STUDY

For the PETI committee

European Parliament

# Air Quality and urban traffic in the EU: best practices and possible solutions



Policy Department for Citizens' Rights and Constitutional Affairs

Directorate General for Internal Policies of the Union

PE 604.988- September 2018


EN

# Air Quality and urban traffic in the EU: best practices and possible solutions

STUDY


**Abstract**

This study, commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the request of the PETI Committee, aims at gaining deeper insights into air quality problems of cities and regions, which are often caused by traffic. Five cities and regions are analysed in more detail. General best practice examples and policy options are provided for transport, but also for domestic heating, construction work and integrated approaches.

## ABOUT THE PUBLICATION

This research paper was requested by the European Parliament's Committee on Petitions and was commissioned, overseen and published by the Policy Department for Citizens' Rights and Constitutional Affairs.

Policy Departments provide independent expertise, both in-house and externally, to support European Parliament committees and other parliamentary bodies in shaping legislation and exercising democratic scrutiny over EU external and internal policies.

To contact the Policy Department for Citizens' Rights and Constitutional Affairs or to subscribe to its newsletter please write to: poldep-citizens@europarl.europa.eu

## RESPONSIBLE RESEARCH ADMINISTRATOR

Mr. Giorgio MUSSA
Policy Department for Citizens' Rights and Constitutional Affairs
European Parliament
B-1047 Brussels
E-mail: poldep-citizens@europarl.europa.eu

## AUTHOR(S)

Mr. Christian NAGL, Umweltbundesamt (Austria)
Ms. Iris BUXBAUM, Umweltbundesamt (Austria)
Mr. Siegmund BÖHMER, Umweltbundesamt (Austria)
Mr. Nikolaus IBESICH, Umweltbundesamt (Austria)
Mr. Hugo RIVERA MENDOZA, Umweltbundesamt (Austria)

## LINGUISTIC VERSION(S)

Original: EN

Manuscript completed in September 2018


This document is available on the internet at:
http://www.europarl.europa.eu/supporting-analyses

## DISCLAIMER

# CONTENTS

# LIST OF ABBREVIATIONS

| | |
|---|---|
| **AAQD** | Ambient Air Quality Directive |
| **AEI** | Average exposure indicator |
| **AOT40** | Accumulated Ozone Exposure over a threshold of 40 Parts Per Billion |
| **AQ** | Air Quality |
| **As** | Arsenic |
| **B[a]P** | Benzo[a]pyrene |
| **Cd** | Cadmium |
| **CDR** | Central Data Repository |
| **CEMS** | Continuous Emission Monitoring Systems |
| **CO** | Carbon Monoxide |
| **CLINSH** | CLean INland Shipping |
| **4DD** | 4th Daughter Directive |
| **DG** | Directorate-General |
| **EC** | European Commission |
| **ECA** | European Court of Auditors |
| **ECO** | Exposure Concentration Obligation |
| **EEA** | European Environment Agency |
| **EP** | European Parliament |
| **LEZ** | Low Emission Zone |
| **NECA** | Nitrogen Emission Control Areas |
| **NECD** | National Emission Ceilings Directive |
| **NERT** | National Exposure Reduction Target |
| **$NH_3$** | Ammonia |

| | |
|---|---|
| **Ni** | Nickel |
| **$NO_2$** | Nitrogen dioxide |
| **$NO_x$** | Nitrogen oxides, the sum of nitrogen monoxide and nitrogen dioxide expressed in units of mass concentration of nitrogen dioxide |
| **PAH** | Polycyclic aromatic hydrocarbons |
| **Pb** | Lead |
| **PM** | Particulate matter |
| **$PM_{10}$** | Particulate matter which passes through a size-selective inlet with a 50% efficiency cut-off at 10 µm aerodynamic diameter |
| **$PM_{2.5}$** | Particulate matter which passes through a size-selective inlet with a 50% efficiency cut-off at 2.5 µm aerodynamic diameter |
| **PPA** | Plan de Protection de l'Atmosphère |
| **$O_3$** | Ozone |
| **RB** | Rural Background |
| **RPMT** | Regional Programme for Mobility and Transport |
| **SB** | Suburban Background |
| **SECA** | Sulphur Emission Control Areas |
| **$SO_2$** | Sulphur dioxide |
| **SUMP** | Sustainable Urban Mobility Plan |
| **UB** | Urban Background |
| **ULEZ** | Ultra Low Emission Zone |
| **UT** | Urban Traffic |
| **VOC** | Volatile Organic Compounds |
| **WHO** | World Health Organization |
| **ZEV** | Zero-emissions vehicle |

# LIST OF TABLES

# EXECUTIVE SUMMARY

## Background

Air quality is a major concern of many European citizens, especially in cities with a lot of traffic. The main air pollutants in this context are $PM_{10}$ and nitrogen dioxide ($NO_2$). Vehicle traffic, especially by diesel vehicles, is the main source of elevated $NO_2$ levels in cities, which also contributes to $PM_{10}$. For $PM_{10}$, further polluters are relevant as well, mainly domestic heating, construction activities and industry.
To protect the health of citizens and the environment, European legislation sets thresholds for levels of different air pollutants in ambient air. The legislation includes provisions for assessment of these pollutants and for requirements in case these thresholds are exceeded.

## Aim

The Petitions Committee of the European Parliament receives numerous petitions pertaining to the issues of air quality problems caused by traffic. This study aims at gaining deeper insights into the problems faced by Member States, cities and regions when trying to improve air quality to comply with related legislation and to protect the health of their citizens.

The analysis covers five petitions sent to the Petitions Committee between 2011 and 2018. These petitions address the following cities and regions:

- Madrid (Spain),
- Antwerp and Brussels (Belgium),
- Lombardy (Italy),
- Marseille, Paris (France),
- Valencia (Spain).

## Current situation

The analysis of pollutant levels in these cities and regions shows that $NO_2$ levels are still above the limit value for the annual mean. However, $PM_{10}$ levels are however mostly in compliance, except for some cities in Lombardy. In general, pollutant levels are decreasing, but large cities and agglomerations will be in non-compliance for some years to co me. The European Commission has launched infringement procedures against a number of Member States, including Belgium and Spain, and has referred six Member States to the Court of Justice of the European Union, including France and Italy.

The petitions analysed within this study address vehicle traffic, especially (private) diesel vehicle traffic, as a major problem for urban air quality and human health.

All these cities and regions have implemented plans and strategies to improve air quality, which also include traffic related measures. Some measures in these plans might be furthered strengthened to account for stagnant trends for some air pollutants and high real-world emissions of diesel vehicles. The cities and regions addressed traffic also within specific transport strategies to improve the traffic system in the city and its surroundings.

The air quality and urban transport problems faced by these cities are not different from the ones encountered by many other cities and regions in Europe. Lombardy and Milan, in particular, face specific problems due to the adverse atmospheric dispersion conditions and the high density of population, traffic and industry in the Po valley. The cities analysed in this study all have implemented air quality plans and transport strategies that include efficient and substantive measures.

## Best practice examples

A large number of best practice examples are available in different databases and studies, which have partly already been implemented in the cities and regions covered in this study.
The main measures for traffic are:

- Low emission zones.
- Long term strategies to foster bicycle traffic in particular and "active modes" in general.
- Spatial planning – redistribution of public space.
- Parking management schemes.
- Promotion of public transport.
- Tax schemes to discourage diesel vehicles.
- Congestion charges.
- Measures to reduce emissions from ships.

$PM_{10}$ levels can be lowered by additionally implementing measures for domestic heating and construction sites. The former has already been successfully addressed by various schemes to reduce the use and impact of solid fuel burning, the latter by implementing guidance for low emission construction work and schemes to reduce construction site traffic.

Agriculture is a major source of secondary particles, which contribute to large scale PM levels and to springtime PM episodes. Implementation of "good agricultural practice" for manure management, optimized fertilizer use and enforcing of bans for open burning of agricultural waste can lower the impact of agriculture.

Integrated approaches and awareness raising campaigns are increasingly important tools for improving air quality in cities.

## Recommendations

As diesel vehicles are major sources of air pollutants in many cities and regions, policies to address the use of these vehicles, including trucks, should be further strengthened at the local and regional, but also at the national level. A reduction of regional background concentrations of PM will help cities to achieve their air quality goals. Thus air quality planning should include the whole region surrounding cities. Regular monitoring of the implementation progress and the effectiveness of measures is important to account for unforeseen changes.

# GENERAL INFORMATION

**KEY FINDINGS**

- Traffic related air pollution is a reason for a number of petitions sent to the Petitions Committee
- This study analyses five key petitions to identify main air quality problems
- Solutions are proposed based on practical examples

The Petitions Committee of the European Parliament receives numerous petitions pertaining to the issue of air quality and traffic related to air quality problems. The aim of this study is to gain deeper insights into the problems faced by Member States when trying to successfully implement European air quality legislation, and to point out ways to improve the situation. This holds true especially for compliance with limit values for $PM_{10}$ and $NO_2$, which are still exceeded in many Member States. As many of these exceedances are related to traffic emissions, this study also analyses petitions against traffic leading to air quality problems.

The study analyses and presents the following topics:

- Assessment of the legal situation for air quality and for traffic related measures to improve air quality in the European Union.
- Brief description of the current status of infringement procedures related to the EU Air Quality Directive.
- Assessment of five selected key petitions, which have been provided by the Petitions Committee of the European Parliament.
- Identification of the main problems leading to air quality problems and insufficient implementation of the air quality legislation.
- Identification of best practice examples showing how similar problems were solved in other Member States.
- Recommendations on how the implementation problems might be solved or improved.

The general objective of this study was to pinpoint common problems and possible solutions, which will be of general validity for the implementation of successful air quality measures and integrated approaches to improve the quality of life in cites.

# 1. CURRENT SITUATION

**KEY FINDINGS**

- The Ambient Air Quality Directive sets objectives for the main air pollutants to protect human health and the environment. The Directive also describes criteria for monitoring and proceedings in case of exceedances.
- Compliance with air quality limit values for $PM_{10}$ and $NO_2$ is not achieved in a number of Member States.
- The European Commission therefore launched infringement procedures against several Member States.
- Levels for $NO_2$ are still rather high in many cities, whereas the situation improved for $PM_{10}$ in some regions and cities.

## 1.1. Legal background

The following sections summarize a study for the European Parliament on the implementation of the Ambient Air Quality Directive (Nagl, Schneider & Thielen 2016).

The Ambient Air Quality Directive (AAQD)[1] lays down objectives for ambient air quality to protect human health and the environment. In general, the AAQD prescribes methods and criteria for the assessment and management of air quality. This includes limit values for specific air pollutants, as laid down in Annex XI of the AAQD (see Annex to this study). These limit values should have been complied with from 2005 onwards (for $SO_2$, CO, Pb and $PM_{10}$) or from 2010 onwards (for $NO_2$ and benzene). According to Article 22 of the AAQD, postponing the deadline (until 2015 for $NO_2$ and benzene, and until June 2011 for $PM_{10}$ at the latest) was possible under specific circumstances and if the Commission raised no objections.

Annex XIV of the AAQD introduced several provisions for $PM_{2.5}$. The limit value, which was a target value until 2015, requires compliance throughout the territory, i.e. both at hotspots and in urban background. The AAQD introduced also the so-called Exposure Concentration Obligation for $PM_{2.5}$ (ECO; 20 µg/m$^3$ for 2013 – 2015, see Table 4) and the National Exposure Reduction Target (NERT, percentage reduction for the average levels between 2018 and 2011, compared to the levels between 2018 and 2020). Compliance with the obligation and the target, respectively, is monitored at specific urban background sites.

The limit values and target values have to be complied with throughout the territory with some exceptions depending on the assessment regime, see section 1.1.1.

In 2015, several annexes to the AAQD were amended by the Commission Directive[2] (EU) 2015/1480 of 28 August 2015. This Directive lays down rules concerning reference methods for monitors, data validation and the location of sampling points for the assessment of ambient air quality.

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1449504722962&uri=CELEX:32008L0050
[2] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1449504754993&uri=CELEX:32015L1480

The 4th Daughter Directive (4DD)[3] under the Air Quality Framework Directive[4] lays downs target values for arsenic (As), cadmium (Cd), nickel (Ni) and benzo[a]pyrene (BaP) as a marker for polycyclic aromatic hydrocarbons (PAH). These target values should be complied from 2013 onwards in case the measures needed for achieving compliance do not entail disproportionate costs.

### 1.1.1. Methods and criteria used for ambient air quality assessment

To assess ambient air quality according to the AAQD, the Member States have to divide their territory into zones and agglomerations (Article 4 of the AAQD). The assessment of ambient air quality has to be carried out in all zones and agglomerations. In general, air quality is assessed at fixed monitoring sites, in some cases supported by modelling.

Annex III B of the AAQD requires that sampling points directed at the protection of human health shall be sited to enable the provision of data on:

- Areas where the highest concentrations occur (so called hotspots).
- Areas which are representative of the general population's exposure (urban background sites).

The number of stations per zone or agglomeration depends on the population, the pollutant and the pollutant levels (Annex V of the AAQD).

Apart from these general provisions, certain additional criteria and objectives have to be fulfilled and specific procedures have to be followed to ensure a high data quality and comparability:

- Data quality objectives (Annex I).
- Quality assurance procedures (Annex I).
- Macroscale and microscale criteria for the siting of monitoring sites (Annex III).
- Use of reference methods for air quality monitors (Annex VI).
- Demonstration of equivalence in cases where methods that are different from the reference method are used (Annex VI).

Even though the AAQD applies to the whole territory of a Member State (with the exception of workplaces to which members of the public do not have regular access (Article 2), the siting criteria for monitoring sites define the domains where air quality has to be assessed. Apart from workplaces, this excludes e.g. any location to which the public does not have access, or which is not used as fixed habitation, as well as roads and carriageways.

No general provisions are laid down in the AAQD regarding the relocation of monitoring sites, which is sometimes necessary e.g. due to construction work. For $PM_{10}$, Annex V states that "sampling points with exceedances of the limit value for $PM_{10}$ within the last three years shall be maintained, unless relocation is necessary owing to special circumstances, in particular spatial development." Nevertheless, the criteria summarized above still apply to the new location.

### 1.1.2. Air quality management, air quality plans in exceedance areas

In principle, Member States are obliged to ensure compliance with the relevant limit values and target values after a certain date (see section 1.1.1). Once compliance has been achieved, Member States are required to keep levels below the thresholds in all zones and agglomerations.

[3] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1454408421830&uri=CELEX:32004L0107

[4] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1450257400573&uri=CELEX:31996L0062

With regard to the target values, the long-term objectives for certain pollutants and the NERT for $PM_{2.5}$, all appropriate measures (as long as they do not entail disproportionate costs) have to be implemented to reach compliance at specific dates. In the case of limit values and the ECO, cost considerations cannot lead to disregarding measures that would enable the achievement of compliance.

When limit or target values are exceeded, Member States have to establish air quality plans for the zone or agglomeration in non-compliance within two years. The air quality plan has to include measures that aim to keep the exceedance period as short as possible (Article 23). Air quality plans have to include at least the information listed in Section A of Annex XV of the AAQD. Section B of Annex XV requires providing information on considered measures in the air quality plan, which includes the following traffic related measures:

- Reduction of emissions from vehicles through retrofitting with emission control equipment;
- Procurement of clean vehicles;
- Procurement of cleaner vehicle transport services;
- Measures to limit transport emissions through traffic planning and management (including congestion pricing, differentiated parking fees or other economic incentives, or establishing low emission zones);
- Measures to encourage a shift of transport towards less polluting modes.

Where exceedances occur due to natural sources (Article 20) or due to winter-sanding or winter–salting (Article 21) and compliance is reached after deducing these sources' contribution, Member States do not have to draw up air quality plans. The Commission has published guidelines[5] relating to these deductions (European Commission 2011a, 2011b).

### 1.2. Current status of infringement procedures

Currently, the AAQD air quality limit values for $PM_{10}$, $PM_{2.5}$ and $NO_2$ are not complied with in a considerable number of Member States (EEA 2017). Breaches of the limit values for $PM_{10}$ and $NO_2$ are still expected for many zones in the near future.

An important objective of European air quality policy is to achieve compliance with air quality limit values as soon as possible (see section 1.1.2 above). That is why in cases of nonconformity with current air quality legislation, infringement procedures have been launched by the European Commission against several Member States for failure to meet the $PM_{10}$, $NO_2$ and $SO_2$ limit values as stated in the AAQD (Nagl, Schneider & Thielen 2016).

As of May 2018, the European Commission[6] has referred six Member States[7] to the Court of Justice of the European Union for exceeding air quality limit values. In total, there are 16 infringement cases pending against Member States[8] regarding $PM_{10}$, and 13 regarding $NO_2$.

[5] http://ec.europa.eu/environment/air/quality/legislation/assessment.htm
[6] http://europa.eu/rapid/press-release_IP-18-3450_en.htm
[7] Germany, France, the United Kingdom regarding $NO_2$, Italy, Hungary and Romania regarding $PM_{10}$.
[8] $PM_{10}$: Belgium, Bulgaria, the Czech Republic, Germany, Greece, Spain, France, Hungary, Italy, Latvia, Portugal, Poland, Romania, Sweden, Slovakia, and Slovenia. $NO_2$: Austria, Belgium, the Czech Republic, Germany, Denmark, France, Spain, Hungary, Italy, Luxembourg, Poland, Portugal, and the United Kingdom.

Bulgaria[9] and Poland[10] have been found in breach of EU legislation by the Court of Justice of the European Union, in April 2017 and February 2018, respectively.

## 1.3. Current status and trends of air quality in the cities considered

The analysis of air quality data focuses on $NO_2$, $PM_{10}$, $PM_{2.5}$ and $O_3$., For some regions, B[a]P data was analysed as well. Official data on exceedances[11] of air quality objectives is available until the year 2016. Trends analysis covers the time period[12] between 2005 and 2017 (for Lombardy only 2016). Preliminary data on exceedances for 2017 was deduced from aggregated up-to-date data; however, this data might be subject to change[13]. Detailed figures of air quality trends for each city and pollutant can be found in Annex B. Statistical trends are shown in Annex C. The analysis covers those air quality zones that cover either the whole metropolitan region of cities[14] or the whole region[15].

### 1.3.1. Madrid

A large number of monitoring sites[16] are available for the metropolitan region[17] of Madrid. $NO_2$ levels of up to 62 µg/m$^3$ were measured in 2017. Exceedances occurred at 10 sites in 2016 and 18 sites in 2017. For many stations the levels are declining. However, some stations showed an increasing trend. $PM_{10}$ and $PM_{2.5}$ levels were well below the respective limit values in recent years. Furthermore, the number of exceedances of the daily mean limit value for $PM_{10}$ has been well below the allowed figure since 2012. Average $PM_{10}$ levels show decline at all sites. The target value for human health for $O_3$ was exceeded at most of the stations; levels do not show a clear trend.

### 1.3.2. Antwerp, Brussels

Data is available for around 8 $NO_2$ monitoring sites in both Antwerp and Brussels. Data on $PM_{10}$ is also available for 5 sites in Antwerp and 6 in Brussels. Exceedances occur for $NO_2$ in both cities at urban traffic sites. Levels are slightly above the limit value in Antwerp and close to 50 µg/m$^3$ in Brussels. Concentrations show a clear and statistical significant downward trend in both cities. In recent years, $PM_{10}$ limit values were complied with in both cities. $PM_{2.5}$ levels are also well below the limit value.

### 1.3.3. Lombardy

Data for more than 80 $NO_2$ monitoring sites and almost 70 $PM_{10}$ sites are available for Lombardy[18]. Exceedances of the $NO_2$ annual mean limit value occurred at several cities in Lombardy. Levels around 70 µg/m$^3$ have been observed in Milan. The criterion for the daily mean limit value for $PM_{10}$ was

[9] Case C-488/15, available at: http://curia.europa.eu/juris/document/document.jsf?text=&docid=189624&pageIndex=0&doclang=EN&mode=lst&dir=&occ=first&part=1&cid=1075080

[10] Case C-336/16, available at: http://curia.europa.eu/juris/document/document.jsf?text=&docid=199566&pageIndex=0&doclang=EN&mode=lst&dir=&occ=first&part=1&cid=1075481

[11] Data was taken from dataset G under the Commission Implementing Decision 2011/850/EU, which is available at the CDR: http://cdr.eionet.europa.eu/

[12] Official data is available only until 2016; data for 2017 is based on provisional data. The data was derived from the EEA website: http://eeadmz1-cws-wp-air.azurewebsites.net/products/data-viewers/statistical-viewer-expert/

[13] Quality assurance and final data validation might result in small changes; more important are exceedances due to natural sources (or winter sanding) that can be deduced from the assessment. Natural sources (Saharan dust) are especially important in Southern Europe. Therefore, the final number of exceedances of the daily $PM_{10}$ limit value might be lower for 2017 than indicated.

