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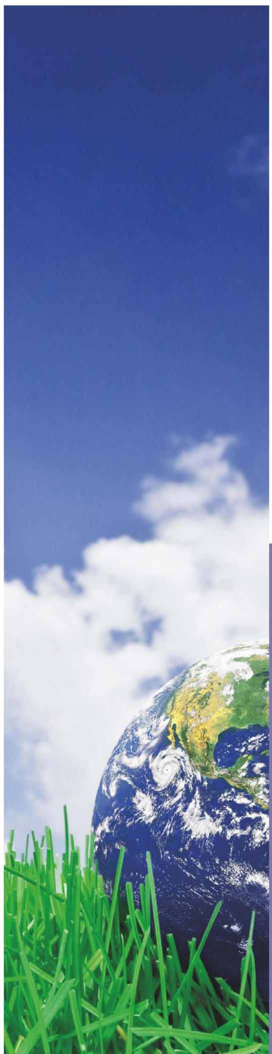

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Implementation of the Ambient Air Quality Directive

Study for the ENVI Committee

EN

2016

DIRECTORATE GENERAL FOR INTERNAL POLICIES

POLICY DEPARTMENT A: ECONOMIC AND SCIENTIFIC POLICY

Implementation of the Ambient Air Quality Directive

STUDY

Abstract

The Ambient Air Quality Directive sets thresholds for certain pollutants in ambient air to protect human health and the environment. Thresholds for particulate matter and nitrogen dioxide are exceeded in several Member States. This study analyses air pollution hotspots in Europe and infringement procedures launched by the European Commission against Member States in non-compliance. In addition, four hotspots are studied in more detail with respect to pollutant levels and approaches to air quality improvement.

This study is provided by Policy Department A at the request of the European Parliament's Committee on Environment, Public Health and Food Safety Committee.

IP/A/ENVI/2015-15REV April 2016

PE 578.986 EN

This document was requested by the European Parliament's Committee on Environment, Public Health and Food Safety.

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LINGUISTIC VERSIONS

Original: EN

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Manuscript completed in April 2016

This document is available on the Internet at:
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LIST OF ABBREVIATIONS

4DD	4th Daughter Directive
AAQD	Ambient Air Quality Directive
AEI	Average Exposure Indicator
As	Arsenic
BaP	Benzo[a]pyrene
BAT	Best Available Techniques
CADC	Common Artemis Driving Cycles
CAFE	Clean Air For Europe
Cd	Cadmium
CH_4	Methane
ECO	Exposure Concentration Obligation
EEA	European Environment Agency
GAINS	Greenhouse Gas - Air Pollution Interactions and Synergies
GDP	Gross domestic product
IED	Industrial Emissions Directive
IIASA	International Institute for Applied Systems Analysis
LEZ	Low Emission Zone
MCPD	Medium Combustion Plant Directive
NAPCP	National Air Pollution Control Programme
NECD	National Emission Ceilings Directive
NEDC	New European Driving Cycle
NERT	National Exposure Reduction Target
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
NRMM	Non-road Mobile Machinery
PAH	Polycyclic Aromatic Hydrocarbons
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
RDE	Real Driving Emission
SO_2	Sulphur dioxide
SUMP	Sustainable Urban Mobility Plan
TFEU	Treaty on the Functioning of the European Union
ULEZ	Ultra Low Emission Zone
VOC	Volatile Organic Compounds
WHO	World Health Organization

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EXECUTIVE SUMMARY

Background

Exposure to elevated air pollution levels has substantial negative impacts on human health and the environment. The main pollutants are particulate matter (PM_{10}, $PM_{2.5}$), nitrogen dioxide (NO_2) and ozone (O_3). The Ambient Air Quality Directive (AAQD, Directive 2008/50/EC) therefore sets thresholds and objectives for the permissible concentrations of air pollutants.

These limit values should have been complied with from 2005 onwards (SO_2, CO, Pb, PM_{10}) or from 2010 onwards (NO_2, benzene). Postponing the deadline (until 2015 for NO_2 and benzene and until June 2011 for PM_{10}) has been possible under specific circumstances. When limit or target values are exceeded, Member States have to establish air quality plans. The air quality plan has to include appropriate measures so that the exceedance period can be kept as short as possible.

Compliance in the EU

In the year 2014, PM_{10} and NO_2 limit values were exceeded in all but five Member States. As of October 2016, the European Commission had infringement procedures against 19 of the 28 Member States open - amounting to a total of 29 infringement procedures covering three pollutants (incl. 16 Member States on PM_{10}, 12 Member States on NO_2, one Member State on SO_2). Ten Member States have been referred to the Court of Justice for exceeding the PM_{10} limit values, but four of these cases have not been executed. For exceedances of NO_2 and SO_2 none of the Member States has been taken to Court so far. The target value for $PM_{2.5}$ was exceeded in six Member States in 2014.

