring, which covers the entire territory of the municipality. From 1 July 2024, polluting vehicles that were not registered in Madrid before 1 January 2022, or do not appear in the list for the city's Motor Vehicle Tax (IVTM), will be restricted from driving anywhere in the city. However, implementation has been happening gradually, allowing citizens to adapt until 2025.



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