[14] Madrid, Antwerp, Brussels, Marseille, Paris, Valencia

[15] Lombardy

[16] 47 $NO_2$ sites, 28 for $PM_{10}$, 14 for $PM_{2.5}$, 37 for $O_3$

[17] Zones ES1301, ES1308, ES1309, ES1310, ES1311, ES1312, ES1313, ES1314

[18] Zones ZON.IT0306, ZON.IT0307, ZON.IT0308, ZON.IT0309, ZON.IT0310, ZON.IT0311, ZON.IT0312, ZON.IT0313, ZON.IT0314

exceeded at the majority of monitoring sites. Even some rural background sites showed exceedances. The limit value for $PM_{2.5}$ was also exceeded at several sites in 2016. The annual mean limit value for $PM_{10}$ was exceeded until the year 2015. Additionally, the target value for B[a]P was exceeded at some sites and the target value for $O_3$ at almost all sites. AEI data is available for the whole of Italy for 2015 and 2016 at the CDR[11]. In both years, the level was 17 µg/m$^3$, hence there should be compliance with the ECO for 2015. Both $NO_2$ and especially $PM_{10}$ concentrations are clearly declining in Lombardy.

### 1.3.4. Marseille, Paris

Data from around 35 $NO_2$ and 18 $PM_{10}$ monitoring sites is available for the agglomeration Paris[19]. Exceedances of the $NO_2$ annual mean limit value are observed at all suburban and urban traffic sites. The highest levels are around 80 µg/m$^3$. Also the criterion for the one-hour mean for $NO_2$ was exceeded at two sites in 2016. Preliminary data shows compliance with this criterion in 2017. The criterion for the daily mean limit value for $PM_{10}$ was exceeded at one urban traffic site close to a major motorway. The annual mean limit values for both $PM_{10}$ and $PM_{2.5}$ are complied with. $NO_2$ and $PM_{10}$ level show a clear decline at all sites.

For Marseille, $NO_2$ data is available for four sites, $PM_{10}$ data for two sites in 2016 and one in 2017. The limit value for the annual mean of $NO_2$ was exceeded at two urban traffic sites. Compliance with the daily mean limit value criterion for $PM_{10}$ has been achieved since 2013. $PM_{2.5}$ data is also in compliance with the limit value for the annual mean. $NO_2$ levels show a clear decline, whereas $PM_{10}$ levels are rather variable and don't show a clear trend.

### 1.3.5. Valencia

Data from 9 $NO_2$ and 3 $PM_{10}$ monitoring sites is available for Valencia. Exceedances of the limit value for $NO_2$ were observed until 2016. Preliminary data shows compliance for 2017. The criterion for the daily mean of $PM_{10}$ was complied with until 2016. Preliminary data shows an exceedance at one urban traffic site. The data shows compliance with the limit value for $PM_{2.5}$ and the criterion for the hourly limit value of $NO_2$. $NO_2$ levels show a clear decline. For $PM_{10}$ there is not enough data available for a trend analysis. The data indicates a stagnant trend in recent years.

[19] Zone FR04A01

# 2. PETITIONS CONSIDERED

**KEY FINDINGS**

- Petitions from Antwerp[20], Marseille, Paris, Lombardy, Madrid and Valencia were considered and analysed.
- The petitioners mainly regard traffic as a major problem for urban air quality and human health and consider that it is not being adequately addressed by the responsible authorities.
- The pollutants of concern are mainly $PM_{10}$ and $NO_2$.
- Similar problems occur in a number of cities and regions throughout Europe.

The Petitions Committee of the European Parliament provided five key petitions submitted by citizens from four Member States (Table 1).

**Table 1: Petitions considered in this study.**

| Petition reference number | Title of the petition | Member State | City / region |
|---|---|---|---|
| 0323/2011 | Alleged infringement of Directive 2008/50/EC by the Community of Madrid and Madrid City Council, Spain | Spain | Madrid |
| 1279/2011 | Air pollution in Antwerp | Belgium | Antwerp |
| 1253/2013 | 8 years (and more) of bad air without sanction | Italy | - |
| 1353/2013 | | Italy | Lombardy |
| 2467/2014 | Air quality in France | France | Marseille, Paris |
| 0048/2018 | Levels of air pollution in the city of Valencia | Spain | Valencia |

**Source:** Petitions Committee of the European Parliament

[20] And additionally an analysis of Brussels.

## 2.1. The petitions in detail

The following table provides an overview on the cities and regions considered in this study.

**Table 2: Characteristics of the cities and regions considered.**

| City / region | Member State | Population (functional urban area) | Comment |
|---|---|---|---|
| Antwerp | Belgium | 1,100,139 | 2nd largest port in Europe |
| Brussels | | 2,625,525 | |
| Lombardy | Italy | 10,019,166 | |
| Milan | | 5,111,481 | |
| Marseille | France | 1,750,885 | |
| Paris | | 11,926,122 | 2nd largest city in Europe |
| Madrid | Spain | 6,675,302 | 3rd largest city in Europe |
| Valencia | | 1,723,352 | 5th largest container port in Europe |

**Source:** Eurostat[21], Eurostat 2017, istat.it,

### 2.1.1. Case 1: petition 0323/2011 on the alleged infringement of Directive 2008/50/EC by Madrid

#### Summary of petition

Three main claims are brought forward by the petitioner:

- Limit and target values in ambient air of several pollutants ($PM_{10}$, $PM_{2.5}$, $NO_2$, $O_3$) are exceeded in Madrid;
- Monitoring sites, which previously showed high pollutant levels, were relocated;
- The road plan for 2007-2011 will increase the number and roads and thereby also pollutant levels.

The petition was declared admissible in June 2011 and information was requested from the European Commission (EC). The EC replied to the request by the European Parliament (EP) in October 2011 and sent further replies with updated information on exceedances and the status of the infringement procedure (see also section 1.2) in March 2013, December 2014, December 2015, January 2017, July 2017, January 2018 and June 2018. In its latest reply, the EC mentioned a meeting with Member States in January 2018, at which Spain presented additional measures. The EC concluded that these measures appear to be adequate to tackle the exceedances if they are fully implemented. The EC will regularly review and assess the situation in Spain.

[21] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_lpop1&lang=en

### Facts

As described in section 1.3.1 the daily mean limit value for $PM_{10}$ was exceeded in 2011 for the last time. $PM_{2.5}$ levels haven't shown any limit value exceedance so far and its levels have been well below the limit in recent years. However, $NO_2$ levels were still well above limit values at several urban traffic monitoring sites in 2017, and annual average levels have even shown an increase in recent years. Additionally, $O_3$ levels were above the target value in all but three years in the period between 2005 and 2017.

The monitoring network was changed in 2010 to account for the siting criteria laid down in the AAQD, which had to be implemented by 2010. The new siting criteria demand a certain representativity of the monitoring site in question, a certain distance to major junctions and a maximum distance from the kerbside. However, the underlying reports are not publicly available.

The road plan[22] for 2007 – 2011 foresaw the duplication of 17 road sections and 7 new road sections. Annual traffic reports are available for both the community of Madrid[23] and the city of Madrid.[24] The latest data reported are from 2017 and 2014, respectively (Comunidad de Madrid 2018, Madrid 2015). The data for Comunidad de Madrid shows mixed results. Total traffic has decreased for the period between 2007 and 2017, but this development benefits from a sharp decrease before 2013. There has been an increase in traffic since around 2013, even though the current values are still lower than those observed in 2007. The data for the city of Madrid also shows mixed results. Vehicle traffic declined in the city, whereas it increased in its outer regions.

### Latest status available

Latest official air quality data is available for 2017 (Madrid 2018). The highest $NO_2$ level observed in that year was 62 $\mu g/m^3$. Up to 59 days above the $O_3$ target value were also recorded in 2017.

The EC sent an additional Reasoned Opinion in November 2014 due to breaches of $PM_{10}$ limit values in five AQ zones and a Reasoned Opinion referring to $NO_2$ in February 2017 in three zones (one in Madrid and two in Barcelona). However, the EC did not refer Spain to court in May 2018, as it was the case for other Member States[7].

### Evaluation

The main AQ problem regarding limit values exceedances is the high and increasing levels of $NO_2$. The city of Madrid addressed this problem in an AQ plan 2011-2015 (Madrid 2012) and more recently in the "Plan A: Plan de Calidad de aire y Cambio Climático" (Madrid 2017). According to the Plan A, the major source for $NO_2$ is (local) road traffic. The Plan A includes 30 measures, which should result in a reduction of $NO_2$ levels in central Madrid by 25% (by 30% in central Madrid) in 2020 compared to 2012. However, due to the recent increase in $NO_2$ levels, it seems doubtful that compliance with the $NO_2$ limit value can be achieved by 2020. No explanation for this increase is provided in the analysis of the AQ data for 2017 (Madrid 2018).

---

[22] http://estaticos.elmundo.es/documentos/2007/11/15/carretera_madrid.pdf, http://www.espormadrid.es/2007/11/plan-de-carreteras-de-la-comunidad-de.html

[23] http://www.madrid.org/cs/Satellite?c=CM_Publicaciones_FA&cid=1354709793265&idConsejeria=1109266187248&idListConsj=1109266100973&idOrganismo=1109266227998&idPagina=1343068184421&language=es&pagename=ComunidadMadrid%2FEstructura&pid=1109265444699&site=ComunidadMadrid&sm=1343068184432

[24] http://www.madrid.es/portales/munimadrid/es/Inicio/Movilidad-y-transportes/Publicaciones/Informe-del-Estado-de-la-Movilidad-de-la-Ciudad-de-Madrid/?vgnextfmt=default&vgnextoid=c1098ff229cf3310VgnVCM2000000c205a0aRCRD&vgnextchannel=9bcf8fb9458fe410VgnVCM1000000b205a0aRCRD

$O_3$ levels are dependent on sources of precursors on a rather large spatial scale. Hence, a reduction of $O_3$ levels has to be addressed at the national and European scale via the NECD.

There is not much information available regarding the relocation of monitoring sites. From the coordinates of the locations abandoned in 2010 it can be concluded that some of these sites did not fully comply with the criteria laid down in the AAQD. Based on the information provided, the EC considers that no breach of requirements can be identified.

In general, vehicle traffic can be influenced by a number of different factors. However, it is difficult to entangle the impact of each individual factor (see e.g. McIntosh et al. 2014). One important factor can be the economic development of a certain city or region. This seems to be the main cause for the decline in Madrid's vehicle traffic between 2007 and 2013, despite the construction of several new roads, which, in general, should lead to an increase in emissions compared to the base case.

### 2.1.2. Case 2: petition 1279/2011 on air pollution in Antwerp and information on air pollution in Brussels

#### Summary of petition

The petitioner claims that due to traffic air quality levels for particulate matter have constantly deteriorated, having an adverse effect on human health. Therefore, the petitioner asks for a ban on further expansion of the road network, as was laid down in the Masterplan Antwerpen.

The EC replied to the request by the EP in June 2012 and sent further replies with updated information on exceedances and the status of the infringement procedure (see also section 1.2) in August 2015, December 2015, June 2016, March 2017 and December 2017.

#### Facts

$PM_{10}$ limit values for the daily mean were exceeded in Antwerp until 2014 and until 2013 in Brussels. No exceedances occurred for the annual mean limit values for both, $PM_{10}$ and $PM_{2.5}$ between 2005 and 2017. $PM_{10}$ levels show a decline since 2005, $PM_{2.5}$ since 2009. $NO_2$ levels are slightly above the limit value for the annual mean at one station in Antwerp[25], and well above the limit value in Brussels. Levels are declining in general in both cities.

The Masterplan[26] Antwerp 2020 includes several major roads and public transport projects (Antwerpen 2010). In 2020, half of individual journeys should be undertaken by public transport, bicycle or on foot, which is also the goal of the Toekomstverbond[27] agreement. However, the Masterplan does not describe any monitoring of traffic indicators. Traffic statistics for Flanders show a clear increase in traffic on motorways since 2012 (Vlaams Verkeerscentrum 2018).

For Brussels, an air, climate and energy plan was published in June 2016 (Bruxelles Environnement 2016a), after an environmental impact assessment was done for that plan in 2015 (Bruxelles Environnement 2015). In April 2016, an environmental declaration was published that summarizes how comments contained in the environmental impact assessment were taken into account (Bruxelles Environnement 2016b). A regional sustainable development plan was published in 2017 (perspective Brussels 2017).

---

[25] The citizen science project curieuze neuzen and modelling results indicate higher levels along some roads and in street canyons.

[26] https://www.oosterweelverbinding.be/algemeen/masterplan-2020

[27] http://toekomstverbond.be/category/een-modal-shift-5050/. The Toekomstverbond is an agreement between the Government of Flanders, the City of Antwerp, Antwerp Port Authority and the citizens' movements.

The air, climate and energy plan includes 64 measures and 144 actions, of which 11 measures address directly transport, and 7 measures address improvements of air quality monitoring. Also, the plan requires an annual implementation monitoring of the measures and an evaluation after 4 years. This is laid down in the ordinance "COBRACE"[28] (Ordonnance portant le Code bruxellois de l'Air, du Climat et de la Maîtrise de l'Energie). However, ClientEarth and citizens of Brussels launched a legal case against the Brussels government as they regard the plan as insufficient[29]. The judge stated that the plan fails to meet the requirements for air quality plans and sought clarification from the Court of Justice of the European Union.

The European Court of Auditors (ECA) noted in a special report that $NO_2$ concentrations changed little in Brussels in recent years (ECA 2018). Furthermore, the ECA noted that Brussels only operates two air quality monitoring stations classified as traffic sites. One station exhibiting very high levels was closed in 2009 due to construction works, but not re-established when the works were finished.

A LEZ[30] was introduced in the beginning of 2018. The traffic statistics show a decline in both vehicle kilometres and passenger kilometres travelled in the Brussels region in recent years[31]. Also for commuting, the share of vehicles declined, whereas that of public transport, trains and bicycles increased[32].

### Latest status available

No exceedances of $PM_{10}$ or $PM_{2.5}$ were recorded in 2017 in Antwerp or Brussels. The "Toekomstverbond"[33] agreement was signed in March 2017. This alliance aims at improving the situation for all traffic modes, and especially to reduce transit traffic in Antwerp, by completing ring roads around the city. It is claimed that air quality should be improved as well.

There is a pending infringement procedure against Belgium for both $PM_{10}$ and $NO_2$ due to exceedances in Brussels, the Ghent port zone and the Roeselare port zone ($PM_{10}$)[34].

### Evaluation

The Eurostat indicator[35] for urban traffic shows a high share of private cars used for journeys to work in Antwerp, and a low share for public transport. In Brussels, the use of private cars is a bit lower, and the use of public transport is much higher compared to Antwerp.

In principle, city bypasses are an important instrument to reduce transit traffic within a metropolitan area, especially for heavy duty vehicles. However, improvements of road infrastructure also increase the attractiveness of private cars (see e.g. McIntosh 2014). Hence, it is important to accompany these improvements with a range of measures and close monitoring to achieve the foreseen traffic reduction within the city and especially in its surroundings.

---

[28] http://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=fr&la=F&table_name=loi&cn=2013050209

[29] http://www.schoneluchtbxl.be/brussels-air-pollution-case-goes-to-eu-court-as-judge-warns-the-air-quality-plans-of-the-brussels-government-is-inadequate/

[30] https://www.lez.brussels/en

[31] http://statistics.brussels/files/figures/13.1_mobility_and_transport_vehicles_network.xls

[32] http://statistics.brussels/files/figures/13.6_mobility_transport_mobility_practices.xls

[33] http://toekomstverbond.be/

[34] http://europa.eu/rapid/press-release_IP-15-5197_EN.htm, case no. 20082184 ($PM_{10}$), 20162005 ($NO_2$). No information available regarding $NO_2$, but in 2016 exceedances were reported for Brussels and Antwerp (annual mean, as well as Gent (hourly mean).

[35] Indicator "urb_ctran", data available at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=urb_ctran&lang=en

### 2.1.3. Case 3: petition 1253/2013 and 1353/2013 on air quality directive and air pollution in Lombardy

#### Summary of petition

The petitioner claims that mandatory air quality limit values are not met. In addition, the petitioner claims that little or no effective action has been taken to comply with limit and target values for $PM_{2.5}$, $PM_{10}$, $O_3$, $NO_2$, B[a]P and $NO_x$. Also, he claims that not all necessary measures have been taken to reduce $PM_{2.5}$ exposure according to Article 15 of the AAQD, and that there is no adequate air quality plan. Furthermore, he claims that, despite the fact that 50% of air pollutants originate from traffic, considerable more public funding is devoted to the construction of highways and motorways as opposed to public transport.

The petitions were declared admissible in April 2014 and information was requested from the European Commission (EC). The EC replied in November 2014, April 2015, January 2017 and June 2018. Overall, the EC concluded that it is primarily the Member States' responsibility to ensure correct implementation of EU legislation, and to address situations of non-compliance. The EC also laid down the differences between measures needed to comply with limit values and target values. In a reply from June 2018, the EC noted that Italy would be taken to the Court of Justice of the European Union for breach of $PM_{10}$ limit values.

#### Facts

Lombardy is one of the European regions showing the highest level of air pollution (EEA 2017). The main causing factors for this situation are described e.g. in a study on the implementation of the AAQD (Nagl, Schneider & Thielen 2016). Limit values for $PM_{10}$, $PM_{2.5}$ and $NO_2$ were exceeded at several locations and values for $NO_x$ at one location between 2005 and 2016 (no data is available for Italy for 2017). The exposure related ECO for $PM_{2.5}$, which is only available for the whole of Italy, was complied with in 2015. Target values were exceeded for B[a]P and $O_3$.

An AQ plan (PRIA, Piano Regionale degli Interventi per la qualità dell'aria)[36] for Lombardy was approved in September 2013 and updated in 2018 (Regione Lombardia 2018). The plan includes measures for transport, energy and agriculture.

The annual monitoring report assesses the implementation and the impact of the plan's measures (Regione Lombardia 2015, 2016a, 2017). The reports state that the PRIA is aligned with other strategies and regional programmes for energy, traffic (RPMT, Regional Programme for Mobility and Transport)[37] and rural development. The RPMT was approved in 2016; one of the four general objectives is to promote the environmental sustainability of the transport system (Regione Lombardia 2016b). According to the RPMT, 38% of investment is required for rail transport, 16% for local public road transport and 45% for road transport. The RPMT also includes a monitoring system using strategic and specific indicators.

[36] http://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioServizio/servizi-e-informazioni/Cittadini/ Tutela-ambientale/Qualita-della-aria/piano-regionale-degli-interventi-per-la-qualita-dell-aria/piano-regionale-degli-interventi-per-la-qualita-dell-aria

[37] http://www.regione.lombardia.it/wps/wcm/connect/81770bab-d560-420f-b073-e83d84b7bc34/PRMT+ inglese .pdf ?MOD=AJPERES&CACHEID=81770bab-d560-420f-b073-e83d84b7bc34

According to the Sustainable Urban Transport Plan for Milan (PUMS[38], Piano Urbano Mobilità Sostenibile[39]) and the RPMT there was a considerable improvement in the modal split in recent years[40] (Comune di Milano 2016).

### Latest status available

Most recent data on exceedances of air quality standards is available for 2016. The data shows breaches for $PM_{10}$, $PM_{2.5}$, $NO_2$, $NO_x$, $O_3$ and B[a]P.
In May 2018 Italy was referred to the Court of Justice of the European Union[6] by the EC due to exceedances of $PM_{10}$ limit values in several regions, including Lombardy, and also due to disregarding of vehicle type approval legislation.

### Evaluation

The Po valley in general as well as Lombardy and the agglomeration Milan in particular experience rather high levels of $PM_{10}$, $PM_{2.5}$, $O_3$, $NO_x$ and $NO_2$, and B[a]P, even though levels declined in recent years. On the one hand, these high levels are mainly caused by emissions from traffic (diesel vehicles), followed by domestic heating (biomass burning) and industry. On the other hand, adverse dispersion conditions in the Po valley, such as rather low wind speeds especially during winter time, aggravate the situation (Nagl, Schneider & Thielen 2016). With respect to cars, Italy shows the second largest number of vehicles per capita of all EU Member States[41] and a high share of diesel vehicles[42]. The city of Milan has also a relatively high number of cars per capita[43].

Nevertheless, a considerable improvement in the modal split towards sustainable modes is foreseen with the help of the PUMS until 2024, both in Milan itself and for the city and its outskirts together. Monitoring of the PRMT is being implemented using strategic and specific indicators.