Implementation problems and hotspots

PM_{10} hotspots in the EU are Eastern European countries, Northern Italy (Po valley) and Belgium/Netherlands. Exceedances are mainly caused by domestic heating as a result of the burning of solid fuels (coal, biomass) and by traffic, industry, and contributions from secondary (transboundary) particles. PM_{10} levels showed some decrease in Western European countries in recent years, but have remained stable in Eastern Europe.

NO_2 limit values are mainly exceeded in large urban areas close to heavily trafficked roads. Diesel vehicles are the primary cause of these exceedances. NO_2 levels showed a small decline at some of the hotspots but constant trends prevail at others.

Main factors impacting pollutant levels

Four hotspots were analysed in more detail:

- Milan, capital of Lombardy in the Po valley (PM_{10} and NO_2 non-compliance).
- London, capital of the United Kingdom (NO_2 non-compliance).
- Krakow, capital of the Lesser Poland Voivodeship (PM_{10} non-compliance).
- Plovdiv, second largest city in Bulgaria (PM_{10} non-compliance).

In Milan, emissions arise mainly from traffic (diesel vehicles), domestic heating (biomass burning) and industry. High pollution levels are favoured by adverse dispersion conditions with rather low wind speeds especially during winter time.

The main reason for NO_2 exceedances in Greater London is road traffic (mainly diesel vehicles).

In Krakow and Plovdiv the main sources of PM_{10} are domestic heating, local industry and traffic.

Measures taken in case of non-compliance

The city of Milan introduced a low emission zone, a charging scheme for vehicles, access restrictions and regulations for biomass burning.

London has implemented a low emission zone, which will be strengthened from 2020 onwards, and a congestion charge. Also, the London bus and taxi fleets are being renewed by replacing Euro III buses with Euro VI and hybrid-electric buses, and by introducing new rules requiring newly licensed taxis to be zero emission capable from 2018. Furthermore, walking and cycling are being promoted.

Krakow's measures focuses on domestic heating, the main measure being a ban on solid fuel heating from 2019. In addition, district heating and gas networks are being extended and building renovations promoted.

In Plovdiv the issue of domestic heating is mainly addressed by providing grants and incentives for the renewal of appliances.

Trends and future prospects for $PM_{2.5}$

$PM_{2.5}$ levels exceeded the target value in 2014 in six Member States; the highest levels were observed in the Czech Republic, Poland and Bulgaria. For these three countries it is doubtful whether compliance with the limit value and the exposure concentration obligation was achieved in 2015, the year in which both objectives had to be met[1].

The Clean Air Policy Package of the European Commission aims at a reduction of $PM_{2.5}$ impacts on human health by 50 % up to 2030 (compared to 2005, European Commission 2013a). Furthermore, under the Clean Air Policy Package, most Member States would reach average urban $PM_{2.5}$ levels close to the WHO guideline value.

Policy options to achieve full compliance

To reduce PM emissions from domestic heating, further measures addressing solid fuel burning need to be implemented. Solid fuel burning has already been banned in some cities and will be restricted in further cities in the future. The measures should be accompanied by and coordinated with renovation schemes to improve energy efficiency.

Industrial sources should be tackled by permits that could even go beyond best available techniques. In addition, inspections of facilities should be carried out more often.

Agricultural waste burning should be banned so as to reduce PM levels on the suburban and regional scale.

Regional background PM concentrations are in many areas most efficiently reduced by tackling NH_3 emissions and thus reducing secondary inorganic particle formation.

Measures to achieve NO_2 compliance have to address in particular diesel vehicles e.g. by introducing progressively stringent low emission zones and thus reducing or even banning diesel vehicles from inner city areas. Measures for motorized vehicles should, however, also address alternatives such as public transport, walking and cycling. Transport demands in general are to be addressed via the implementation of strategic urban mobility plans.

[1] The officially reported air quality data for 2015 will not be available before October 2016.

Relationship and interaction with other legislation

The European air quality policy includes several interlinked instruments such as the National Emission Ceilings Directive (NECD, Directive 2001/81/EC) and source related regulations and standards and product regulations (such as the Directive on sulphur content of liquid fuels 1999/32/EC, Directive on the quality of liquid fuels 2003/17/EC, or the Paints Directive (2004/42/EC). The NECD, currently under revision, limits emissions of selected air pollutants in the Member States with the aim to reduce the health and environmental impacts attributed to transboundary pollution. Important source related regulations include the Industrial Emissions Directive 2010/75/EU (IED), the EURO standards for mobile sources, the Ecodesign Directive 2009/125/EC and the Medium Combustion Plant Directive 2015/2193/EU (MCPD).