### 2.1.4. Case 4: petition 2467/2014 on air quality in France (Marseille, Paris)

### Summary of petition

The petitioner claims that levels of particles (especially of nanoparticles) pose a threat to human health in France, particularly in Paris and Marseille. The levels are said to be constantly high and deteriorating. No threshold has yet been set for nanoparticles so far. The measures set until now have not been sufficient to sufficiently improve air quality.

The petition was declared admissible in July 2015. The EC replied in March 2016 and January 2018. France was referred to the Court of Justice of the European Union in May 2018 due to exceedances of the $NO_2$ limit values.

### Facts

The conurbation Paris is the second largest in Europe. Hence, air quality is affected by a large number of pollutant sources. $PM_{10}$ limit values have been exceeded in the agglomeration Paris, including both the daily mean limit value and the annual mean limit value. However, levels are declining and the exceedances are now restricted to one monitoring site close to a motorway. The $PM_{2.5}$ has been

[38] https://www.amat-mi.it/it/mobilita/pums/
[39] https://www.comune.milano.it/wps/portal/ist/it/servizi/mobilita/Pianificazione_mobilita/piano_urbano_mobilita
[40] PUMS: between 2002 and 2013; RPMT: between 2002 and 2014
[41] 54 % of newly registered passenger cars in 2013, http://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU
[42] 54 % of newly registered passenger cars in 2013, http://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU
[43] http://ec.europa.eu/eurostat/cache/RCI/#?vis=city.statistics&lang=en

complied with since 2014. The obligation for the AEI was also well below 20 µg/m³ in France in 2016. $NO_2$ levels are still well above the limit value at all urban traffic sites, even though concentrations have been showing a constant decline since 2005. Concentrations of nanoparticles (or ultrafine particles) are not available at the EEA website.

The first air quality plan for the conurbation Paris (Ile-de-France, Plan de Protection de l'Atmosphère, PPA) was published in 2006, a second plan in 2013 and the most recent one in January 2018 (Ile-de-France 2006, Ile-de-France 2013, DRIEE 2018). A dedicated website[44] provides information on the PPA. The city of Paris published a climate plan in May 2018 setting an objective of zero diesel vehicles from 2024 onwards and zero fossil fuel driven vehicles by 2030 (Mairie de Paris 2018). These goals are to be reached with the help of (financial) incentives and by providing alternatives.

In Marseille, the $PM_{10}$ annual mean limit value has been complied with since 2012, the limit value for the daily mean since 2014. The limit value for the annual mean of $NO_2$ has been exceeded at two sites. Dedicated websites[45] inform on air quality in Marseille and the region. A first air quality plan for the region Bouches-du-Rhône was published in 2006 (not available), a revised plan was approved in 2013, a progress report was published in 2017 (Préfet des Bouches-du-Rhône 2013, 2017).

### Latest status available

Most recent data on exceedances of air quality limit values is available for 2017. The $PM_{10}$ annual mean limit value was slightly exceeded in the conurbation Paris at one station, up to 58 exceedances of the daily mean limit value were observed at this station. The annual mean for $NO_2$ was up to twice the limit value.

The limit value for the hourly mean was complied with in 2017. In Marseille, compliance was achieved for $PM_{10}$ in 2017. However, the $NO_2$ annual mean levels were almost twice above the limit value.

### Evaluation

According to the PPA, the main sources for $PM_{10}$ in Ile-de-France are traffic, residential heating, construction work and agriculture, contributing 28%, 26%, 18% and 18% to $PM_{10}$ levels, respectively (DRIEE 2018). $PM_{10}$ and especially $NO_2$ levels are still well above the limit values, even though concentrations have declined in recent years. $NO_x$ emissions are dominated by traffic, especially from diesel vehicles, as 2/3 of passenger cars kilometres driven concern diesel vehicles. The PPA includes various measures to address the main sectors involved. With the help of the PPA, a clear reduction of pollution levels and exposed population was modelled for 2020, even though exceedances of both the annual limit value for $NO_2$ and the daily limit value for $PM_{10}$ will occur at major roads. Compliance with these limit values is expected for 2025 in the scenario, including the PPA and an extension of the low emission zone[46]. The PPA should result in a slight reduction of vehicle kilometres driven by diesel passenger cars.

The PPA for Marseille has inter alia objectives for $PM_{10}$ and $NO_x$ emission reductions for 2020. The evaluation conducted in 2017 showed that $PM_{10}$ emissions have been stagnating in recent years and are still well above the objective (Préfet des Bouches-du-Rhône 2017). In contrast to $PM_{10}$, the objective

[44] https://www.maqualitedelair-idf.fr/
[45] http://www.air-marseille.eu/, https://www.airpaca.org/
[46] https://www.crit-air.fr/en/

for $NO_x$ emissions was almost reached in 2015, which is contradictory to the city's high $NO_2$ concentrations.

### 2.1.5. Case 5: petition 0048/2018 on air pollution in the city of Valencia

#### Summary of petition

The petitioner claims the occurrence of $PM_{10}$ pollution episodes in Valencia requiring adequate measures to address the problem. The petitioner also notes that despite the pollution issues, traffic volume in one of the city's central streets has recently increased considerably due to changes in traffic directions. He also considers that a large share of traffic in this particular street would be caused by public transport buses.

The petition was declared admissible in April 2018. The EC replied on 30 July 2018. The EC clarified that the regulation of traffic flows is the sole responsibility of the Member State. The EC also concluded that $PM_{10}$ and $NO_2$ levels are below the limit values. Nevertheless, the EC has taken action regarding the Noise Directive due to missing strategic noise maps and action plans.

#### Facts

No criteria exceedance for the daily mean limit value for $PM_{10}$ has occurred in recent years. The limit value for the annual $NO_2$mean showed a slight exceedance in 2016, but compliance in 2017. $NO_2$ levels are more or less stagnant since 2011, both at urban traffic and urban background stations. Also $PM_{10}$ levels haven't shown a clear trend in recent years.

In addition to the automatic monitoring network, passive sampling campaigns[47] were performed between 2015 and 2017 to analyse the spatial distribution of $NO_2$ levels. At some of the sampling points, concentrations were higher compared to the continuous monitoring sites. An evaluation of the air quality monitoring network for the region Valencia was done in 2017, but it focused mainly on the number of sites according to different types of stations (CEAM 2017).

An air quality plan for the metropolitan region Valencia was published in 2013 (Valencia 2013). The majority of measures address traffic, both on-road and off-road. The plan also addressed the monitoring sites' location and the creation of a low emission zone. In addition, the plan refers to further strategies, plans and measures by the city of Valencia, which also have a focus on reducing the impact caused by transport.
A more general environmental action plan was published in 2011, which also includes several measures to improve air quality (Valencia 2011).

#### Latest status available

An exceedance of the $NO_2$ annual mean limit value was observed in 2016 at one urban traffic station. The most recent air quality plan was published in 2013.

#### Evaluation

The air quality plan for Valencia includes a number of traffic and other measures. However, no information is available on how the implementation will be monitored. Additionally, the air quality plan includes rather general objectives, but no detailed objectives for the measures' impact on emissions and/or pollutant levels. Furthermore, $NO_2$ and $PM_{10}$ levels seem to have stagnated in recent years.

[47] http://www.agroambient.gva.es/es/web/calidad-ambiental/campanas-de-dosimetria

## 2.2. Summary of main problems identified

The petitions analysed within this study address vehicle traffic, especially by (private) diesel vehicles, as a major problem for urban air quality and human health. The pollutants of concern are mainly $PM_{10}$ and $NO_2$, partly also $O_3$ and B[a]p. In one case, public transport buses were also seen as a substantial source of emissions.

## 2.3. Comparison with other cities

The air quality and urban transport problems raised within the petitions are not different from the problems faced by many other cities and regions in Europe. The only exception is Lombardy, and Milan in particular, due to specific circumstances in the Po valley (EEA 2017, Nagl et al. 2016). The cities analysed in this study all have implemented air quality plans and transport strategies that include efficient and substantive measures, even though some measures might be further strengthened to account for stagnant trends of some air pollutants and emissions of diesel passenger cars and light duty vehicles, which are still too high.

# 3. BEST PRACTICE EXAMPLES

**KEY FINDINGS**

- A wealth of information on successful examples for air quality measures in general, and traffic measures in particular is available in Europe.
- To address traffic, low emission zones and parking management schemes were implemented and bicycle, public and pedestrian traffic were improved in many cities.
- Solid fuel burning for domestic heating was banned in some cities, while awareness raising campaigns or district heating were also implemented.
- Best practice for agriculture to reduce ammonia emissions contributed to lower regional background particle levels.
- Best practice guidance to reduce dust emissions from construction work have been developed and successful examples for the implementing measures are available.
- Examples are also available for successful integrated approaches to simultaneously address several environmental issues and improve quality of life in cities.
- Awareness raising is important for public acceptance of (air quality) measures.

A large number of successful examples and initiatives that lead to improved urban air quality in general and transport systems in particular are available and documented (e.g. European Platform on Sustainable Urban Mobility Plans[48], Querol & Amato 2017, catalogue of measures[49], soot free cities initiative[50], MARLIS database[51], Clean Air Outlook reports[52], EC Urban Agenda[53], LIFE projects[54], Nagl et al. 2016). Some of the best practice examples listed below have been successfully implemented in different regions in Europe. However, it is beyond the scope of this study to assess if individual measures have already been implemented in a certain city or region, or if a specific measure will indeed be a suitable solution for the specific circumstances of an individual city or region. Furthermore, air quality related measures often show a close relationship with plans and strategies tackling further issues, such as climate change, traffic, energy, noise and quality of life. Therefore, the examples provided should be considered in the broader context of related plans and strategies for each individual city or region.

## 3.1. Traffic

Many sustainable transport strategies to reduce climate change risks have large, immediate health benefits for the majority of the world's population, and large equity benefits for vulnerable groups. Well-designed transport policies and infrastructure investment priorities can lead to far-reaching reductions in traffic-related health risks from air and noise pollution and injuries.

[48] http://www.eltis.org/mobility-plans
[49] http://fairmode.jrc.ec.europa.eu/measure-catalogue/
[50] http://www.sootfreecities.eu/sootfreecities.eu/public/best-practice
[51] https://www.bast.de/BASt_2017/DE/Verkehrstechnik/Fachthemen/v3-MARLIS/MARLIS-DB/MARLIS_node.html
[52] http://ec.europa.eu/environment/air/pdf/clean_air_outlook_agriculture_report.pdf, http://ec.europa.eu/environment/air/pdf/clean_air_outlook_combustion_sources_report.pdf
[53] https://ec.europa.eu/futurium/en/urban-agenda
[54] http://ec.europa.eu/environment/life/bestprojects/index.htm

Sustainable development strategies for the transport sector with significant health co-benefits include[55]:

- Public transport;
- Walking and cycling;
- Land use and built environment;
- Vehicle technologies;
- Fuel technologies

The following traffic related measures are regarded as main best practice examples of sustainable development strategies. They are described in more detail below:

- Low emission zones, i.e. zones within a city or region where vehicles have to comply with certain emission standards or are obliged to pay a fee.[56]
- Long term strategies to foster bicycle traffic in particular and "active modes" in general (as in Copenhagen, the Netherlands).
- Spatial planning – redistribution of public space.
- Parking management.
- Promotion of public transport.
- Tax schemes to discourage diesel vehicles. E.g. in the Netherlands, the share of diesel passenger cars is the lowest within the EU, despite having the largest gasoline to diesel price differentials (Querol & Amato 2017). However, taxes for diesel cars are higher, as Dutch tax policy aims at penalising diesel vehicles.
- Congestion charges.
- Emission reduction from shipping.
- Integrated urban freight transport.

The EC DG MOVE developed six nonbinding guidance documents on different aspects of urban access regulations related to traffic (EC DG MOVE 2017)[57]:

- Information and communication.
- Enforcement (including cross-border), vehicle types, their identification and exemptions.
- Planning, consultation and design (including definitions and typologies).
- National legal frameworks.
- Evaluation and assessment.
- Technology options and interoperability.

[55] Source: http://www.who.int/sustainable-development/transport/strategies/en/
[56] An overview is provided at a dedicated website: http://www.urbanaccessregulations.eu/
[57] See https://ec.europa.eu/transport/themes/urban/studies_en for detailed technical reports

### 3.1.1. Low emission zones

There is a large number of low emission zones (LEZ) in a number of European countries[58]. In Germany alone, low emission zones have been implemented in almost 60 cities[59]. These zones were implemented in cities of rather different size, ranging from cities with several thousand inhabitants up to large agglomerations such as Paris[60] or London[61]. The zones either affect both passenger cars and trucks, or trucks only. In most cases, it is forbidden for vehicles that do not comply with the specified emission standard to enter the LEZ. In London trucks have to pay a certain daily charge. Compliance is also checked by different instruments, such as stickers or license plate recognition. In general, exemptions are in place for specific vehicles, such as ambulances or police cars. The main effect of a LEZ is to accelerate the renewal of the vehicle fleet. While cleaner vehicle technologies are an important element of air pollution and climate mitigation strategies, reducing reliance on private vehicles and motorized transport is as important, as it can yield additional benefits to health, such as physical activity (WHO 2011).

Due to the large differences in size and characteristics of LEZ, the impact on air quality can also vary to a great extent.

An analysis of German Umweltbundesamt for three German cities showed a reduction of $PM_{10}$ concentrations of 5-10% or sometimes even of above 10% in sites close to traffic (Umweltbundesamt Dessau 2017). For human health, the strong decline of 50% in observed elemental carbon (EC) concentrations is of great importance. Overall, the effect is obviously dependent on the size of the zone, the number and types of vehicles affected, the number of exemptions and compliance checking.
Of the cities described in this study, all but Valencia and Marseille have currently implemented at least one LEZ scheme.

### 3.1.2. Strategies to foster bicycle traffic and "active" modes

According to the WHO, the lack of physical activity is linked to over 3 million deaths per year globally (WHO 2011). Inclusion and improvement in the quality of pedestrian and bicycle paths encourages people to walk and cycle, thereby promoting a healthy lifestyle. Other interventions targeting the built environment have been successfully enhancing the appeal of physically active forms of transport. Examples include:

- Improvements in urban aesthetic features and attractiveness.
- Decreased travel time between neighbourhoods.
- Access to green and recreational spaces.
- Good lighting.
- Road safety.

Safe infrastructure for walking and cycling is also a pathway for achieving greater health equity. Walking and cycling can provide a form of transport while reducing the risk of heart disease, stroke, certain cancers, diabetes, and even death. Accordingly, improved active transport is not only healthy; it is also equitable and cost-effective.

[58] http://urbanaccessregulations.eu/
[59] http://gis.uba.de/website/umweltzonen/index.html
[60] https://www.crit-air.fr/en/
[61] https://tfl.gov.uk/modes/driving/lez-lez-vehicle-checker-35896

Copenhagen is often regarded as a world leader in bicycle friendly policies due to it's large share of trips made via bicycles (Escayol 2015, City of Copenhagen 2017). Its high share of more than 40% of modal split is a result of a long-term strategy, dating back to the period between the 1910s and the 1940s and then again after the 1970 and especially after 1990 (Carstensen et al. 2015; City of Copenhagen 2012). Essential success factors are a safe infrastructure for cycling, separated cycle tracks, secure and numerous parking facilities, interconnections with all modes of transport, especially public transport, bike sharing schemes, and a long-term political will (see e.g. Escayol 2015, Hull & O'Holleran 2014, sootfreecities 2014d).

A good example of a successful bike sharing scheme is the Vélib' system in Paris. It was launched in July 2007 and replaced by the Vélib' Métropole[62] system in January 2018. The system encompasses around 18,000 bicycles and 1,200 bicycle stations, located across Paris and in some surrounding municipalities, with an estimated average daily ridership of 110,000. In combination with improvements of the bicycle infrastructure, it led to a large increase of the share of bicycle traffic in Paris[63].

Cargo bikes are expected to play an increasingly important role in reducing goods transport in cities. Schemes to promote the use of cargo bikes have been implemented in Bremen, Vienna and Copenhagen (sootfreecities 2014e). These municipalities support the use of cargo bikes and promote their use for city services.

### 3.1.3. Spatial planning – redistribution of public space

Land use patterns are important drivers of personal vehicle use and transport-related emissions in cities. Urban planning strategies that prioritize compact development by placing residential and commercial areas in close proximity can improve health by reducing the population's reliance on private motor vehicles and encouraging a shift towards healthier modes of travel (WHO 2011).

Patterns of land use characterized by sprawl and low-density planning make walking, cycling and public transport impractical and thus are associated with greater private vehicle use and more energy consumption.

In contrast, urban areas characterized by greater urban density, mixed land use, and a better street design and connectivity are associated with reduced travel demands, higher volumes of walking and cycling, increased accessibility to public transit networks, and therefore, lower energy consumption. For example, a study in Santiago de Chile estimated that relocating schools closer to existing residential areas could reduce transport-related climate emissions by 12% at a cost of only US$ 2 per ton of carbon reduction over 20 years (Wright & Fulton 2005).

Shifting transport modes from private vehicles to active and rapid/public transport must be combined with shifts in planning. Emphasis on "proximity planning" makes walking, cycling and public transport to access schools, jobs and services more feasible. Since compact and mixed land use improve accessibility of destinations via walking and cycling, vulnerable groups are likely to benefit from such land-use measures.

A number of cities have made or are in the course of making the transition from a car-orientated traffic policy to a sustainable mobility city, towards a "City of places" (CREATE 2018). This involves

[62] https://www.velib-metropole.fr/en_GB#/

[63] https://www.citycle.com/43306-le-velo-acteur-majeur-des-grandes-metropoles/

redistributing public space within cities, enabling a transition from sole use by (mainly) vehicle traffic to a public realm, street activities, transport on demand and mixed use developments. A number of examples is available on how such a redistribution can increase the attractiveness of public space in cities and thereby also increase the share of active modes.

The city of Paris implemented the following measures[64]:

- Lowering the speed limit to 30 km/h in several urban areas (a speed limit of 30 km/h has also been implemented for roads in residential areas in many cities, such as Vienna, but also for selected major roads in order to lower noise levels, as it is the case in Berlin; Umweltbundesamt 2015).
- For several main roads a new distribution of public space was undertaken, including giving priority to pedestrians, cyclists and buses (bus lanes were physically separated).
- A bicycle plan includes the creation of a 600 km network of bicycle lane.
- A new tramway line was built on the ring boulevards around the city.
- The city entrances were rehabilitated to improve their urban character and environmental quality

### 3.1.4. Parking management

Parking management is an important tool for cities to manage the amount of traffic, especially in cases when the amount of vehicles exceed the number of parking spaces, which can create additional traffic of drivers looking for a free parking space.

Parking management is an important tool to foster a shift from private motorized transport to public transport. This measure is very flexible and can be applied in combination with low emission zone criteria. It is also better practicable (in particular in smaller cities) as congestion charging or road pricing. Parking management can be applied to a small number of parking spaces or to whole zones. Influencing factors are the numbers of parking sites (both public and private), the allowed duration and the fee. The share of private public spaces in a certain area is an important limiting factor for the effectiveness of this measure (Umweltbundesamt 2018). However, parking policies have to be seen in a wider context, taking into account land-use, quality of life and transport strategies to work towards the environmental, social and economic objectives of a city or region (Marsden 2014, VTI 2010). Successful examples for parking management that working in this direction are listed below (sootfreecities 2014a)[65]:

- Paris: According to the sootfreecities guideline, the city has reduced the on-street parking supply by 9% since 2003. At the same time, 95% of free parking spots were transformed to paid parking spaces. In combination with other measures, this is said to have led to a vehicle kilometre reduction of 13%. At the same time, the share of private vehicles in the modal split decreased from 68% to 60% between 2003 and 2006.
- Copenhagen: On average, parking charges were raised by 50% since the introduction of a parking strategy in 2005 (sootfreecities 2014a). The strategy included increased effectiveness

[64] http://fairmode.jrc.ec.europa.eu/measure-catalogue/

[65] an overview on parking fees in various cities is provided in VTI 2016

of the parking supply, higher price schemes for resident permits, and a shift from on- to off-street parking. It led to a decrease of the inner city car traffic by about 8%.

- Amsterdam: A parking permit, valid for specific districts, is necessary for residents to be allowed to park on public roads and places.[66]. Since April 2017, owners of diesel vehicles registered before 2005 are not eligible for a new parking permit. Residents of new buildings are also not eligible for parking permits as parking space is considered to be available in these cases. The costs of a six month parking permit varies between 15 € and around 270 € in the city centre. Additionally, the number of permits per district is limited. However, permit holders can use parking garages, where parking spaces were reserved for permit holders[67]. This measure aims at reducing the traffic in search of a parking space. For non-permit holders, hourly parking fees vary between 1.30 € and 5 €, depending on the district[68]. However, residential parking schemes are much cheaper than commercial parking lots. This is why they can be regarded as an income regressive subsidy favourable for high-income households (De Groote 2016).