Emissions from industrial installations are limited under the IED in particular through application of best available techniques.

The Medium Combustion Plant Directive covers combustion plants between 1 and 50 MW, which are an important source of emissions of sulphur dioxide, nitrogen dioxide and PM in the EU.

Emissions from domestic heating devices, like boilers and ovens, are partly addressed by the Ecodesign Directive. These devices are a main source of PM and black carbon emissions in the EU.

Air pollutants from vehicles should be reduced significantly by implementing Euro 5 and Euro 6 emission standards for light vehicles and the Euro VI standard for heavy duty vehicles. However, differences in NO_x emission levels between type approval tests and real world emissions of vehicles lead to exceedances of NO_2 limit values in cities in Europe. The use of diesel particle filters has reduced PM exhaust emissions from vehicles considerably.

Concerning the interaction between climate change and air quality, a coordinated policy strategy can lead to benefits in both areas.

Outlook

One of the main objectives of the Clean Air Policy Package is to achieve full compliance with existing limit values by 2020 at the latest, e.g. by transposing the amended Gothenburg Protocol, which includes commitments to limit national total emissions of $PM_{2.5}$, PM and ozone precursors from 2020 onwards. However, these objectives will most probably not be achieved for PM_{10}, $PM_{2.5}$ and NO_2 in several air quality hotspots in Europe. Almost full compliance can however be achieved by 2030 if stringent measures are implemented on a European, national and local scale. The large differences between laboratory conditions and real driving emissions even for Euro 6 diesel vehicles will however further delay compliance with NO_2 limit values.

GENERAL INFORMATION

KEY FINDINGS

- Ambient air pollution is a major threat to human health.
- Various sources on different spatial scales contribute to elevated levels of particulate matter, nitrogen dioxide and ozone.
- Levels of air pollution have declined in most European regions in recent years, but are still increasing in some developing countries.

Exposure to elevated air pollution levels, especially to particulate matter (measured as PM_{10}, $PM_{2.5}$), nitrogen dioxide (NO_2) and ozone (O_3), has substantial negative impacts on human health. Studies analysed and reviewed by the World Health Organization WHO[2] clearly support the conclusion that air pollution is causing considerable adverse health impacts, in particular exposure to ambient $PM_{2.5}$ (WHO 2013a, 2013b). Though levels have declined in recent years air pollution is still one of the most important environmental risk factors for human health in Europe (Lim et al. 2012). Next to human health, air pollutants also affect the environment through ecosystem acidification and eutrophication.

In general, air pollutants come from a variety of sources, both anthropogenic and natural[3]. Ozone and some constituents of PM are secondary pollutants, formed by precursors in the atmosphere. The main sources of primary PM are emissions from traffic, industry and domestic heating; precursors of secondary PM are nitrogen oxides (NO_x), ammonia (NH_3), sulphur dioxide (SO_2) and various organic substances. O_3 is formed by photochemical reactions mainly of volatile organic compounds (VOCs) and NO_x, and on a larger geographical scale also by carbon monoxide and methane. NO_x is emitted mainly by traffic, industry and households, while VOCs originate mainly from solvent and product use in commerce, industry, households and traffic, but also from natural sources. The relatively long atmospheric lifetime of PM and O_3 emissions leads to impacts on a wide geographical scale; thus the control of these pollutants requires national and international cooperation.

Levels of air pollutants have increased with industrialization, urbanization and the rise of motorized traffic. They peaked in Europe in the 1970s up until the 1990s and showed a decline in the years thereafter (Mylona 1996). For SO_2 this decline has been strongest, whereas for O_3 only the peak concentrations declined and the average concentrations even increased until some years ago (TFMM 2015). Globally air pollution is still on the rise in several developing countries (UNECE 2010).

[2] http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/activities/health-aspects-of-air-pollution-and-review-of-eu-policies-the-revihaap-and-hrapie-projects

[3] for an overview see e.g. EEA 2013

1. INTRODUCTION

KEY FINDINGS

- Air quality thresholds to protect human health and the environment are laid down in the Ambient Air Quality Directive.
- Legally binding limit values are breached in several Member States.

The Ambient Air Quality Directive (AAQD, Directive 2008/50/EC) sets thresholds and objectives for ambient air concentrations of air pollutants to protect human health and the environment. It covers the following pollutants:

- Sulphur dioxide (SO_2);
- Nitrogen dioxide (NO_2) and other nitrogen oxides;
- Particulate matter PM_{10} and $PM_{2.5}$;
- Lead (Pb) in PM_{10};
- Carbon monoxide (CO);
- Benzene (C_6H_6);
- Ozone (O_3).

It furthermore includes methods and criteria for the assessment of ambient air quality in the Member States. Based on specific conditions the AAQD also provides for the possibility of a time extension (three years in the case of PM_{10} or up to five years for NO_2 and benzene) for complying with the limit values.