### 3.1.5. Public transport

Shifting from private motorised transport to rapid transit/public transport, such as rail, metro and bus, is associated with a wide range of potential health and climate benefits, including: lower urban air pollution concentrations, lower rates of traffic injury risk, less noise stress and improved equity of access for people without cars (WHO 2011).

By clustering many passengers together in one vehicle, public transport modes reduce total traffic emissions of climate and air pollutants. Public transport use is also associated with more physical activity and less obesity, since public transport services are often accessed by walking and cycling. Strong public transport systems tend to have the advantage of reducing traffic intensity, which is associated with road traffic injuries and noise-related health impacts. In developed countries, for instance, the injury risk for public transport users is much lower than the risk for car users.

Investment in mass public transport can also yield equity benefits by improving the mobility of women, elderly and the poor, who often lack access to private vehicles. This, in turn, provides employment, education, health services and recreational opportunities.

Promotion of public transport is a key instrument for a sustainable transport system. Public transport is currently already partly powered by electricity. The switch to renewable electricity and to an overall electrification is thus much easier and more efficient than for private fossil fuel driven vehicles. Achieving a high share of public transport requires an area-wide and efficient infrastructure, high frequency and high quality of service, as well as safety and a public support for an attractive pricing scheme (sootfreecities 2014b). The latter is also an important social aspect. Good practice exmples for a well-functioning public transport system are amongst others Berlin, Vienna and Zurich:

- Berlin has a low share of private car ownership, also due to the extensive public transport network, which includes regional trains ("S-Bahn"), subway, tramways and busses (see e.g. CREATE 2018). This network was distorted when the Berlin wall was built, but it has been constantly re-established and improved after the reunification.

[66] https://www.amsterdam.nl/parkeren-verkeer/parkeervergunning/
[67] https://www.amsterdam.nl/parkeren-verkeer/parkeerplan/oplossing-parkeerpro/
[68] https://www.amsterdam.nl/parkeren-verkeer/parkeertarieven/

- Vienna: The already high share of public transport of the urban modal split was further increased by the introduction of an annual ticket for 365 €. On-going improvements and extensions of subway and tramway lines are further important factors (see e.g. CREATE 2018).
- Zurich: Acceleration initiatives for public transport began in Zurich already in the 1980s and 1990s. Redistribution of public space was a further important aspect for the high share of public transport in the modal split, as well as the continuing support of voters for this public transport policy.

### 3.1.6. Congestion charges

Congestion charges are a very flexible tool to foster the shift from private motorized transport to public transport. The differentiation of congestion charging systems is based primarily on tariff design (and thus also on the relevant vehicle categories), the system of fee calculation and the type and technique of toll collection, billing and control.

The tariff can be set according to space-, time- or vehicle-related criteria or a combination thereof. Examples of spatial criteria are the number of kilometres driven or the number of crossings by a particular section. For time-related criteria, the tariff design can, for example, be differentiated according to weekdays, time of the day, traffic density at certain times of the day. Vehicle-related criteria relate for example to vehicle weight, vehicle dimensions, the number of axles (and thus the vehicle category) or the noise and exhaust emissions of a vehicle. Variable rates require more complex payment and monitoring systems than fixed rates.

In the fee calculation, a distinction can be made between different systems:

- In the case of the cordon system ("cordon charge"), tolling is achieved by crossing the toll ring and the fee for using the entire area is paid within the toll ring.
- In the area system ("area charge"), the use of the roads within one area is charged once (area-licensing) or depending on the kilometres driven (area-charging).
- In the case of the point or network system, the fees are paid when crossing a specific point, which authorizes the use of single or multiple sections of the route (comparable to the toll system on high-ranking road networks throughout the EU).

Congestion charges in Stockholm, Gothenburg, Milan, London set a price for driving into specific areas of the city (sootfreecities 2014c).

The charge is usually higher during peak hours. Revenues are mainly used to improve public transport. It has to be noted that the main focus of the congestion charge is to reduce congestion during peak hours. Improving air quality however, is a welcomed side-effect. This can be emphasized for example by combining higher charges with older technology vehicles and lower charges for Zero Emission Vehicles (ZEV).

### 3.1.7. Emission reduction from shipping

The Saltsjöbaden VI conference[69] in March 2018 has named the following and recommendations to reduce emissions from ships until 2030:

[69] http://saltsjobaden6.ivl.se/saltsjobadenvirecommendations

- Sulphur Emission Control Areas (SECA) and Nitrogen Emission Control Areas (NECA) should be implemented in all European sea areas and in the Arctic.
- Ensure monitoring/compliance/enforcement of global S-standards and SECA/NECA-standards. Evaluate the introduction of mandatory Continuous Emission Monitoring Systems (CEMS).
- $NO_x$-reduction schemes for existing ships, for example by economic instruments such as the levy & fund system in Norway.
- Mandatory speed reduction schemes.
- Economic instruments for PM and Black Carbon reduction measures.
- Ensure availability of cleaner/alternative fuels (and fuel quality) in ports as well as of on-shore power supply.

The European Life Program CLINSH (CLean INland Shipping)[70] aims at demonstrating the effectiveness of measures to reduce emissions from inland ships. The port of Antwerp is one of the project partners.

### 3.1.8. Integrated urban freight transport

A number of European projects are available that aim at reducing the impact of urban freight traffic on air quality and on quality of urban life in general. The project C-LIEGE (Clean Last mile transport and logistics management for smart and efficient local Governments in Europe)[71] provides showcases for good practices for urban freight traffic improvements in 7 pilot cities. The CityLog (Sustainability and Efficiency of City Logistics)[72] project aimed at providing examples and solutions for logistic-oriented telematics services, vehicle technologies and innovative load units to reduce the number of delivery trucks in a city. Freight bicycles are fostered in many cities and provide for emission free delivery[73]. In the Netherlands, the "Green Deal Zero Emission City Logistics"[74], a network of 80 companies and municipalities, aims at achieving zero emission logistics by 2025.

## 3.2. Domestic heating

Solid fuel burning, either from biomass or coal, is the main source of emissions by domestic heating. The following measures can be regarded as best practice examples to address emissions resulting from this source (Amann 2018a; Querol & Amato 2017; Nordic Council of Ministers 2018):

- Awareness campaigns, informal platforms, qualification of focus groups, product declaration and expert advice on site. Examples are: environmental labelling schemes (Nordic Swan[75], Austrian ecolabel[76]), awareness campaigns for proper operation of the appliance and fuel use (Austria, Switzerland, Germany, Denmark[77]), qualification schemes for professionals (France)[78], public education (Italy[79], Czech Republic[80]).

[70] https://www.clinsh.eu/
[71] http://www.c-liege.eu/home.html
[72] https://cordis.europa.eu/result/rcn/58755_en.html
[73] http://cyclelogistics.eu/
[74] http://www.smartcityembassy.nl/initiative/green-deal-zero-emission-city-logistics/
[75] http://www.nordic-ecolabel.org/about/
[76] https://www.umweltzeichen.at/cms/de/home/vision/content.html
[77] http://www.clean-heat.eu/en/home.html
[78] http://www.auvergne-rhone-alpes.developpement-durable.gouv.fr/IMG/pdf/2016-06-20_charte_Club_des_pros.pdf
[79] http://www.cleanaircities.net/
[80] http://vec.vsb.cz/smokeman/o-smokemanovi/smokemanovo-desatero.html

- Provisions for proper installation and improved maintenance (e.g. by requirements for regular chimney sweeps (Germany), regular inspection (Switzerland), see Amann 2018a.
- Subsidies for thorough building renovation, for switching to other fuels or upgrading to new facilities (e.g. for the installation of energy efficient technologies, such as replacement of solid fuel boilers in Austria.
- A ban of solid fuels (e.g. in Krakow[81] from September 2019 onwards, or Dublin[82] since 1990).
- Integrated measures to fight energy poverty (e.g. supports for energy efficiency in Belgium[83], Seasonal Health Interventions Network SHINE[84] in the UK, warmer homes scheme in Ireland[85], EU project to Reduce Energy use And Change Habits, REACH[86] in Southern European countries, financed by the European Fund for Strategic Investments EFSI[87].
- Extension of district heating and cooling as e.g. in Vienna (Lucha et al. 2016), and Sweden (Amann 2018a).

## 3.3. Agriculture

Ammonia ($NH_3$) emissions from agriculture contribute substantially to the regional background levels of secondary particles. Thus, an $NH_3$ emission reduction can also contribute to reduced PM levels in urban areas (Amann 2017). Open burning of agricultural residues is an additional important source of primary particles, even though it was banned under the EU regulation[88] 1306/2013, at least of arable stubbles. A guidance document on "good agricultural practice" and on preventing and abating ammonia emissions were developed under the UNECE convention on Long-range Transboundary Air Pollution[89] (UNECE 2014, UNECE 2015). These guidance documents are now also part of the revised Directive on the reduction of national emissions of certain atmospheric pollutants (NEC Directive 2016/2284/EU)[90].

The main measures to reduce emissions from agriculture are (Amann 2017):

- Banning open burning of agricultural residues. This is already common practice in many countries and has led to a substantial reduction of regional pollutant levels. However, training, enforcement and inspection schemes are crucial to accrue the full reduction potential.
- Integrated manure management approaches. Thereby, the whole chain of feeding, housing, storage and application is addresses by measures such as low protein feed, extended grazing periods, control of emissions from housing, tight manure storage and deep injection application.
- Optimised use of mineral fertilizers, including precision farming and the use of urease inhibitors for urea fertilizers.

[81] http://powietrze.malopolska.pl/en/life-ip/
[82] http://www.dccae.gov.ie/en-ie/environment/topics/air-quality/smoky-coal-ban/Pages/default.aspx
[83] http://sjtn.brussels/fr/urbanisme-logement/guichet-primes
[84] http://www.bestclimatepractices.org/practices/seasonal-health-interventions-network-shine/
[85] http://www.seai.ie/Power_of_One/Grants_Available/
[86] https://ec.europa.eu/easme/en/news/energy-inefficient-homes-hit-household-budgets-why-tackling-energy-poverty-important
[87] http://www.eib.org/efsi/index.htm
[88] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1530790641831&uri=CELEX:32013R1306
[89] http://www.unece.org/env/lrtap/welcome.html
[90] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1531834666059&uri=CELEX:32016L2284

### 3.4. Construction work

Even though rather difficult to quantify, construction work is a relevant source of PM in urban areas, both due to the construction and demolition activities themselves, as well as due to construction related traffic. A number of best practice guidance is available from several countries and cities (Querol & Amato 2017).

- Proper planning is a prerequisite to avoid emissions and construction traffic from the beginning. This includes a central logistics, reuse of material at the site, incentives to reduce travel distances. Examples are the rebuilding of Potsdamer Platz[91] in Berlin and the construction of a new district in Aspern[92], Vienna.

- Site management to ensure that low emission practices are properly implemented. This includes e.g. fixing a set of appropriate measures, a complaint management, inspections, site layout, green infrastructure to prevent dust emissions and a proper site maintenance.

- Emissions from vehicles. These can be addressed by reducing the amount of transports needed through thorough planning (e.g. with the help of an integrated construction site traffic management[93]), but also by fostering the use of new trucks, preferable Euro VI. Also transport via rail and ships should be used, if available near the site.

- Emissions from machinery[94]. Diesel particle filters should be required for construction machinery (e.g. required in Switzerland[95]); also the use of electric equipment instead of fuel driven ones should be fostered.

### 3.5. Integrated approaches

Many measures in air quality plans, especially for traffic and domestic heating, are taken from transport and energy strategies. Also to improve quality of life in general within a city requires taking into account many different and interacting topics. One integrated approach dealing with them is the “smart city”[96] concept, for which the following successful examples can be provided:

- “zero:e park[97]”: In Hannover-Wettbergen in Germany, Europe´s largest zero emission housing development is being built (planned project duration: 2010 to 2018) on a total area of 260,000 m$^2$, with around 330 detached and semi-detached houses. All houses are built using passive house standard and are oriented to maximise the exploitation of solar energy. There is a sustainable water concept (through-trench system) and a green-spaces concept. Furthermore, supported campaigns and analyses of the development area and comprehensive advice on energy, water and green planning are offered to its residents.

[91] http://www.stadtentwicklung.berlin.de/planen/staedtebau-projekte/leipziger_platz/de/planungen/planungsgrundl/baulogistik/index.shtml
[92] https://www.aspern-seestadt.at/
[93] http://fairmode.jrc.ec.europa.eu/measure-catalogue/
[94] an overview on construction machinery is provided in a brochure by the sootfreecities initiative
[95] https://www.bafu.admin.ch/bafu/de/home/themen/luft/publikationen-studien/publikationen/luftreinhaltung-auf-baustellen.html
[96] no common definition is available but “smart cities” are generally considered cities that are ready to meet their economic, social and environmental challenges, that strive to increase energy efficiency and to reduce environmental pollution and that plan and implement climate change mitigation measures
[97] https://www.hannover.de/Leben-in-der-Region-Hannover/Umwelt-Nachhaltigkeit/Klimaschutz-Energie/Akteure-und-Netzwerke/Klima-Allianz-Hannover/Klimaschutzprojekte/Klimaschutzsiedlung-zero-e-park

- The Stockholm Royal Seaport[98] in Sweden is one of the largest urban development areas in northern Europe, with around 12 000 houses and 35 000 workplaces on a total area of 236 ha (planned project duration: 2010 to 2030). Its goal is to make the district of Royal Seaport completely independent of fossil fuels by 2030. One main challenge is to switch from today's fossil-fuel-driven transport to transport that runs on renewable energy (e.g. biogas and electric hybrid buses). In 2015 Stockholm Royal Seaport received a "C40 Cities Award"[99] for the best sustainable urban development project.
- The district of Hunziker[100] in Zurich (Switzerland) offers living space for around 1,200 residents and working place for 150 persons. Its buildings present clear environmental benefits, namely maximum energy efficiency and maximum comfort features. Photovoltaic systems on the buildings' roofs cover about 20% of its energy consumption. The area is conceived as a low-traffic district, as the residents of Hunziker are committed to giving up their private cars. However, the district is easily accessible by public transport. In 2017, Hunziker became certified as a "2000 Watt district". The "2000 Watt site[101]" certificate evaluates large site developments in terms of building quality, density, mixed usage and mobility.
- Other examples for smart city areas are "Quartier Vauban[102]" in Freiburg (Germany), Greencity[103] in Zurich (Switzerland), Bahnstadt[104] in Heidelberg (Germany), Neckarbogen[105] in Heilbronn (Germany), Western Harbour[106] in Malmö (Sweden) and Technologiepark Adlershof[107] in Berlin (Germany).

## 3.6. Awareness raising

A strong public support for air quality issues is an important element to successfully implement effective measures. Some successful examples are listed below:

- In the city of Antwerp a citizen science project was launched called "curieuze neuzen[108]" (curious noses). It aimed at mapping the $NO_2$ levels in Antwerp. At around 2000 locations low-cost diffuse samplers were installed by inhabitants and exposed for four weeks. The analysis of the samples provided a precise map of $NO_2$ levels and thereby supported the validation of air quality models, but it also resulted in many newspaper articles and several TV reports. It also changed the attitude of the participants to measures such as a congestion charge or low emission zones.
- The implementation of the congestion charge in Stockholm was achieved with the help of a trial phase and a referendum (Johansson et al. 2008). It provided a substantial decrease in $NO_2$

98 https://international.stockholm.se/city-development/the-royal-seaport/
99 https://www.c40.org/events/c40-cities-awards-2015
100 http://www.2000watt.ch/fileadmin/user_upload/2000Watt-Gesellschaft/alle_sprachen/faktenblaetter/BFE-0656-01-2000_Watts_Factsheet_A4_Hunziker-DE.pdf
101 http://www.2000watt.ch/
102 https://www.freiburg.de/pb/,Lde/208732.html
103 http://www.greencity.ch/de/
104 https://www.heidelberg-bahnstadt.de/953958
105 https://www.heilbronn.de/bauen-wohnen/bundesgartenschau-2019-stadtausstellung-neckarbogen/stadtausstellung-neckarbogen.html
106 https://malmo.se/Nice-to-know-about-Malmo/Sustainable-Malmo-/Sustainable-Urban-Development/Western-Harbour.html
107 https://www.berlin.de/sen/wirtschaft/wirtschaft/technologiezentren-zukunftsorte-smart-city/zukunftsorte/adlershof/artikel.109390.php
108 http://www.curieuzeneuzen.eu/en/

and $PM_{10}$ levels, as well as in traffic and congestion. Before the trial phase, public opinion was against the congestion charge. However, this changed after the trial phase. The subsequent referendum following the trial phase went in favour of converting the provisory congestion charge to a permanent one.

- In London, the Mayor launched clean air strategies and accompanied them by awareness raising campaigns and consultations[109]. The background material is made publicly available, some of it in different languages. The latest consultation[110] was dedicated to the possible implementation of a so-called Ultra Low Emission Zone (ULEZ)[111], which will levy an extra charge to diesel vehicles up to EURO 5/V in inner London beginning in October 2021.
- The European Commission's LIFE programme[112] also supports the development and implementation of air quality related measures. The results are disseminated via websites and conferences. A selection of best projects is done based on an evaluation according to certain criteria[113], including transferability. The most recent successful projects related to air quality were AIRUSE[114] (Testing and Development of air quality mitigation measures in Southern Europe), clean air [115]and PERHT[116] (Parking green services for better environment in historic towns), among others.

[109] https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/how-were-cleaning-londons-air
[110] https://consultations.tfl.gov.uk/environment/air-quality-consultation-phase-3b/
[111] https://tfl.gov.uk/modes/driving/ultra-low-emission-zone?intcmp=26434
[112] http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.getProjects&themeID=1
[113] http://ec.europa.eu/environment/life/bestprojects/index.htm
[114] http://airuse.eu/
[115] http://www.cleanair-europe.org/en/home/
[116] http://www.perht-lifeplus.com/

# 4. RECOMMENDATIONS

**KEY FINDINGS**

- A number of policy options are available to address diesel vehicles, including trucks, in cities and Member States.
- Regional background PM levels can be reduced by addressing ammonia emissions and by banning open burning of (agricultural) waste.
- Policy options in the cities addressed in the petitions of this study include strengthening low emission zones, addressing construction activities, increasing diesel taxations, reducing ammonia emissions and updating air quality plans.

The air quality plans developed for a particular city are in most cases the result of a process involving various stakeholders and requiring extensive underlying data to allow for a thorough selection of effective measures. Not all of this data and information is available. Therefore the following recommendations are based on general principles and the successful examples described in section 3. In all cases, their applicability to the individual cities and regions described in sections 1.3 and 2 has to be individually analysed for each case.

The two main problems in the cities and regions described in this study seem to be diesel vehicles, in particular diesel passenger cars, as well as the overall amount of traffic.

## 4.1. General policy options to reduce the overall amount of traffic

To address the traffic amount in cities, numerous tools are already available for cities and regions, as well as for measures at the national level:

- The European Platform on Sustainable Urban Mobility Plans platform Eltis[117] provides a wealth of information, including guidelines, information on funding, case studies, tools, an annual conference, etc. Additionally, the European Commission's Urban Agenda deals with urban mobility and air quality, and has also developed an urban mobility draft action plan (Urban Agenda 2018).
- Promotion of active transport modes (cycling, walking), especially with the help of an extensive and high quality infrastructure, as well as attractive public transport (at the city and regional level).
- Spatial planning: redistributing public spaces to all transport modes, direct short paths for active modes and compact settlement structures, among others, help to reduce the reliance on private motor vehicles and to encourage a shift towards healthier modes of travel.
- Parking management and congestion charging are very flexible tools to foster the shift from private motorized transport to public transport.

[117] http://www.eltis.org/

- The White Paper on Transport[118] spells out 10 strategic goals and benchmarks. The first one deals with trucks in cities. To achieve the city logistics goal a legal framework and framework conditions have to be put in place:
  - Goal 1: To halve the use of 'conventionally fuelled' cars in urban transport by 2030; phase them out of cities by 2050; achieve $CO_2$-free city logistics in major urban centres by 2030.

## 4.2. General policy options to reduce emissions from diesel vehicles

To address diesel vehicles in particular, the following measures can be scrutinized for applicability in a city or region, as well as at the national level:

- Stringent low emission zones or congestion charges, addressing diesel passenger cars and light-duty vehicles up to Euro 5, with a long term perspective of substituting fossil fuel driven vehicles altogether (city and regional level).

- Increase of taxes on diesel fuel. The taxation of diesel and diesel vehicles cannot be changed at the city level. Nevertheless, taxes have a strong influence on the share of diesel vehicles and sales of diesel fuel (Harding 2014). Hence, taxation should be changed to shift the tax burden for citizens and companies in favour of environmentally related taxation[119] (at the national level).