In case of non-compliance with the AAQD limit and target values, air quality plans must be established and implemented in the zones where exceedances occur. Currently, limit values for PM_{10} and NO_2 as well as the target value for $PM_{2.5}$ are not complied with in a considerable number of Member States. At specific hotspots there are also breaches of the SO_2 limit values.

The European Commission conducted a review[4] of the European Air Quality Policy in 2013. The result of this review was the clean air policy package "A Clean Air Programme for Europe", which was published on 18 December 2013. No changes were made to the AAQD given the widespread non-compliance with existing standards.

The Committee on the Environment, Public Health and Food Safety of the European Parliament has thus requested a study that summarises the information available on the status of implementation of the AAQD in the EU Member States.

[4] http://ec.europa.eu/environment/air/review_air_policy.htm

2. THE AMBIENT AIR QUALITY DIRECTIVE

KEY FINDINGS

- The Ambient Air Quality Directive sets limit and target values for the concentration of air pollutants, and specifies the monitoring and reporting requirements.
- Compliance with the limit value must be ensured from specific years onwards.
- Member States are obliged to implement air quality plans in case of exceedances of thresholds.

2.1. Background

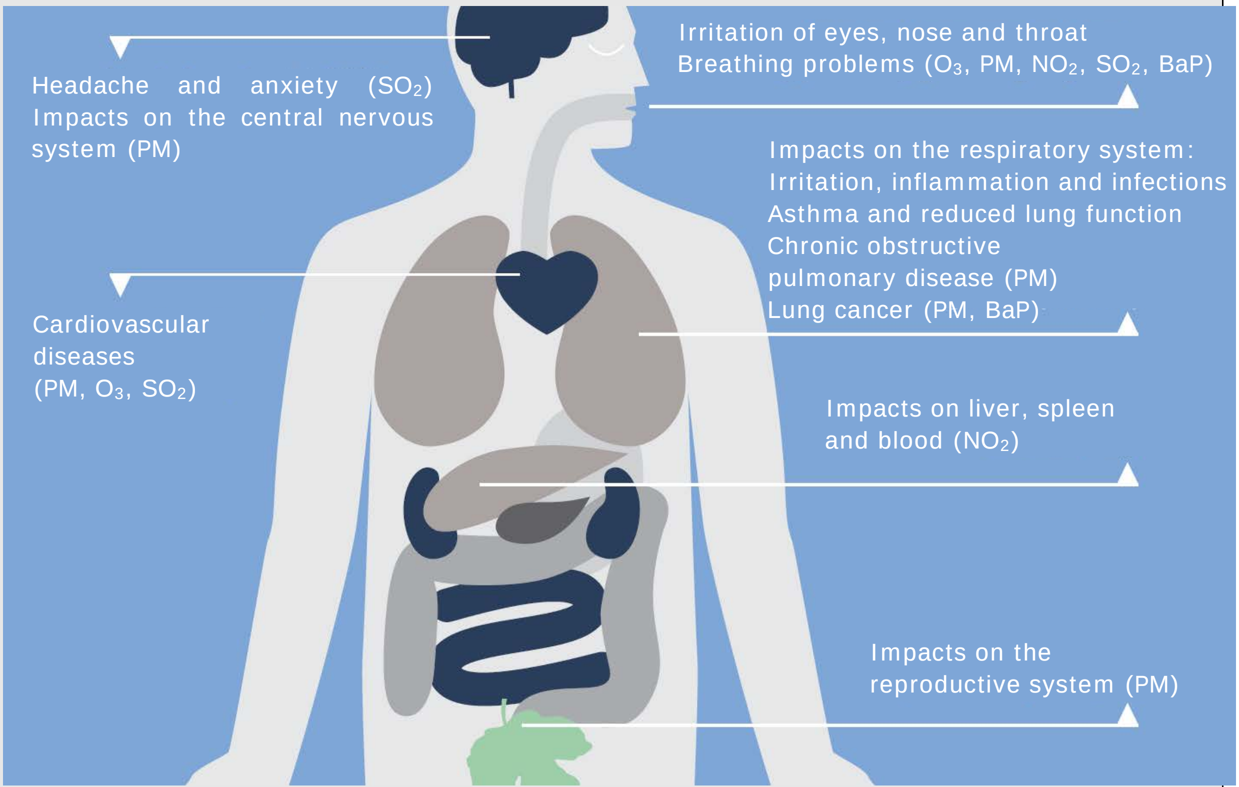
The Ambient Air Quality Directive (AAQD) lays down objectives for ambient air quality and methods and criteria for the assessment of air quality in the Member States.

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

The 4th Daughter Directive (4DD) under the Air Quality Framework Directive lays downs target values for arsenic (As), cadmium (Cd), nickel (Ni) and benzo[a]pyrene (BaP) as a marker for polycyclic aromatic hydrocarbons (PAH).

Box 1: Health impacts of air pollutants

Air pollutants can have severe impacts on human health (WHO 2013a, 2013b, 2015). $PM_{2.5}$, PM_{10}, O_3 and NO_2 are pollutants of major health concern in general. The illustration below provides a schematic overview of health impacts.



There is widespread evidence throughout the world on adverse health effects associated with exposure to ambient $PM_{2.5}$ and PM_{10} (WHO 2013a, 2013b). These health impacts include effects on the respiratory and cardiovascular system for large groups of the general population, leading to an increased risk of premature mortality and thus a reduced life expectancy.

Ozone affects respiratory and cardiorespiratory mortality. Adverse effects of ozone on asthma incidence and lung function growth have also been reported. Short-term exposure (as analysed for 1-hour and 8-hour mean ozone concentrations) has been shown to have adverse effects on all-cause, cardiovascular and respiratory mortality.

There are many new studies showing associations between short-term and long-term exposure to NO_2 and mortality and morbidity. These effects were found in areas where concentrations were at or below the current standard values.

These health impacts are associated with substantial costs for society; thus, the benefits of stringent air quality policies are usually much higher than the costs (European Commission 2013a, US EPA 2011)

Source: EEA 2013

Box 2: Sources of air pollutants

PM is composed of directly emitted primary particles and secondary particles formed in the atmosphere. The main precursor gases for secondary PM are SO_2, NO_x, NH_3, which form secondary inorganic particles, and volatile organic compounds (VOCs), which form secondary organic particles.

Primary PM originates from both anthropogenic and natural sources. Anthropogenic sources include fuel combustion processes and mechanical processes (e.g. construction work; tyre, brake, road wear; resuspension of road dust; soil cultivation and crop harvesting). The main natural sources are sea salt and Saharan dust.

Nitrogen oxides (NO_x, which is mainly NO and NO_2) are by-products of combustion processes. NO_2 is mainly formed by the oxidation of NO, with the exception of newer diesel vehicles which directly emit a large share of NO_2 due to exhaust after-treatment.

Ground-level ozone (O_3) is formed during chemical reactions of precursor gases such as NO_x, VOCs, CH_4 and CO of both natural and anthropogenic origin.

SO_2 is mainly emitted during the combustion of fuels containing sulphur such as coal and oil. Volcanoes are the biggest natural source of SO_2.

Benzo[a]pyrene (BaP) is emitted during the incomplete combustion of various fuels, used mainly for domestic heating (coal and wood burning), coke and steel production.

Source: EEA 2013, 2015a

2.2. Ambient air quality standards

2.2.1. Limit values for the protection of human health

Table 1 describes the limit values for specific air pollutants as laid down in Annex XI of the AAQD. These limit values should have been complied with from 2005 onwards (SO_2, CO, Pb, PM_{10}) or from 2010 onwards (NO_2, benzene). According to Article 22, postponing the deadline (until 2015 for NO_2 and benzene, and until June 2011 for PM_{10}) has been possible under specific circumstances. The Commission objected to a considerable number of applications for time extension[5] from the Member States.

The limit values have to be complied with throughout the territory with some exceptions depending on the assessment regime, see section 2.3.

A comparison and an analysis of the differences between the AAQD limit values and the guidelines developed by the World Health Organization (WHO) can be found in a recent study carried out for European Parliament's Committee on the Environment, Public Health and Food Safety (Schneider, J. et al. 2014).

[5] http://ec.europa.eu/environment/air/quality/legislation/time_extensions.htm

Table 1: Limit values of the AAQD.

Pollutant	Averaging period	Limit value	Remark
SO_2	One hour	350 µg/m³	not to be exceeded more than 24 times a calendar year
SO_2	One day	125 µg/m³	not to be exceeded more than 3 times a calendar year
NO_2	One hour	200 µg/m³	not to be exceeded more than 18 times a calendar year
NO_2	Calendar year	40 µg/m³	
Benzene	Calendar year	5 µg/m³	
CO	Maximum daily eight hour mean	10 mg/m³	
Lead	Calendar year	0.5 µg/m³	
PM_{10}	One day	50 µg/m³	not to be exceeded more than 35 times a calendar year
PM_{10}	Calendar year	40 µg/m³	