- Electric vehicles are in principle free of direct emissions of air pollutants, with the exception of non-exhaust emissions (abrasion, road dust re-suspension). Nevertheless, there are strong indications that fostering the use of private electric vehicles through different schemes might lead to rebound effects and a decline in the share of public transport and active modes (see e.g. Dimitropoulos et al. 2016, VCÖ 2018, Holtsmark 2014). The main focus for incentivising electric vehicles should thus be laid on large commercial urban fleets (e.g. local distributors) and public transport.

There is an on-going debate in Germany regarding banning of diesel vehicles in several cities, as a result of court decisions[120]. This might lead to an increase in sales of used diesel vehicles, potentially also in neighbouring countries and regions. It seems therefore advisable to closely monitor relevant trends.

## 4.3. General policy options to reduce regional background levels

A reduction of regional background concentrations of PM is an increasingly efficient way to also reduce urban background levels (see e.g. Amann 2017, Umweltbundesamt Dessau 2013a, 2013b). Thus, air quality planning should include the whole region surrounding cities to address inter alia the following sources:

- $NH_3$ emissions from agriculture.
- PM emissions from open burning of agricultural waste.
- PM emissions from domestic wood burning.

In most cities, traffic is also strongly interconnected with their surroundings. In addition, city residents often show a lower use of private cars compared to commuters living outside the city. Therefore, traffic planning has to be coordinated between a city and its surrounding region. Sustainable Urban Mobility Plans (SUMP)[121] are an important instrument to address traffic in a comprehensive way across different

[118] https://ec.europa.eu/transport/themes/strategies/2011_white_paper_en
[119] http://www.oecd.org/environment/environmentaltaxation.htm
[120] http://www.bverwg.de/de/270218U7C26.16.0, http://www.bverwg.de/de/270218U7C30.17.0
[121] https://ec.europa.eu/transport/themes/urban/urban_mobility/urban_mobility_actions/sump_en

policy areas and government levels. For this purpose, the European Commission already has provided guidelines, funding and the information hub Eltis[117] (European Commission 2014).

## 4.4. Indicators, monitoring

The foreseen impact of an air quality plan can only be accrued if the implementation of the measures is regularly (annually) monitored with the help of suitable indicators, including indicators for:

- Active travel/physical activity;
- Use of non-motorized and public transport;
- Traffic volume, modal split;
- Air and noise pollution exposures;
- Pedestrian injuries;
- Emission standards of registered vehicles;
- Access to transport.

## 4.5. Further policy options

### 4.5.1. Madrid

The air quality and climate plan for Madrid ("Plan A") includes many measures to reduce the environmental and health impact of traffic, Additionally, it also incorporates most of the general options described in section 4.1 above. The Plan A has also identified the need to change the taxation for diesel vehicles at the national level. However, it doesn't describe the following aspects in detail:

- Measures to reduce emissions from construction activities, including construction traffic (see section 3.4).
- Measures to reduce emissions from agriculture, including open burning (see section 3.3) in the region to lower regional background levels of air pollution.
- Measures to avoid rebound effects in traffic, especially when fostering electric vehicles (see section 4.1).

### 4.5.2. Antwerp, Brussels

The current LEZ in Brussels[122] will ban EURO 4/IV diesel vehicles after 2022 and EURO 5/V after 2025. This will affect vehicles that are around 15 years old. This approach is less stringent compared to Antwerp or other similar cities. For Brussels the ECA also noted that the reduction of $NO_2$ claimed in the air quality plan is unreliable, as the calculations are not based on real-driving emissions (ECA 2018).

### 4.5.3. Lombardy

A number of measures including a LEZ, a congestion charge and measures for domestic heating have been implemented in Milan and Lombardy. They are regularly monitored and evaluated (Nagl, Schneider & Thielen 2016). According to a recent newspaper article[123], the requirements for entering the LEZ in Milan will be strengthened in October 2019. EURO 4 diesel vehicles will no longer be allowed to enter the city. After 2025, the LEZ will also affect EURO 5 diesel cars, according to another recent

[122] https://www.lez.brussels/en/content/my-vehicle#1

[123] https://milano.corriere.it/notizie/cronaca/18_giugno_08/confine-digitale-fermare-diesel-telecamere-multe-21-gennaio-2019-19a1878e-6ada-11e8-9458-812edbd9a164.shtml?refresh_ce-cp

article[124]. As real-driving-emissions of diesel EURO 5 vehicles are often even higher than that of EURO 4 vehicles, and considering that EURO 5 vehicles will be around 15 years old in 2025, it should be considered to ban EURO 5 diesel vehicles some years earlier (ICCT 2017).

### 4.5.4. Marseille, Paris

As in Milan, the city of Paris and the region Ile-de-France have implemented numerous measures and are constantly improving public transport schemes. Nevertheless, the share of diesel vehicles in France is rather high, which strongly affects $NO_2$ levels in its cities. Hence, the taxation of diesel fuel and vehicles could be progressively raised by the national government in order to discourage diesel vehicle use and to foster a lower fuel consumption.

Paris was affected by episodes of high PM levels during springtime in recent years, which were caused by high concentrations of secondary inorganic particles, mainly driven by $NH_3$ emissions from agriculture (Bessagnet & Rouil 2014). However, $NH_3$ emissions[125] in France have been slightly increasing in recent years, and projections show emissions higher than the reduction commitment for 2020 and 2030. Thus further efforts are needed to lower $NH_3$ emissions.

As for Paris, $NO_2$ levels are still too high in Marseille. Therefore, measures to reduce $NO_x$ emissions from diesel vehicles should be enforced at the national, regional and local level. So far, no permanent LEZ has been implemented in Marseille. However, restrictions apply to vehicles based on their pollutant levels, type and the vehicle's EURO standard[126].

### 4.5.5. Valencia

The most recent air quality plan for Valencia dates from 2013. Therefore, the plan should be updated, including specific objectives, a description of the overall expected impact of the plan, and a monitoring and evaluation scheme for its measures. The update should analyse the stagnant $NO_2$ trend in recent years and take it into account when considering further measures.

[124] https://milano.corriere.it/notizie/cronaca/18_luglio_14/milano-low-emission-zone-triplo-controllo-antismog-diesel-e13d9758-8725-11e8-bfdc-8bbc13b64da8.shtml?refresh_ce-cp

[125] see EEA data for France for $NH_3$: https://www.eea.europa.eu/data-and-maps/dashboards/necd-directive-data-viewer-1

[126] https://www.crit-air.fr/nc/en/information-about-the-critair-vignette/french-environmental-zones-zcr/bouches-du-rhonemarseille-zone-zpad.html

# REFERENCES


- 4th Daughter Directive (4DD): Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. OJ L 23/3. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1454408421830&uri=CELEX:32004L0107, last accessed on 2 July 2018.
- Air Quality Framework Directive (AQFWD): Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management. OJ L 296. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1450257400573&uri=CELEX:31996L0062, last accessed on 2 July 2018.
- Amann (ed.) (2017): Measures to address air pollution from agricultural sources. February 2, 2018. IIASA, Laxenburg. Available at: http://ec.europa.eu/environment/air/pdf/clean_air_outlook_agriculture_report.pdf, last accessed on 2 July 2018.
- Amann (ed.) (2018a): Measures to address air pollution from small combustion sources. February 2, 2018. IIASA,.Laxenburg & Umweltbundesamt, Vienna. Available at: http://ec.europa.eu/environment/air/pdf/clean_air_outlook_combustion_sources_report.pdf, last accessed on 2 July 2018.
- Ambient Air Quality Directive (AAQD): 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. OJ L 152/1. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1449504722962&uri=CELEX:32008L0050, last accessed on 2 July 2018.
- Antwerpen (2010): Masterplan 2020. Bouwstenen voor de uitbreiding van het Masterplan Mobiliteit Antwerpen. Antwerp. Available at: https://www.oosterweelverbinding.be/algemeen/masterplan-2020, last accessed on 2 July 2018.
- Bessagnet, B. & Rouil, L. (2014): Feedback on and analysis of the PM pollution episode in March 2014. Presentation at the 19th EIONET Workshop on Air Quality Assessment and Management Berne, Switzerland, 30 September and 1 October 2014. Available at: http://acm.eionet.europa.eu/docs/meetings/140930_eionet_aq_noise_back2back_ws/20_Bessagnet_PMepisode_march2014.pdf, last accessed on 13 July 2018.
- City of Copenhagen (2012): Bicycle Strategy 2011-2025. Available at: http://kk.sites.itera.dk/apps/kk_pub2/?mode=detalje&id=823, last accessed on 16 July 2018.
- City of Copenhagen (2017): Bicycle Account 2016. Available at: http://kk.sites.itera.dk/apps/kk_pub2/index.asp?mode=detalje&id=1698, last accessed on 16 July 2018.
- Commission Directive (EU) 2015/1480 of 28 August 2015 amending several annexes to Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council laying down the rules concerning reference methods, data validation and location of sampling points for the assessment of ambient air quality. OJ L 226/4. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1528369875247&uri=CELEX:32015L1480, last accessed on 2 July 2018.

- Commission Implementing Decision 2011/850/EU of 12 December 2011 laying down rules for Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council as regards the reciprocal exchange of information and reporting on ambient air quality. OJ L 335. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1449504822560&uri=CELEX:32011D0850, last accessed on 10 August 2018.
- Comune di Milano (2016): Piano Urbano Mobilità Sostenibile Milano – PUMS. Documento di Piano. Milan. Available at: http://download.comune.milano.it/13_07_2017/DdP%20Documento%20di%20Piano%20emendato%20(1499955646081).pdf?pgpath=/SA_SiteContent/UTILIZZA_SERVIZI/MOBILITA/Pianificazione_mobilita/piano_urbano_mobilita, last accessed on 22 June 2018.
- Comunidad de Madrid (2018): IMD. Tráfico 2017. Comunidad de Madrid. Available at: http://www.madrid.org/cs/Satellite?c=CM_Publicaciones_FA&cid=1354709793265&idConsejeria=1109266187248&idListConsj=1109266100973&idOrganismo=1109266227998&idPagina=1343068184421&language=es&pagename=ComunidadMadrid%2FEstructura&pid=1109265444699&site=ComunidadMadrid&sm=1343068184432, last accessed on 18 June 2018.
- CREATE - Congestion Reduction in Europe - Advancing Transport Efficiency (2018): D7.5: A city's introduction to CREATE. Available at: http://nws.eurocities.eu/MediaShell/GetMediaBytes?mediaReference=id173997, last accessed on 16 July 2018.
- Dimitropoulos, A., W. Oueslati and C. Sintek (2016): "The Rebound Effect in Road Transport: A Meta-analysis of Empirical Studies", OECD Environment Working Papers, No. 113, OECD Publishing, Paris. http://dx.doi.org/10.1787/8516ab3a-en.
- DRIEE - Direction Régionale et Interdépartementale de l'Environnement et de l'Energie (2018): Plan de Protection de l'Atmosphère d'Île-de-France 2018-2025. Direction Régionale et Interdépartementale de l'Environnement et de l'Energie, Vincennes. Avalable at: https://www.maqualitedelair-idf.fr/nouveau-plan-de-protection-de-latmosphere-a-ete-approuve-31-janvier-2018/, last accessed on 2 July 2018.
- ECA – European Court of Auditors (2018): Air pollution: Our health still insufficiently protected. Special Report No. 23. European Court of Auditors, Luxembourg. Available at: https://www.eca.europa.eu/en/Pages/DocItem.aspx?did=46723, last accessed on 12 September 2018.
- EEA –European Environment Agency (2017): Air quality in Europe – 2017 report. EEA Report No 13/2017. Copenhagen. Available at: https://www.eea.europa.eu/publications/air-quality-in-europe-2017, last accessed on 2 July 2018.
- Escayol, E. M. (2015): A critical examination of cycling policies in Buenos Aires, Copenhagen, and Auckland. Dissertation, Auckland University of Technology. Available at: http://aut.researchgateway.ac.nz/handle/10292/9256, last accessed on 16 July 2018.
- European Commission (2011a): Commission Staff Working Paper establishing guidelines for determination of contributions from the re-suspension of particulates following winter sanding or salting of roads under the Directive 2008/50/EC on ambient air quality and cleaner air for Europe. SEC(2011) 207 final. Available at: http://ec.europa.eu/environment/air/quality/legislation/pdf/sec_2011_0207.pdf, last accessed on 10 August 2018.

- European Commission (2011b): Commission Staff Working Paper establishing guidelines for establishing guidelines for demonstration and subtraction of exceedances attributable to natural sources under the Directive 2008/50/EC on ambient air quality and cleaner air for Europe. SEC(2011) 208 final. Available at: http://ec.europa.eu/environment/air/quality/legislation/pdf/sec_2011_0208.pdf, last accessed on 10 August 2018.

- European Commission (2014): Guidelines. Developing and implementing a sustainable urban mobility plan. Available at: http://www.eltis.org/sites/default/files/guidelines-developing-and-implementing-a-sump_final_web_jan2014b.pdf, last accessed on 14 August 2018.

- EC DG MOVE – European Commission Directorate-General for Mobility and Transport (2017): Study on Urban Vehicle Access Regulations. Final Report. Brussels. Available at: #https://ec.europa.eu/transport/sites/transport/files/uvar_final_report_august_28.pdf, last accessed on 6 September 2018.

- European Parliament (2018): Air and noise pollution. Fact sheet. Available at: http://www.europarl.europa.eu/RegData/etudes/fiches_techniques/2017/N54609/en.pdf, last accessed on 4 July 2018.

- FMI– Finnish Meteorological Institute (2002): MAKESENS 1.0. Mann-Kendall Test and Sen's Slope Estimates for the Trend of Annual Data. Version 1.0 Freeware. Available at: http://en.ilmatieteenlaitos.fi/makesens, last accessed on 17 July 2018.

- De Groote, J. (2016): Car ownership and residential parking subsidies: Evidence from Amsterdam. Economics of Transportation 6 (2016) p25–37. Available at: https://www.sciencedirect.com/science/article/pii/S2212012216300132, last accessed on 13 August 2018.

- Harding, M. (2014): "The Diesel Differential: Differences in the Tax Treatment of Gasoline and Diesel for Road Use", OECD Taxation Working Papers, No. 21, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jz14cd7hk6b-en.

- Hull, A. & O'Holleran, C. (2014): Bicycle infrastructure: can good design encourage cycling?, Urban, Planning and Transport Research, 2:1, 369-406, DOI:10.1080/21650020.2014.955210. Available at: https://doi.org/10.1080/21650020.2014.955210, last accessed on 16 July 2018.

- ICCT – The International Council on Clean Transportation (2017): Road tested: comparative overview of real-world versus type-approval $NO_x$ and $CO_2$ emissions from diesel cars in Europe. Available at: https://www.theicct.org/publications/road-tested-comparative-overview-real-world-versus-type-approval-nox-and-co2-emissions, last accessed on 13 July 2018.

- Ile-de-France (2006): Plan de Protection de l'Atmosphère d'Île-de-France. Available at: https://www.maqualitedelair-idf.fr/w2020/wp-content/uploads/2017/10/PPA-complet-version-legere-compressed.pdf, last accessed on 2 July 2018.

- Ile-de-France (2013): Plan de Protection de l'Atmosphère d'Île-de-France. Revision approuvee le 25 mars 2013.

- Johansson, C.; Burman, L. & Forsberg, B. (2009): The effects of congestions tax on air quality and health. Atmospheric Environment Volume 43, Issue 31, October 2009, Pages 4843-4854.

- Lucha, C.; Prahl, A.; Kampman, B.; Cherif, S.; Rothballer, C. & Storch, A. (2016): Local and Regional State of Play and Policy Recommendations Concerning Sustainable Heating and Cooling: Focusing on EU Level Policy. European Committee of the Regions: Brussels. Available at: https://cor.europa.eu/en/engage/studies/Documents/Sustainable%20Heating%20and%20Cooling.pdf, last accessed on 2 July 2018.
- Madrid (2012): Plan de Calidad del Aire de la Ciudad de Madrid 2011-2015. Madrid. Available at: http://www.mambiente.munimadrid.es/opencms/opencms/calaire/Publicaciones/plan_calidad_2011_15.html, last accessed on 18 June 2018.
- Madrid (2015): Informe del Estado de la Movilidad de la Ciudad de Madrid 2014. I.Indicadores Bases de conocimiento compartido Madrid. Available at: http://www.madrid.es/portales/munimadrid/es/Inicio/Movilidad-y-transportes/ Publicaciones/ Informe-del-Estado-de-la-Movilidad-de-la-Ciudad-de-Madrid/?vgnextfmt=default& vgnextoid =c1098ff229cf3310VgnVCM2000000c205a0aRCRD&vgnextchannel=9bcf8fb9458fe410VgnVCM1000000b205a0aRCRD, last accessed on 18 June 2018.
- Madrid (2017): Plan A: Plan de Calidad de aire y Cambio Climático. Madrid. Available at: http://www.madrid.es/UnidadesDescentralizadas/Sostenibilidad/CalidadAire/Ficheros/PlanAireyCC_092017.pdf, last accessed on 18 June 2018. English version. Available at: http://www.madrid.es/UnidadesDescentralizadas/Sostenibilidad/CalidadAire/Ficheros/PlanAire&CC_Eng.pdf, last accessed on 18 June 2018.
- Madrid (2018): Calidad del Aire. Madrid 2017. Dirección General de Sostenibilidad y Control Ambiental. Madrid. Available at: http://www.mambiente.munimadrid.es/opencms/opencms/calaire/Publicaciones/memoria_2017.html, last accessed on 18 June 2018.
- Mairie de Paris (2018): Plan climat de Paris. Vers une ville neutre en carbone et 100% énergies renouvelables. Available at: https://api-site-cdn.paris.fr/images/100009, last accessed on 4 July 2018.
- Marsden, G.R. (2014): Parking Policy. In: Ison, S and Mulley, C, (eds.) Parking Issues and Policies. Transport and Sustainability, 5. Emerald Group Publishing Limited, 11 - 32. ISBN 978-1-78350-919-5.. Available at: http://eprints.whiterose.ac.uk/81820/7/__ds.leeds.ac.uk_staff_staff15_libmh_SCoReS_Parking%20Policy%20Chapter%20Greg%20Marsden%202014%20Final.pdf, last accessed on 13 August 2018.
- McIntosh, J;, Trubka, R.; Kenworthy, J. & Newman, P. (2014): The role of urban form and transit in city car dependence: Analysis of 26 global cities from 1960 to 2000. Transportation Research Part D 33 (2014) 95–110. Available at: https://www.sciencedirect.com/science/article/pii/S136192091400114X, last accessed on 13 August 2018.
- Nagl, C.; Schneider, J. & Thielen, P. (2016): Implementation of the Ambient Air Quality Directive, Study for the ENVI Committee, PE 578.986, European Parliament, Brussels. Available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/578986/IPOL_STU(2016)578986_EN.pdf, last accessed on 20 June 2018.
- Nordic Council of Ministers (2018): Clean Air for a Sustainable Future – Goals and Challenges. Saltsjöbaden VI Workshop 2018. Editors: Anna Engleryd and Peringe Grennfelt. Available at: http://norden.diva-portal.org/smash/get/diva2:1240407/FULLTEXT01.pdf, last accessed on 6 September 2018.