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

2.2.2. Targets, obligations and limit value for $PM_{2.5}$

Annex XIV of the AAQD introduced several provisions for $PM_{2.5}$, which are summarized in Table 2 and Table 3. The limit value, which was a target value until 2015, was set to provide an overall limit throughout the territory, hence also at local hotspots. From a public health perspective much larger health benefits can accrue if the overall $PM_{2.5}$ levels are reduced. This is due to the fact that health effects have been found even at fairly low levels of concentrations and that the findings suggest a fairly linear dose-response relationship (WHO 2013a, 2013b). To account for these facts the AAQD introduced the so-called Exposure Concentration Obligation (ECO; 20 µg/m³ for 2013 – 2015 at urban background sites, see Table 2) and the National Exposure Reduction Target (NERT, percentage reduction between 2009 – 2011 and 2018 – 2020, see Table 3). Compliance with the ECO and reaching the NERT will reduce $PM_{2.5}$ urban background concentrations for a large share of the population. The ECO and NERT are determined via the Average Exposure Indicator (AEI).

The AEI is assessed at a specific number of urban background stations throughout the territory. It is calculated as a three-calendar year running annual mean over all sampling points. This means that one AEI value is provided for the whole Member State. The reference year 2010 is the mean concentration for the period 2008 - 2010 or 2009 - 2011. The exposure concentration obligation for 2015 is calculated on the basis of the annual means for 2013-2015 and the national exposure reduction target 2020 on the basis of the annual means for 2018-2020.

In contrast to the ECO and the NERT, which are assessed at urban background sites only, compliance with the target and limit values has to be achieved throughout the territory (with certain exceptions regarding the assessment regime, see section 2.3).

Table 2: Provisions for $PM_{2.5}$ of the AAQD.

Provision	Value	Year	Remark
Exposure concentration obligation	20 µg/m^3	2015	Average Exposure Indicator
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 3: National exposure reduction target compared to the reference year for $PM_{2.5}$.

Initial concentration in µg/m^3	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/m^3

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

The objectives for ozone, as well as the 4DD target values along with information and the alert threshold are provided in Annex A.

2.3. Methods and criteria used for ambient air quality assessment

In order to assess ambient air quality, the Member State is divided into zones and agglomerations (Article 4 of AAQD). The assessment has to be carried out in all zones and agglomerations. In general, air quality is assessed at fixed monitoring sites. The number of stations per zone or agglomeration depends on the population and the pollutant levels. When pollutant levels are below the so-called upper assessment thresholds[6], modelling techniques and/or indicative measurements in addition to monitoring may be used.

Below the lower assessment thresholds[7] modelling techniques and/or objective estimates may be used (Article 5).

Apart from these general provisions, certain additional criteria and objectives have to be fulfilled and specific procedures have to be followed:

- 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 (with the exception of workplaces to which members of the public do not have regular access (Article 2)), the siting criteria for air quality monitoring stations limit 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 and which is not used as a fixed habitation, as well as roads and carriageways.

2.4. Air quality management, air quality plans in exceedance areas

In principle, Member States have been obliged to ensure compliance with the relevant limit values from specified dates onwards (see section 2.2.1). Once compliance has been achieved, Member States are required to keep levels below the limit values in zones and agglomerations.

As regards the target values, the long-term objectives and the NERT, all appropriate measures (as long as they do not entail disproportionate costs) have to be implemented to reach compliance. In the case of limit values and the ECO, cost considerations can in principle not lead to the disregarding of 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. The air quality plans have to include at least the information listed in Section A of Annex XV.

Where exceedances are due to natural sources (Article 20) or winter-sanding or –salting (Article 21) and compliance is reached after deducing the contribution of these sources Member States do not have to draw up air quality plans. The Commission has published guidelines[8] relating to these deductions (European Commission 2011a, 2011b).

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[6] The upper assessment threshold is 60 % to 70 % of the limit or target value.
[7] The lower assessment threshold is 40 % to 50 % of the limit or target value.
[8] http://ec.europa.eu/environment/air/quality/legislation/assessment.htm

The AAQD also offered the possibility for Member States to apply for a time extension[9] for achieving compliance with limit values for NO_2, benzene (until 2015) and PM_{10} (until 2011) (Article 22).

The AAQD furthermore requires short-term action plans (Article 24) to be drawn up where there is a risk that alert thresholds will be exceeded. Such action plans have rarely been implemented; they will thus not be discussed further here (AEA & Umweltbundesamt 2012).

[9] http://ec.europa.eu/environment/air/quality/legislation/time_extensions.htm

3. COMPLIANCE IN EU MEMBER STATES

KEY FINDINGS

- PM_{10} and NO_2 limit values were exceeded in all but five European Member States, the target value for $PM_{2.5}$ in six Member States in 2014.
- As of October 2016, the European Commission had infringement procedures against 19 of the 28 Member States open – amounting to a total of 29 infringement procedures covering three pollutants (incl. 16 Member States on PM_{10}, 12 Member States on NO_2 and one Member State on SO_2).
- Ten Member States have been referred to the Court of Justice for exceeding PM_{10} limit values, but four of these cases have not been executed. None of the Member States has been taken to Court for exceedances of NO_2 and SO_2 to date.
- No penalties had to be paid so far.

Currently, the AAQD air quality limit values for PM_{10} and NO_2 - as well as the target value for $PM_{2.5}$ - are not complied with in a considerable number of Member States. At specific air quality hotspots there are also breaches of the SO_2 limit values. Breaches of the limit values for PM_{10} and NO_2 are still expected for many zones in the near future, even though the exemption period for compliance with the PM_{10} limit values ended in 2011 and the compliance date for NO_2 was postponed until 2015. There are also a considerable number of zones for which a time extension for NO_2 has not been granted because the relevant conditions have not been met (e.g. difficulty to demonstrate compliance in 2015).

An important objective of European air quality policy is to achieve compliance with air quality limit values as soon as possible. Nevertheless, 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.

3.1. Compliance with AQ standards

To analyse the compliance situation in 2014, official data from reports to the European Commission submitted under Commission Implementing Decision 2011/850/EU[10] and, where necessary, Decision 2004/461/EC, were used. For 2013 data from the EEA's report on Air Quality in Europe (EEA 2015a) were analysed.

In 2014 the limit value for the annual mean of NO_2 was exceeded in 18 Member States[11], the hourly limit value for NO_2 in five Member States[12]. The highest NO_2 levels were observed in large urban areas in Germany, France and the UK.

[10] Data taken from Dataset G provided at EEA's air quality portal. Data provided via questionnaire according to Decision 2004/461/EC for Italy was downloaded from the website of the Ministro dell'Ambiente e della Tutela del Territorio e del Mare. Dataset G in principle includes information on the (individual) surface area affected and the population exposed; however, this data is not available for all Member States. At least in one case the surface area and population of the whole zone is given.

[11] Austria, Belgium, Czech Republic, Germany, Denmark, Greece, Spain, Finland, France, Hungary, Italy, Luxembourg, Netherlands, Poland, Portugal, Sweden, Slovakia, United Kingdom

[12] Germany, Spain, Hungary, Italy, United Kingdom

The limit value for the daily mean of PM_{10} was exceeded in 17 Member States[13], the annual mean limit value in six Member States[14].

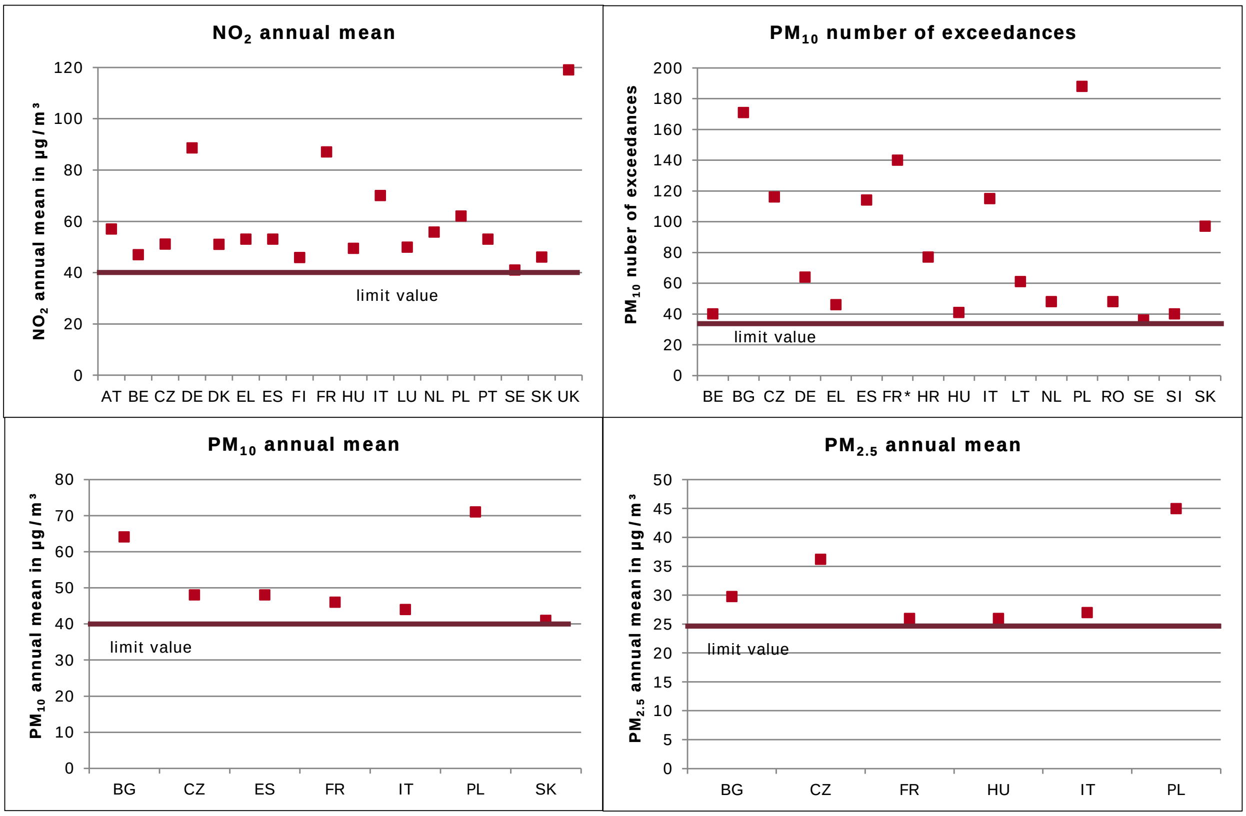
The target value for $PM_{2.5}$, which became a limit value in 2015, was exceeded in six Member States[15].