- Préfet des Bouches-du-Rhône (2013): Plan de Protection de l'Atmosphère des Bouches-du-Rhône. Révision approuvée le 17 mai 2013. Available at: http://www.paca.developpement-durable.gouv.fr/le-ppa-revise-des-bouches-du-rhone-a2394.html, last accessed on 2 July 2018.
- Préfet des Bouches-du-Rhône (2017): Avancement du Plan de Protection de l'Atmosphère des Bouches-du-Rhône. Point informatif CODERST du 22.02.17. Available at: http://www.paca.developpement-durable.gouv.fr/le-ppa-revise-des-bouches-du-rhone-a2394.html last accessed on 2 July 2018.
- Querol, X & Amato, F. (eds.) (2017): GuideBook - Measures to improve urban air quality. Barcelona. Available at: http://www.cleanaircities.net/, last accessed on 2 July 2018.
- Regione Lombardia (2014): L'aria che respire. L'inquinamento atmosferico locale e globale. Regione Lombardia, Milano. Available at: http://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioServizio/servizi-e-informazioni/Cittadini/Tutela-ambientale/Qualita-della-aria/piano-regionale-degli-interventi-per-la-qualita-dell-aria, last accessed on 20 June 2018.
- Regione Lombardia (2015): Relazione Sull'attuazione Del Piano Regionale Degli Interventi Per La Qualita' Dell'aria (Pria), Anno 2014 - Primo Monitoraggio. Regione Lombardia, Milano. Available at: http://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioServizio/servizi-e-informazioni/Cittadini/Tutela-ambientale/Qualita-della-aria/piano-regionale-degli-interventi-per-la-qualita-dell-aria, last accessed on 20 June 2018.
- Regione Lombardia (2016a): Stato Di Attuazione Del Piano Regionale Degli Interventi Per La Qualita' Dell'aria (Pria) – Secondo Monitoraggio – Anno 2016. Regione Lombardia, Milano. Available at: http://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioServizio/servizi-e-informazioni/Cittadini/Tutela-ambientale/Qualita-della-aria/piano-regionale-degli-interventi-per-la-qualita-dell-aria, last accessed on 20 June 2018.
- Regione Lombardia (2016b): Programma Regionale della Mobilità e dei Trasporti. Available at: http://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioRedazionale/istituzione/x-legislatura/direzione-generale-infrastrutture-e-mobilita/programma-regionale-mobilita-trasporti, last accessed on 20 June 2018.
- Regione Lombardia (2017): Relazione Di Monitoraggio Triennale Del Piano Regionale Degli Interventi Per La Qualita' Dell'aria (PRIA). Regione Lombardia, Milano. Available at: http://www.regione.lombardia.it/wps/portal/istituzionale/HP/DettaglioServizio/servizi-e-informazioni/Cittadini/Tutela-ambientale/Qualita-della-aria/piano-regionale-degli-interventi-per-la-qualita-dell-aria, last accessed on 20 June 2018.
- Regione Lombardia (2018): PRIA - Piano Regionale degli Interventi per la qualità dell'Aria. Aggiornamento 2018. Available at: http://www.regione.lombardia.it/wps/wcm/connect/fb99bca7-07c6-4af3-bdaa-e1f89a6982c4/Allegato+1+Aggiornamento+PRIA+2018.pdf?MOD=AJPERES&CACHEID=fb99bca7-07c6-4af3-bdaa-e1f89a6982c4, last accessed on 14 August 2018.
- Sootfreecities (2014a): Guideline Sustainable Parking Management. Available at: http://www.sootfreecities.eu/sootfreecities.eu/public/download/best-practice/parking-management.pdf, last accessed on 14 July 2018.

- Sootfreecities (2014b): Guideline Promotion of Public Transport. Available at: http://www.sootfreecities.eu/sootfreecities.eu/public/download/best-practice/public-transport.pdf, last accessed on 14 July 2018.
- Sootfreecities (2014c): Guideline Congestion Charges. Available at: http://www.sootfreecities.eu/sootfreecities.eu/public/download/best-practice/congestion-charge .pdf, last accessed on 14 July 2018.
- Sootfreecities (2014d): Guideline Cycling – Cost-Effective Measures. Available at: http://www.sootfreecities.eu/sootfreecities.eu/public/download/best-practice/cycling-promotion.pdf, last accessed on 14 July 2018.
- SPF Mobilité et Transports (2018): Kilomètres parcourus par les véhicules belges en 2016. Available at: https://mobilit.belgium.be/sites/default/files/kilometers_2016_fr.pdf, last accessed on 2 July 2018.
- Umweltbundesamt Dessau (2013a): Stein, R.: $PM_{10}$-Ursachenanalyse auf der Basis hypothetischer Emissionsszenarien. Teilbericht zum F&E-Vorhaben „Strategien zur Verminderung der Feinstaubbelastung - PAREST“. Texte 60/2013. Umweltbundesamt, Dessau. Available at: https://www.umweltbundesamt.de/publikationen/pm10-ursachenanalyse-auf-basis-hypotheti sher, last accessed on 9 July 2018.
- Umweltbundesamt Dessau (2013b): Thiruchittampalam, B.; Köble, R.; Theloke, J.; Kugler, U.; Uzbasich, M. & Kampffmeyer, T.: Berechnung von räumlich hochaufgelösten Emissionen für Deutschland. Teilbericht zum F&E-Vorhaben „Strategien zur Verminderung der Feinstaubbelastung - PAREST“. Texte 51/2013. Umweltbundesamt, Dessau. Available at: https://www.umweltbundesamt.de/publikationen/berechnung-von-raeumlich-hochaufgeloesten last accessed on 9 July 2018.
- Umweltbundesamt Dessau (2017): Cyrys, J.; Jianwei Gu, J. & Soentgen, J.: Analyse der Wirksamkeit von Umweltzonen in drei deutschen Städten: Berlin, München und Augsburg. Texte 46/2017. Umweltbundesamt, Dessau. Available at: https://www.umweltbundesamt.de/publikationen/auswertung-der-wirkung-von-umweltzonen-auf-die, last accessed on 14 August 2018.
- Umweltbundesamt (2015): Weniger ist mehr! Was bringen Tempolimits? Tagungsband der Veranstaltung der Plattform „Saubere Luft“, 06.11.2014, Wien. Umweltbundesamt, Vienna. Available at: http://www.umweltbundesamt.ataktuell/presse/lastnews/news2014/news_141107/, last accessed on 17 July 2018.
- Umweltbundesamt (2018): Dippold, M.; Fellendorf, M.; Flucher ,S.; Haberl, M.; Hausberger, S.; Heinfellner, H.; Hofer, K.; Lichtblau, G. & Nagl, C.: Massnahmen zur Verbesserung der Luftqualität in Graz. Quantifizierung und Beurteilung. Reports, Band REP-0657. Umweltbundesamt, Vienna. Available at: http://www.umweltbundesamt.at/aktuell/publikationen/publikationssuche/publikationsdetail/?pub_id=2257, last accessed on 17 July 2018.
- UNECE - United Nations Economic Commission for Europe (2014): Guidance document on preventing and abating ammonia emissions from agricultural sources. ECE/EB.AIR/120. Available at: http://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE_EB.AIR_120_ENG.pdf, last accessed on 17 July 2018.

- UNECE - United Nations Economic Commission for Europe (2015): United Nations Economic Commission for Europe Framework Code for Good Agricultural Practice for Reducing Ammonia Emissions. ECE/EB.AIR/129. Available at: http://www.unece.org/fileadmin/DAM/env/documents/2015/AIR/EB/ECE_EB.AIR_129_ENG.pdf, last accessed on 17 July 2018.

- Urban Agenda (2018): Urban Agenda for the EU. Partnership for Urban Mobility. Final Draft Action Plan. Available at: https://ec.europa.eu/futurium/en/system/files/ged/pum_draft_action_plan.pdf, last accessed on 2 July 2018.

- Valencia (2011): Plan de acción medioambiental del Municipio de Valencia AYUNTAMIENTO DE VALENCIA. Delegación de Calidad Medioambiental, Energías Renovables y Cambio Climático. Available at: https://www.valencia.es/ayuntamiento/Energias.nsf/0/7ABD14C45FA34ECAC1257ED7002C2A96/$FILE/Plan%20de%20accion%20ambiental.pdf?OpenElement&lang=2, last accessed on 12 July 2018.
- Valencia (2013): Planes para la mejora de la calidad del aire de la aglomeración es1016: l'horta (Valencia y entorno metropolitano). Available at: http://www.agroambient.gva.es/documents/20549779/92789116/PLAN_VALENCIA+definitivo11/7b7f5ad7-ee7c-4181-a8ed-41f16242f004, last accessed on 12 July 2018.

- Vlaams Verkeerscentrum (2018): Verkeersindicatoren Snelwegen Vlaanderen 2017. Antwerpen. Available at: http://www.verkeerscentrum.be/verkeersinfo/verkeersindicatoren/overzicht, last accessed on 18 June 2018.

- VTI - väg- och transportforskningsinstitut (2010): Parkering. Politik, åtgärder och konsekvenser för stadstrafik. VTI notat 23-2010. VTI, Linköping. Available at: http://vti.diva-portal.org/smash/get/diva2:670442/FULLTEXT01.pdf, last accessed on 13 August 2018.

- VTI - väg- och transportforskningsinstitut (2016): Parkeringsavgifter. En översikt av parkeringsavgifter i sex europeiska städer. VTI notat 28-2016. VTI, Linköping. Available at: http://vti.diva-portal.org/smash/get/diva2:1052312/FULLTEXT01.pdf, last accessed on 10 August 2018.

- WHO – World Health Organization (2011): Health co-benefits of climate change mitigation Transport sector. Health in the green economy. Available at: http://www.who.int/hia/green_economy/transport_sector_health_co-benefits_climate_change_mitigation/en/, last accessed on 12 September 2018.

# ANNEX A: OBJECTIVES OF AAQD AND 4DD

**Table 3: Limit values of the AAQD.**

| Pollutant | Averaging period | Limit value | Remark |
|---|---|---|---|
| $SO_2$ | One hour | 350 µg/m$^3$ | not to be exceeded more than 24 times per calendar year |
| $SO_2$ | One day | 125 µg/m$^3$ | not to be exceeded more than 3 times per calendar year |
| $NO_2$ | One hour | 200 µg/m$^3$ | not to be exceeded more than 18 times per calendar year |
| $NO_2$ | Calendar year | 40 µg/m$^3$ | |
| Benzene | Calendar year | 5 µg/m$^3$ | |
| CO | Maximum daily eight hour mean | 10 mg/m$^3$ | |
| Lead | Calendar year | 0.5 µg/m$^3$ | |
| $PM_{10}$ | One day | 50 µg/m$^3$ | not to be exceeded more than 35 times per calendar year |
| $PM_{10}$ | Calendar year | 40 µg/m$^3$ | |

**Source:** Directive 2008/50/EC on ambient air quality and cleaner air

**Table 4: Provisions for $PM_{2.5}$ of the AAQD.**

| Provision | Value | Year | Remark |
|---|---|---|---|
| Exposure concentration obligation | 20 µg/m$^3$ | 2015 | Average Exposure Indicator. Three year running mean 2013-2015 |
| Target value | 25 µg/m$^3$ | 2010 | Applicable throughout the territory |
| Limit value stage 1 | 25 µg/m$^3$ | 2015 | Applicable throughout the territory |
| Limit value stage 2 | 20 µg/m$^3$ | 2020 | Indicative limit value, no changes in 2013 review |

**Source:** Directive 2008/50/EC on ambient air quality and cleaner air

**Table 5: National exposure reduction target compared to the reference year for $PM_{2.5}$.**

| Initial concentration in µg/m³ | Reduction target in percent |
|---|---|
| < 8.5 = 8.5 | 0% |
| > 8.5 — < 13 | 10% |
| = 13 — < 18 | 15% |
| = 18 — < 22 | 20% |
| ≥ 22 | All appropriate measures to achieve 18 µg/m³ |

**Source:** Directive 2008/50/EC on ambient air quality and cleaner air

**Ozone target values and long-term objectives**

Target values

| Objective | Averaging period | Target value |
|---|---|---|
| Protection of human health | Maximum daily eight-hour mean | 120 µg/m³ not to be exceeded on more than 25 days per calendar year averaged over three years |
| Protection of vegetation | May to July | AOT40 (calculated from 1 h values) 18 000 µg/m³.h averaged over five years |

**Source:** Directive 2008/50/EC on ambient air quality and cleaner air

Long-term objectives

| Objective | Averaging period | Target value |
|---|---|---|
| Protection of human health | Maximum daily eight-hour mean within a calendar year | 120 µg/m³ |
| Protection of vegetation | May to July | AOT40 (calculated from 1 h values) 6 000 µg/m³.h, averaged over five years |

**Source:** Directive 2008/50/EC on ambient air quality and cleaner air

Information and alert thresholds for ozone

| Purpose | Averaging period | Thresholds |
|---|---|---|
| Information | 1 hour | 180 µg/m³ |
| Alert | 1 hour | 240 µg/m³ |

**Source:** Directive 2008/50/EC on ambient air quality and cleaner air

**Critical levels for the protection of vegetation**

Sampling points shall be representative for an area of at least 1 000 $km^2$ and shall be sited at a certain distance from agglomerations, industry and major roads.

| Pollutant | Averaging period | Critical level |
|---|---|---|
| $SO_2$ | Calendar year and winter (1 October to 31 March) | 20 µg/$m^3$ |
| $NO_x$ | Calendar year | 30 µg/$m^3$ |

**Source:** Directive 2008/50/EC on ambient air quality and cleaner air

**Target value of the 4th Daughter Directive**

Total content in $PM_{10}$ averaged over a calendar year.

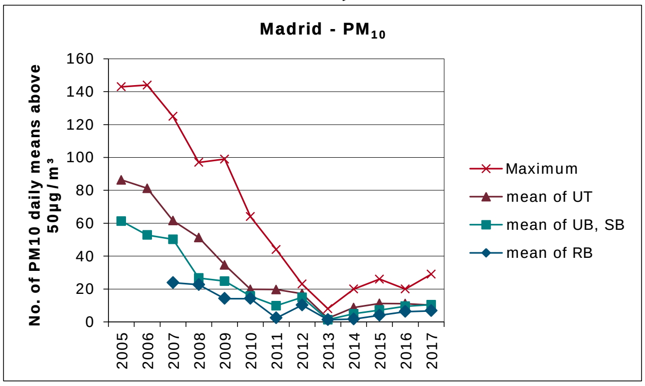
| Pollutant | Target value |
|---|---|
| As | 6 ng/$m^3$ |
| Cd | 5 ng/$m^3$ |
| Ni | 20 ng/$m^3$ |
| BaP | 1 ng/$m^3$ |

**Source:** 4DD.

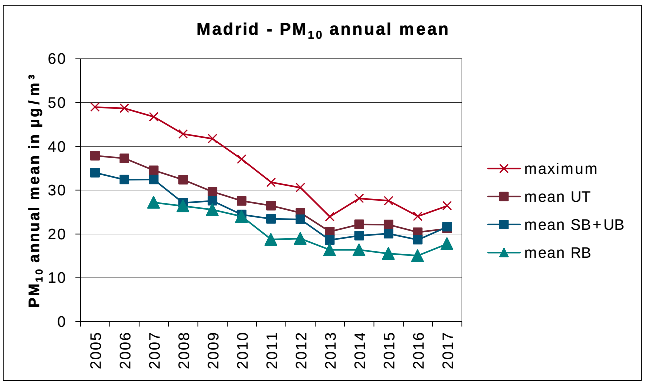
# ANNEX B: AIR QUALITY TRENDS IN DETAIL

## Madrid

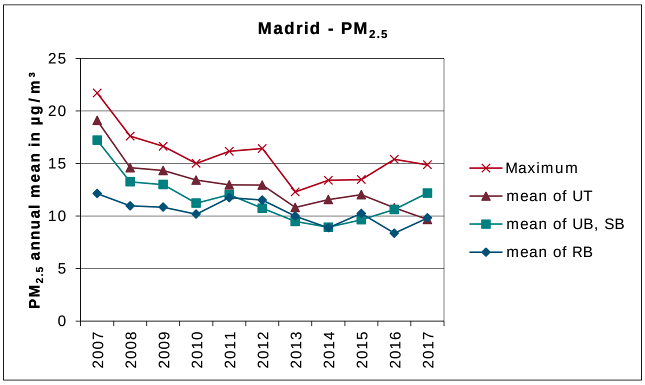
### $PM_{10}$ exceedances of the daily mean limit value



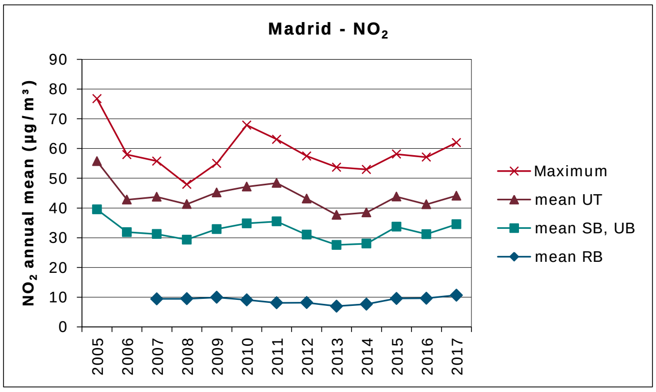

### $PM_{10}$ annual mean



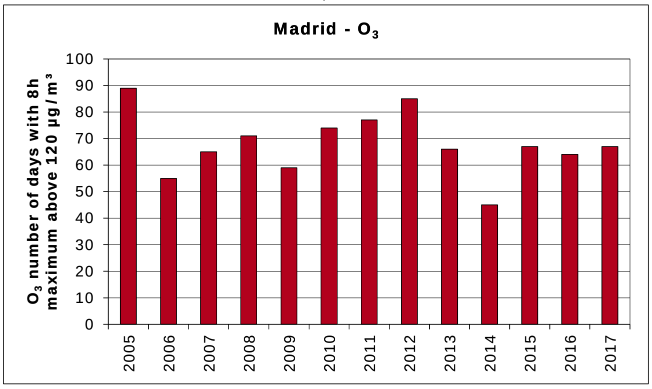

### $PM_{2.5}$ annual mean



## $NO_2$ annual mean values

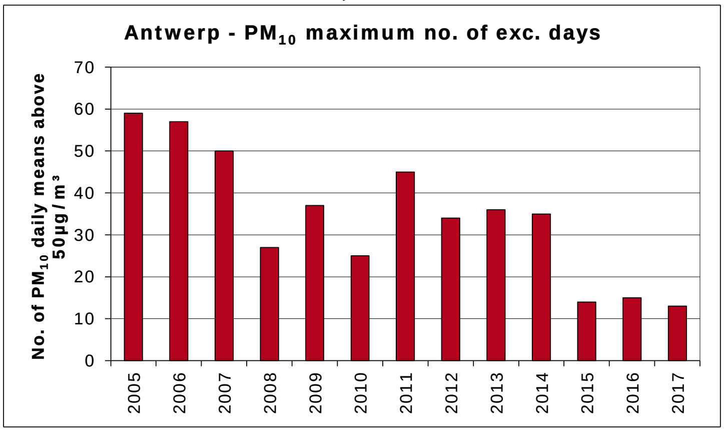



## $O_3$ maximum number of days with 8h mean levels above 120 µg/m³

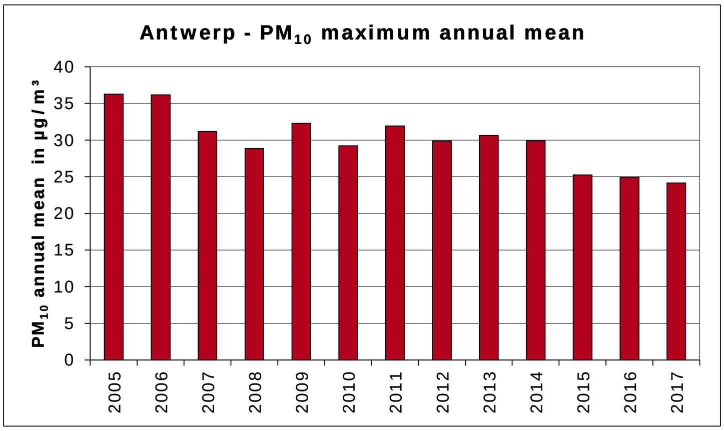



# Antwerp, Brussels

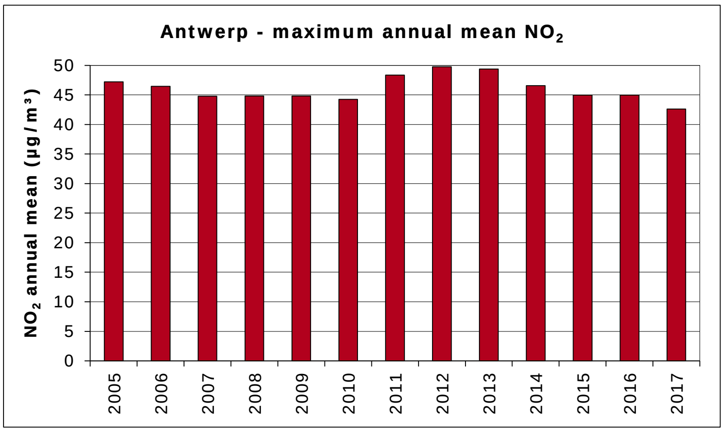
## $PM_{10}$ exceedances of the daily mean limit value



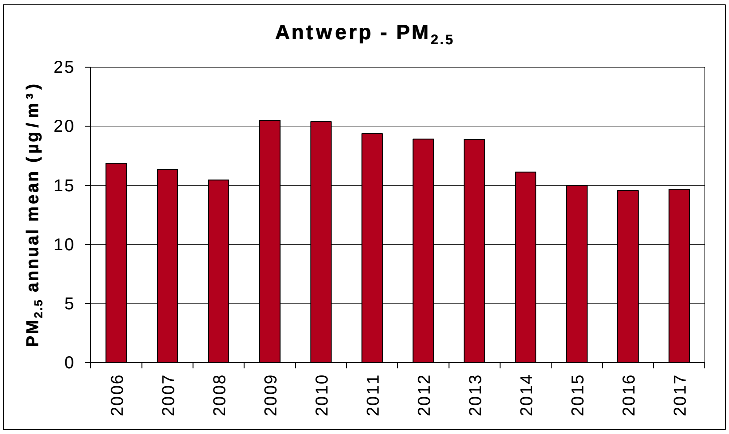
### $PM_{10}$ maximum annual mean



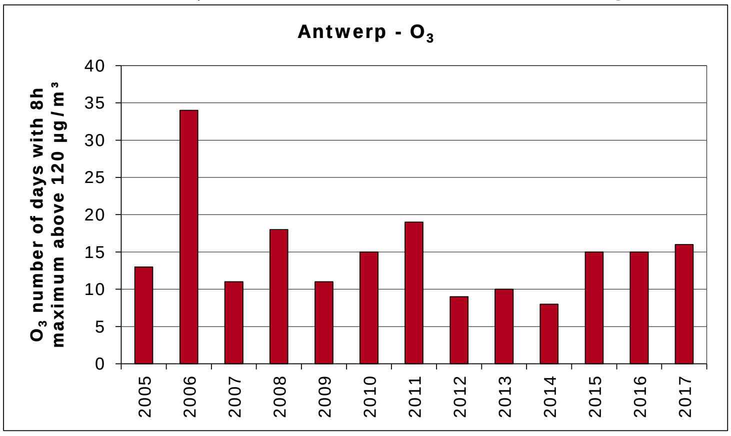

### $NO_2$ maximum annual mean



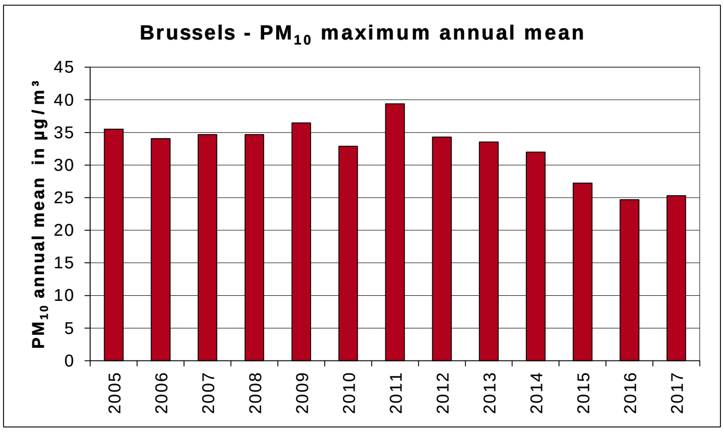

### $PM_{2.5}$ maximum annual mean



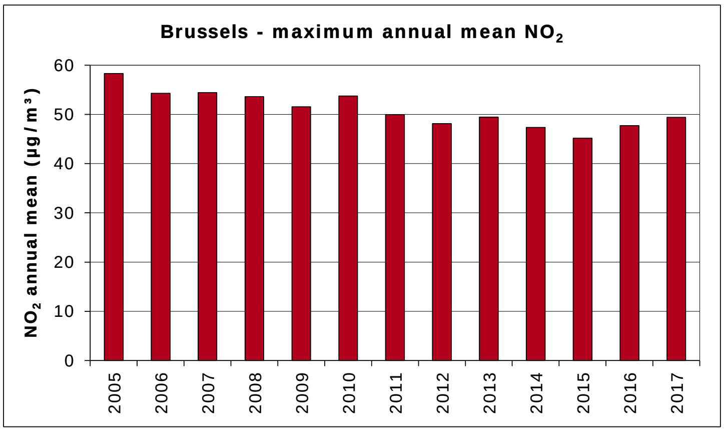
**$O_3$ number of days with 8h mean levels above 120 μg/m³**



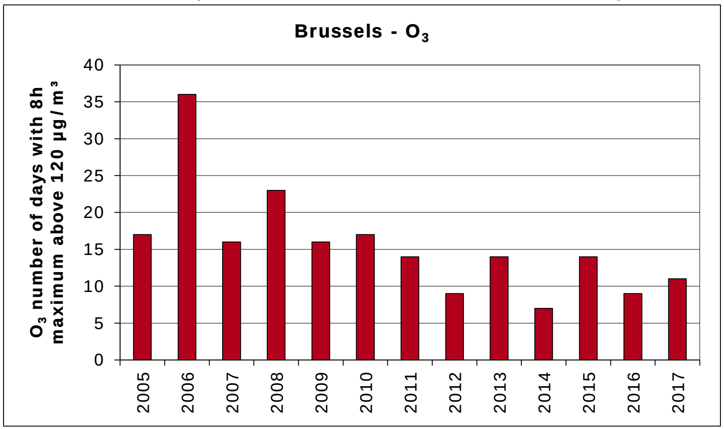

**$PM_{10}$ maximum annual mean**




**$NO_2$ maximum annual mean**

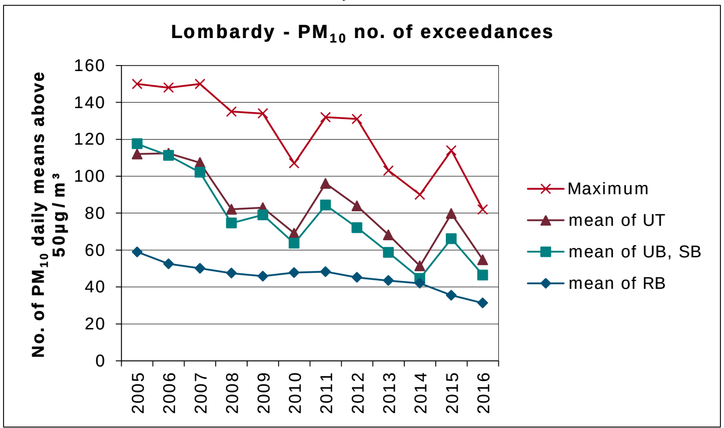


### $O_3$ number of days with 8h mean levels above 120 µg/m³

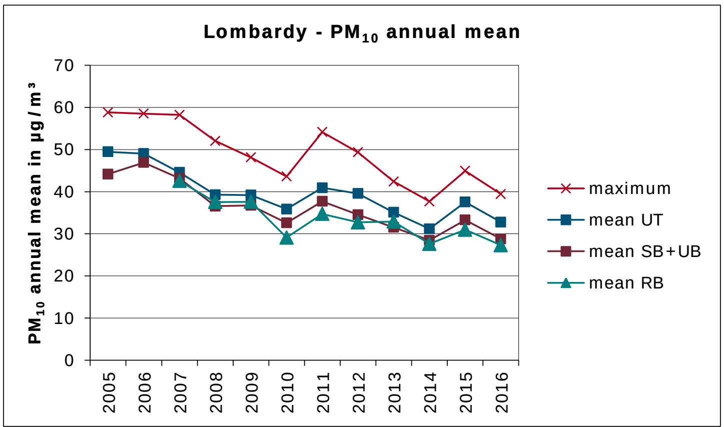



## Lombardy

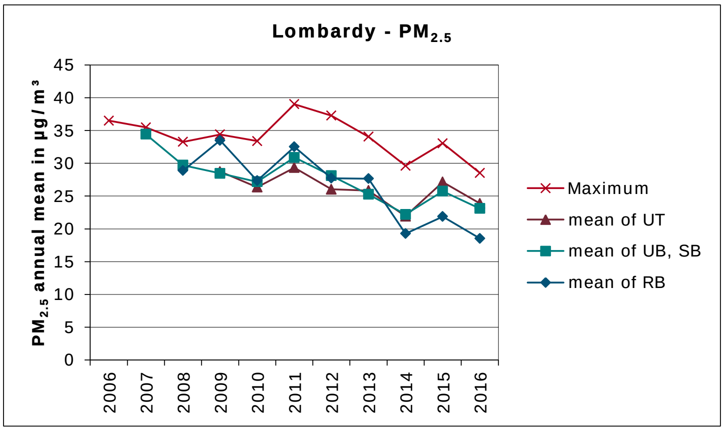
### $PM_{10}$ exceedances of the daily mean limit value



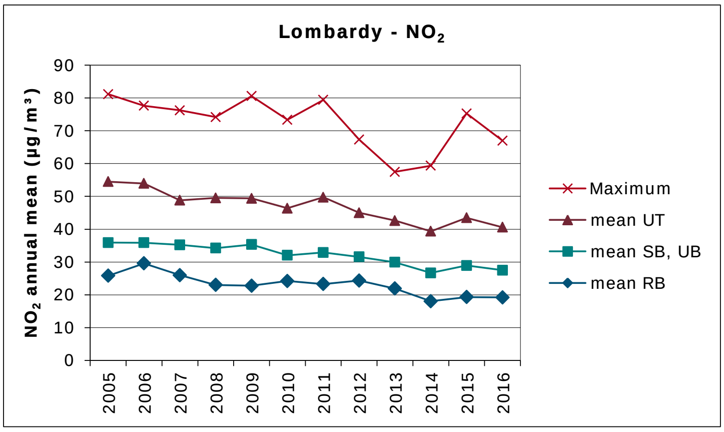

### $PM_{10}$ annual mean



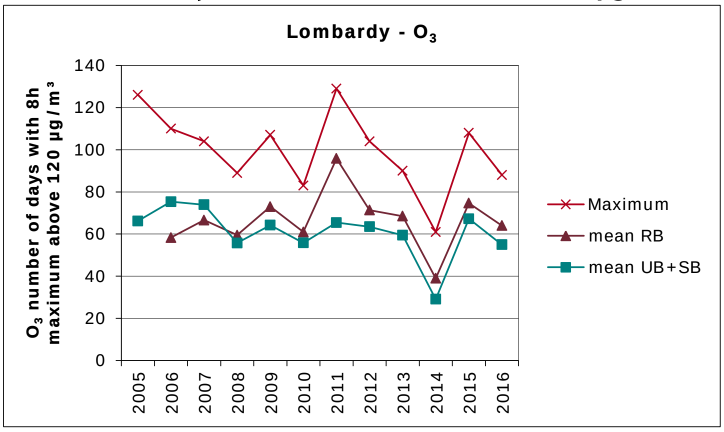
### $PM_{2.5}$ annual mean



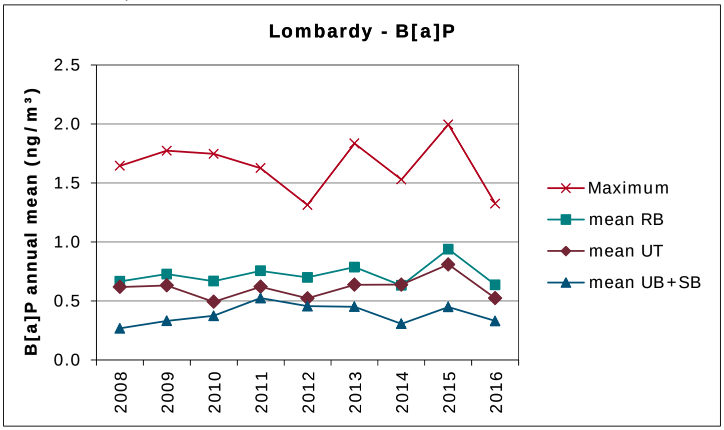

### $NO_2$ annual mean values




### $O_3$ number of days with 8h mean levels above 120 µg/m³

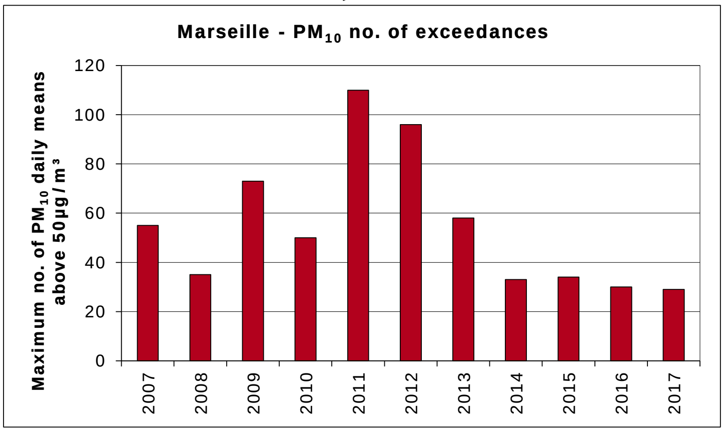


**Benzo[a]pyren annual mean**

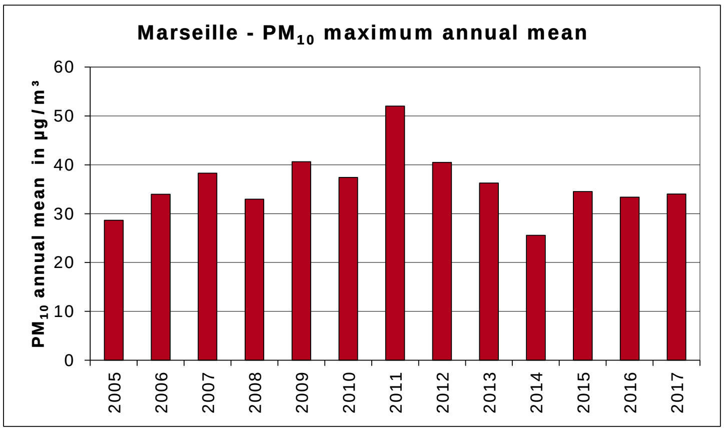



## France (Marseille, Paris)

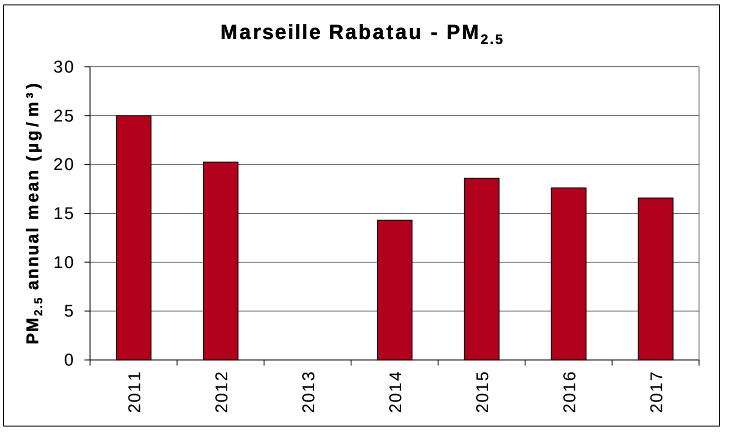
**$PM_{10}$ exceedances of the daily mean limit value**



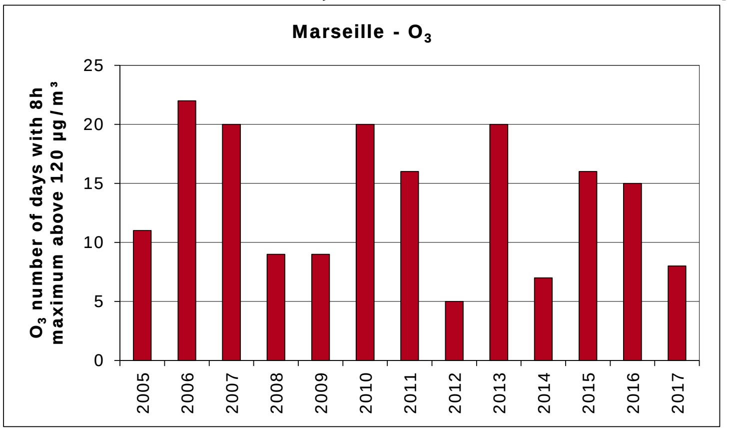

**$PM_{10}$ maximum annual mean**



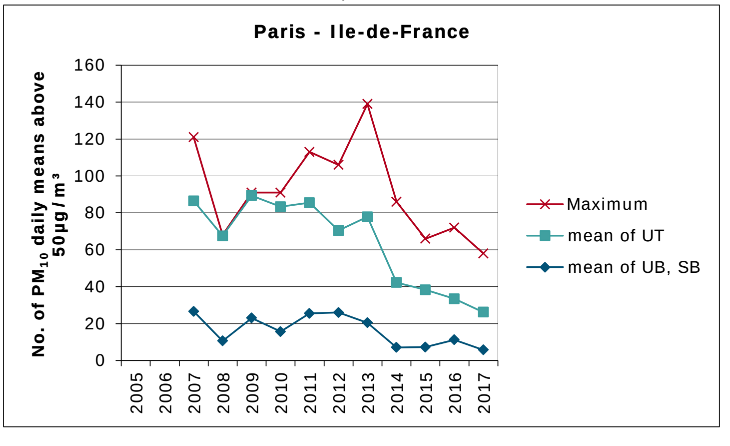
## $PM_{2.5}$ annual mean



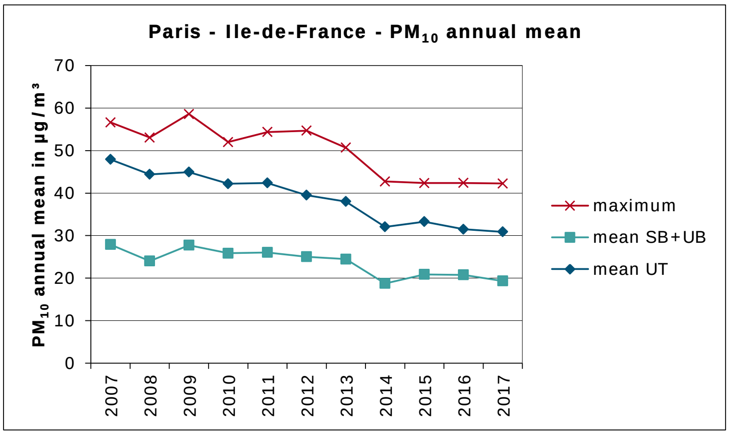

## $O_3$ maximum number of days with 8h mean levels above 120 µg/m³



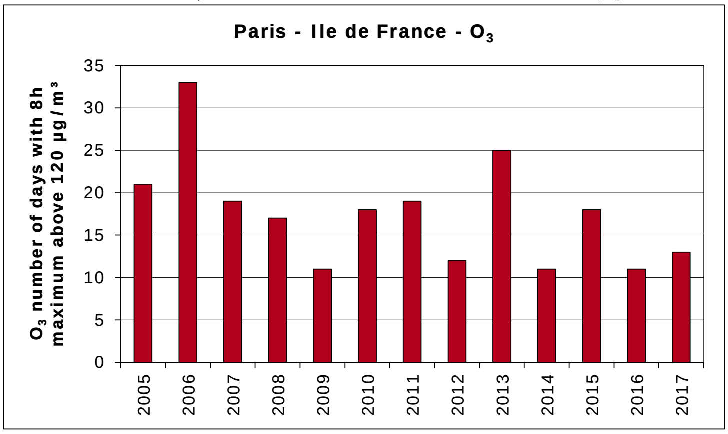

## $PM_{10}$ exceedances of the daily mean limit value



### $PM_{10}$ annual mean

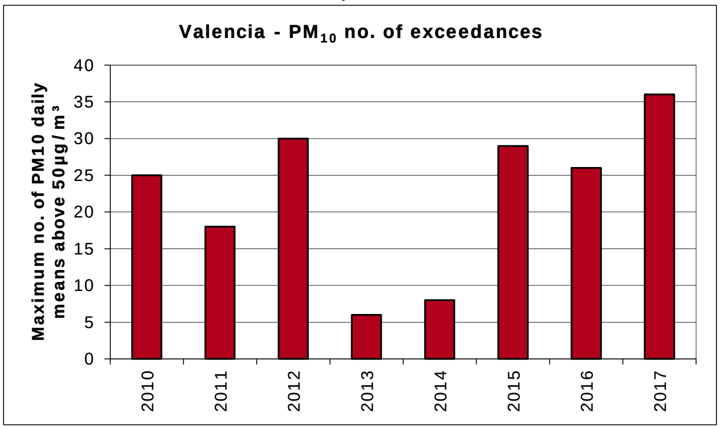



### $O_3$ number of days with 8h mean levels above 120 µg/m³

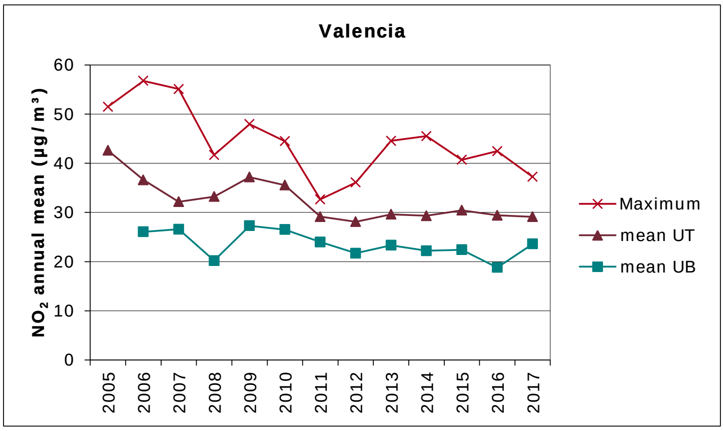



## Valencia

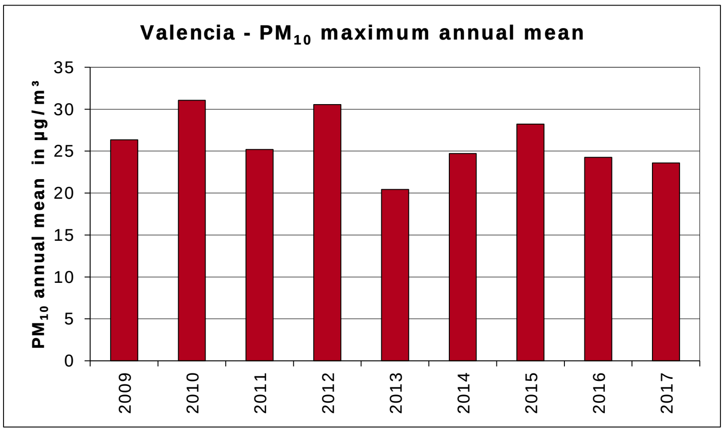
### $PM_{10}$ exceedances of the daily mean limit value



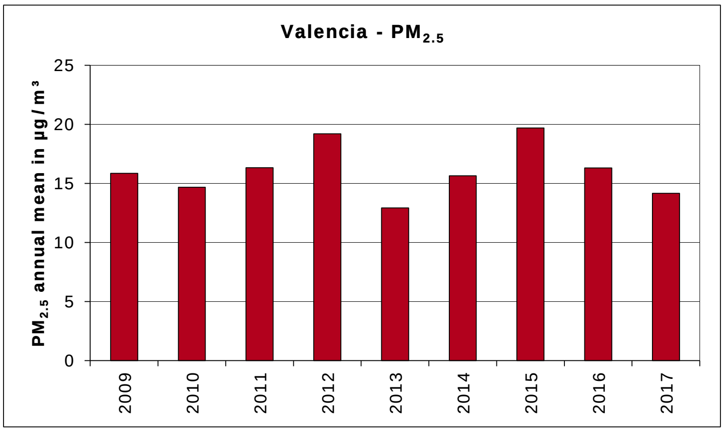
## $NO_2$ annual mean levels




## $PM_{10}$ maximum annual mean

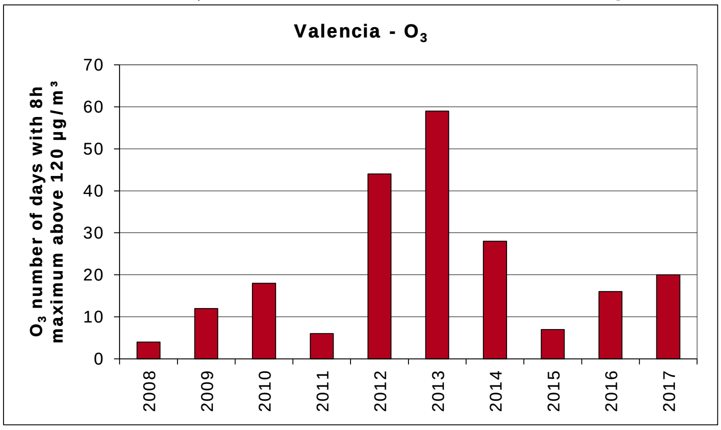



## $PM_{2.5}$ maximum annual mean level




N.B.: No data for 2017 available for the site (València-Vivers) that had highest levels in the years before.

**$O_3$ number of days with 8h mean levels above 120 µg/m$^3$**



# ANNEX C: TREND STATISTICS

**Table 6: Statistics for annual mean $PM_{10}$ trends (n: number of annual means available between 2005 and 2017. Signif.: tested significance levels of the trends. Slope: Sen's slope estimate).**

| city | station | n | signif. | slope |
|---|---|---|---|---|
| Antwerp | 40AL01 - LINKEROEVER | 13 | 0.1 | -0.6 |
| | 40HB23 - HOBOKEN | 13 | 0.001 | -1.1 |
| | 42R801 - BORGERHOUT | 13 | 0.01 | -0.9 |
| | 42R811 - SCHOTEN | 13 | 0.1 | -0.8 |
| Brussels | 41B011 - BERCHEM S.A | 13 | 0.01 | -1.0 |
| | 41N043 - HAREN | 13 | 0.01 | -0.8 |
| | 41R001 - MOLENBEEK | 13 | 0.001 | -1.0 |
| | 41R012 - UCCLE | 13 | 0.01 | -0.8 |
| | 41WOL1 - WOL.ST.L. | 13 | 0.001 | -0.8 |
| Paris | TREMBLAY-EN-FRANCE | 11 | | -0.4 |
| | BOBIGNY | 12 | 0.05 | -0.9 |
| | CERGY-PONTOISE | 13 | | -0.5 |
| | GENNEVILLIERS | 13 | | -0.5 |
| | LA DEFENSE | 13 | 0.1 | -0.7 |
| | LOGNES | 13 | | -0.3 |
| | NOGENT-SUR-MARNE | 13 | | -0.4 |
| | PARIS 18eme | 13 | | -0.5 |
| | VITRY-SUR-SEINE | 13 | | -0.4 |
| | Auto A1 -Saint-Denis | 11 | 0.01 | -1.6 |
| | Av Champs Elysees | 10 | | -0.7 |
| | Place Victor Basch | 12 | 0.05 | -0.9 |
| Marseille | MARSEILLE 5 AVENUES | 12 | | -0.3 |
| | MARSEILLE ST LOUIS | 11 | | 0.1 |
| Madrid | EL ATAZAR | 11 | | -0.9 |
| | GUADALIX DE LA SIERRA | 11 | 0.05 | -1.4 |
| | ORUSCO DE TAJUÑA | 11 | 0.05 | -1.2 |

| city | station | n | signif. | slope |
|---|---|---|---|---|
| | VILLA DEL PRADO | 11 | 0.01 | -1.4 |
| | CASA DE CAMPO | 13 | 0.01 | -0.9 |
| | MAJADAHONDA | 13 | 0.01 | -0.6 |
| | ARANJUEZ | 13 | 0.001 | -1.2 |
| | FAROLILLO | 13 | 0.05 | -0.9 |
| | MÓSTOLES | 13 | 0.001 | -1.4 |
| | PUENTE DE VALLECAS | 13 | 0.01 | -1.0 |
| | TORREJON DE ARDOZ | 13 | 0.001 | -2.7 |
| | ALCOBENDAS | 13 | 0.05 | -1.2 |
| | ARGANDA DEL REY | 11 | 0.01 | -1.1 |
| | FUENLABRADA | 13 | 0.001 | -1.5 |
| | ALCALÁ DE HENARES | 13 | 0.001 | -2.3 |
| | COLMENAR VIEJO | 13 | 0.05 | -0.9 |
| | COSLADA | 10 | 0.05 | -1.6 |
| | LEGANÉS | 13 | 0.01 | -2.5 |
| | MORATALAZ | 13 | 0.05 | -0.9 |
| Lombardy | CASIRATE D'ADDA | 11 | 0.01 | -1.7 |
| | SAN ROCCO AL PORTO | 11 | 0.05 | -0.9 |
| | BUSTO ARSIZIO - ACCAM | 12 | 0.01 | -1.9 |
| | CALUSCO | 10 | 0.05 | -1.4 |
| | CANTU - VIA MEUCCI | 12 | 0.05 | -1.5 |
| | OSIO SOTTO | 12 | 0.05 | -1.7 |
| | TAVAZZANO | 10 | 0.1 | -1.2 |
| | BERGAMO - VIA MEUCCI | 12 | 0.01 | -1.5 |
| | BORMIO | 12 | 0.05 | -0.7 |
| | BRESCIA VILLAGGIO SERENO | 11 | 0.001 | -1.6 |
| | CREMONA VIA FATEBENEFRATELLI | 10 | | -0.6 |
| | LIMITO | 12 | 0.01 | -1.8 |
| | MAGENTA | 11 | 0.05 | -1.0 |

| city | station | n | signif. | slope |
|---|---|---|---|---|
| | MANTOVA - VIA ARIOSTO | 12 | 0.001 | -1.8 |
| | MANTOVA SANT'AGNESE | 10 | 0.05 | -1.3 |
| | MONZA - VIA MACHIAVELLI | 11 | 0.01 | -1.7 |
| | SAREZZO | 12 | 0.001 | -1.4 |
| | SARONNO - SANTUARIO | 12 | 0.01 | -1.4 |
| | SONDRIO - VIA MAZZINI | 12 | 0.001 | -2.3 |
| | VOGHERA - VIA POZZONI | 10 | 0.01 | -1.7 |
| | ODOLO | 10 | | -0.6 |
| | REZZATO | 12 | 0.01 | -1.7 |
| | BRESCIA - BROLETTO | 12 | 0.01 | -1.4 |
| | CODOGNO | 10 | 0.01 | -2.2 |
| | COMO - VIALE CATTANEO | 12 | 0.01 | -1.7 |
| | LECCO VIA AMENDOLA | 12 | 0.01 | -1.1 |
| | LODI Vignati | 12 | 0.001 | -2.0 |
| | MANTOVA - piazza GRAMSCI | 10 | 0.05 | -0.8 |
| | MEDA | 12 | 0.01 | -1.9 |
| | MERATE | 12 | 0.001 | -2.2 |
| | MILANO - VERZIERE | 12 | 0.01 | -1.6 |
| | PAVIA - P.ZZA MINERVA | 12 | 0.1 | -0.7 |
| | TREVIGLIO | 12 | 0.01 | -1.7 |
| | VARESE - VIA COPELLI | 12 | | -0.6 |

**Source:** EEA[127], FMI (2002).

[127] http://eeadmz1-cws-wp-air.azurewebsites.net/products/data-viewers/statistical-viewer-expert/

**Table 7: Statistics for annual mean $NO_2$ trends (n: number of annual means available between 2005 and 2017. Signif.: tested significance levels of the trends. Slope: Sen's slope estimate).**

| city | station | n | signif. | slope |
|---|---|---|---|---|
| Antwerp | 42R811 - SCHOTEN | 12 | 0.001 | -0.9 |
| | 42R831 - BERENDRECHT | 12 | 0.01 | -0.6 |
| | 42R893 - ANTWERPEN | 13 | 0.01 | -0.7 |
| | 42R897 - ANTWERPEN | 10 | 0.01 | -0.4 |
| | 42M802 - ANTWERPEN | 13 | 0.001 | -1.0 |
| | 42R801 - BORGERHOUT | 13 | 0.001 | -0.8 |
| | 40HB23 - HOBOKEN | 12 | 0.001 | -0.8 |
| Brussels | 41MEU1 - MEUDON | 12 | 0.05 | -0.6 |
| | 41R012 - UCCLE | 13 | 0.001 | -0.9 |
| | 41N043 - HAREN | 13 | 0.001 | -0.5 |
| | 41R002 - IXELLES | 9 | 0.05 | -0.6 |
| | 41WOL1 - WOL.ST.L. | 9 | | -0.6 |
| | 41B006 - PARL.EUROPE | 11 | 0.01 | -0.7 |
| | 41B004 - STE.CATHERI | 11 | 0.01 | -1.1 |
| | 41R001 - MOLENBEEK | 13 | 0.001 | -1.1 |
| | 41B011 - BERCHEM S.A | 13 | 0.001 | -0.8 |
| Paris | GONESSE | 13 | 0.01 | -0.4 |
| | MANTES-LA-JOLIE | 13 | 0.001 | -0.4 |
| | MELUN | 13 | 0.01 | -0.4 |
| | TREMBLAY-EN-FRANCE | 13 | 0.05 | -0.5 |
| | VERSAILLES | 13 | 0.05 | -0.5 |
| | ARGENTEUIL | 13 | 0.01 | -0.6 |
| | AUBERVILLIERS | 13 | 0.05 | -0.4 |
| | BOBIGNY | 13 | 0.001 | -0.5 |
| | CHAMPIGNY-SUR-MARNE | 13 | 0.05 | -0.4 |
| | EVRY | 13 | 0.01 | -0.6 |
| | GENNEVILLIERS | 13 | 0.01 | -0.4 |

| city | station | n | signif. | slope |
|---|---|---|---|---|
| | IVRY-SUR-SEINE | 9 | 0.05 | -0.4 |
| | LA DEFENSE | 13 | 0.001 | -1.0 |
| | LOGNES | 13 | 0.01 | -0.5 |
| | MONTGERON | 13 | 0.05 | -0.4 |
| | NEUILLY-SUR-SEINE | 13 | 0.001 | -0.7 |
| | PARIS 12eme | 11 | 0.01 | -0.4 |
| | PARIS 13eme | 10 | 0.01 | -0.8 |
| | PARIS 18eme | 13 | 0.001 | -0.7 |
| | PARIS 7eme | 13 | 0.01 | -0.8 |
| | SAINT-DENIS | 13 | 0.001 | -0.6 |
| | VILLEMOMBLE | 13 | 0.01 | -0.5 |
| | VITRY-SUR-SEINE | 13 | 0.01 | -0.6 |
| | Auto A1 -Saint-Denis | 13 | 0.05 | -0.8 |
| | Av Champs Elysees | 13 | 0.01 | -1.6 |
| | Place Victor Basch | 13 | 0.001 | -1.7 |
| | Quai des Celestins | 13 | 0.001 | -1.9 |
| | Rue Bonaparte | 13 | 0.001 | -1.7 |
| Marseille | MARSEILLE 5 AVENUES | 9 | 0.1 | -0.5 |
| | MARSEILLE PLOMBIERES | 9 | 0.01 | -0.9 |
| | MARSEILLE RABATAU | 11 | 0.05 | -0.8 |
| | MARSEILLE ST LOUIS | 11 | | -0.2 |
| Madrid | EL ATAZAR | 11 | | 0.1 |
| | GUADALIX DE LA SIERRA | 11 | | -0.1 |
| | ORUSCO DE TAJUÑA | 11 | | 0.0 |
| | SAN MARTIN DE VALDEIGLESIAS | 11 | | 0.0 |
| | VILLA DEL PRADO | 11 | | 0.1 |
| | VILLAREJO DE SALVANES | 11 | | 0.0 |
| | ALGETE | 11 | | -0.2 |
| | CASA DE CAMPO | 13 | 0.05 | -1.1 |

| city | station | n | signif. | slope |
|---|---|---|---|---|
| | MAJADAHONDA | 13 | | 0.2 |
| | RIVAS-VACIAMADRID | 11 | | 0.6 |
| | VALDEMORO | 11 | | -0.3 |
| | ARANJUEZ | 13 | 0.05 | -0.4 |
| | ARTURO SORIA | 10 | | -0.9 |
| | FAROLILLO | 13 | 0.01 | -1.4 |
| | MÓSTOLES | 13 | 0.1 | -0.7 |
| | PLAZA DEL CARMEN | 9 | | -0.7 |
| | PUENTE DE VALLECAS | 10 | | 0.0 |
| | TORREJON DE ARDOZ | 13 | 0.1 | 0.3 |
| | ALCOBENDAS | 13 | 0.05 | -1.6 |
| | ARGANDA DEL REY | 11 | | 0.3 |
| | FUENLABRADA | 13 | | -1.2 |
| | ALCALÁ DE HENARES | 13 | | 0.1 |
| | BARRIO DEL PILAR | 13 | 0.01 | -1.2 |
| | COLLADO VILLALBA | 11 | | 0.0 |
| | COLMENAR VIEJO | 13 | | -0.5 |
| | COSLADA | 9 | 0.05 | -1.6 |
| | CUATRO CAMINOS-PABLO IGLESIAS | 10 | 0.1 | -1.5 |
| | ESCUELAS AGUIRRE | 9 | | 0.6 |
| | LEGANÉS | 13 | 0.05 | -0.7 |
| | MORATALAZ | 13 | 0.01 | -1.9 |
| | PLAZA DE ESPAÑA | 9 | | -0.6 |
| | RAMÓN Y CAJAL | 10 | 0.05 | -1.2 |
| Valencia | PATERNA-CEAM | 10 | | -0.4 |
| | VALÈNCIA-VIVERS | 13 | 0.1 | -0.8 |
| | BURJASSOT - FACULTATS | 13 | | -0.9 |
| | QUART DE POBLET | 13 | 0.1 | -0.9 |
| | VALÈNCIA-PISTA DE SILLA | 13 | 0.05 | -1.4 |

| city | station | n | signif. | slope |
|---|---|---|---|---|
| Lombardy | ABBADIA CERRETO | 10 | | -0.4 |
| | BORGOFRANCO | 10 | 0.01 | -0.9 |
| | CASIRATE D'ADDA | 11 | 0.1 | -1.2 |
| | CORNALE | 11 | | -0.2 |
| | GAMBARA | 12 | | -0.2 |
| | MOGGIO | 10 | 0.05 | -0.7 |
| | SCHIVENOGLIA | 10 | 0.1 | -0.4 |
| | ARCONATE | 12 | 0.01 | -1.5 |
| | BUSTO ARSIZIO - ACCAM | 12 | 0.01 | -1.2 |
| | CALUSCO | 10 | 0.05 | -1.2 |
| | CANTU - VIA MEUCCI | 12 | 0.05 | -2.0 |
| | COLICO | 12 | | -0.2 |
| | CREMA | 12 | 0.05 | -0.7 |
| | OSIO SOTTO | 12 | | -0.5 |
| | PONTI SUL MINCIO | 10 | | -1.3 |
| | SAN ROCCO AL PORTO | 11 | 0.001 | -1.4 |
| | TAVAZZANO | 10 | | -0.4 |
| | VALMADRERA | 11 | | -0.6 |
| | REZZATO | 12 | 0.01 | -1.5 |
| | SORESINA | 10 | 0.05 | -0.7 |
| | BERGAMO - VIA MEUCCI | 12 | 0.01 | -1.6 |
| | BORMIO | 12 | | -0.1 |
| | CREMONA VIA FATEBENEFRATELLI | 11 | | -0.6 |
| | FERNO | 10 | | 0.1 |
| | LIMITO | 12 | 0.1 | -1.3 |
| | LONATO | 12 | | -0.2 |
| | MANTOVA SANT'AGNESE | 10 | 0.01 | -2.1 |
| | MONZA - VIA MACHIAVELLI | 11 | | 0.2 |
| | MORBEGNO | 10 | 0.05 | -1.3 |

| city | station | n | signif. | slope |
|---|---|---|---|---|
| | PAVIA - VIA FOLPERTI | 12 | 0.05 | -1.4 |
| | SAREZZO | 12 | 0.05 | -1.2 |
| | SARONNO - SANTUARIO | 12 | | -0.8 |
| | VARESE - VIA VIDOLETTI | 12 | | -0.4 |
| | VOGHERA - VIA POZZONI | 11 | | -1.5 |
| | BERGAMO - VIA GARIBALDI | 12 | | -1.3 |
| | BRESCIA - BROLETTO | 12 | 0.05 | -1.3 |
| | CASSANO VIA MILANO | 10 | | -0.4 |
| | CODOGNO | 10 | | 0.1 |
| | COMO - VIALE CATTANEO | 12 | 0.01 | -2.6 |
| | CREMONA - P.ZZA CADORNA | 12 | 0.01 | -0.9 |
| | LECCO VIA AMENDOLA | 12 | 0.001 | -2.0 |
| | LODI Vignati | 12 | 0.05 | -1.5 |
| | MANTOVA - piazza GRAMSCI | 10 | 0.1 | -0.9 |
| | MEDA | 12 | | -0.1 |
| | MERATE | 12 | 0.001 | -1.6 |
| | MILANO - SENATO | 12 | 0.1 | -1.1 |
| | MILANO - V.LE MARCHE | 12 | 0.05 | -1.1 |
| | MILANO - VERZIERE | 12 | 0.05 | -1.1 |
| | PAVIA - P.ZZA MINERVA | 12 | | -1.1 |
| | SONDRIO - VIA MAZZINI | 12 | | -0.6 |
| | TREVIGLIO | 12 | | -1.1 |
| | VARESE - VIA COPELLI | 12 | | -0.3 |

**Source:** EEA[127], FMI (2002).

This study, commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the request of the PETI Committee, aims at gaining deeper insights into air quality problems of cities and regions, which are often caused by traffic. Five cities and regions are analysed in more detail. General best practice examples and policy options are provided for transport, but also for domestic heating, construction work and integrated approaches.



Print ISBN 978-92-846-3852-9| doi: 10.2861/61641| QA-04-18-779-EN-C
PDF ISBN 978-92-846-3853-6|doi: 10.2861/029641 QA-04-18-779-EN-N