The SO_2 limit values for the protection of human health were exceeded in Bulgaria and Slovakia; the critical levels for the protection of vegetation were exceeded in the Czech Republic.

Figure 1 shows the maximum levels for those Member States that reported exceedances.

No exceedances for NO_2, PM_{10}, $PM_{2.5}$ or SO_2 were reported from five Member States[16].

Figure 1: Maximum NO_2, PM_{10} and $PM_{2.5}$ levels in 2014 in Member States where exceedances occurred.



*** Note:** Data on PM_{10} - number of exceedances for France from 2013

Source: EEA Dataset G. Data for Italy from Ministry website.

Estimates of the population exposed to concentrations above the limit values are provided in the EEA *Air Quality in Europe 2015* report (based on data from 2013) (EEA 2015a):

- NO_2 (annual mean): about 9 % of the EU-28 urban population.
- PM_{10} (daily mean limit value): about 17 % of the EU-28 urban population.

[13] Belgium, Bulgaria, Czech Republic, Germany, Greece, Spain, France, Croatia, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Sweden, Slovenia, Slovakia. For Romania the indication of an exceedance is ambiguous in Dataset G ("exceedance" labelled as "false", although 48 exceedances are named).

[14] Bulgaria, Czech Republic, Spain, France, Poland, Slovakia

[15] Bulgaria, Czech Republic, France, Hungary, Italy, Poland. Slovakia and the United Kingdom also indicated exceedances in Dataset G; however, the $PM_{2.5}$ levels provided are below or equal to 25 µg/m³.

[16] Cyprus, Estonia, Ireland, Latvia, Malta

- $PM_{2.5}$: about 9 % of the EU-28 urban population.
- SO_2 (daily mean limit value): under 0.5 %

A much larger share of the population is exposed to levels in excess of the WHO guideline levels for PM_{10} and $PM_{2.5}$, ranging between 61 % and 83 % for PM_{10}, and between 87 % and 93 % for $PM_{2.5}$ in the period 2011 - 2013.

3.2. Completed and ongoing infringement cases

Box 3: Infringement procedure

The infringement procedure comprises a number of informal and formal steps[17]:

1. Letter of formal notice: Commission requests the national government to comment on the non-compliance problem within 2 months or less;
2. Reasoned opinion (Article 258 of the Treaty on the Functioning of the European Union, TFEU): In case of no or an unsatisfactory reply, the Commission states reasons why it believes the Member State has breached EU law. The Member State has 2 months or less to comply;
3. Referral to the Court of Justice of the European Union ("the Court" in the following), if the Member State fails to make appropriate commitments
4. Judgment by the Court: If the Court rules against a Member State, the Member State must then take the necessary measures to comply with the Court's judgment;

When a Member State still fails to make any progress, the Commission will initiate a second round of infringement actions and a second referral to the Court. In this case the Commission may also request the Court to impose a financial penalty on the Member State concerned, consisting either of a daily or a lump sum fine or both. However, it is not possible to predict with reasonable accuracy how large the penalty will be. In general, penalty payments are based on 3 criteria:

- the Member State's size (based on GDP and votes in the Council),
- the seriousness and
- the duration of the infringement.

Instead of launching an infringement procedure, the European Commission can also start so-called pilots, i.e. a structured dialogue between the Commission and the Member State in cases where the Commission has identified a possible infringement. However, the information on these pilots is not publicly available and thus it is not possible to provide details about these pilot procedures within the scope of this study.

In any case, the infringement procedure is often tedious and time consuming. It is not possible to make definite statements about how long the whole process will take; it depends on the particular case. The Commission thus declared in 2009 that the average time from opening the file to sending the application to the Court had been reduced to twenty-four months (Craig & de Búrca 2015).

It should be noted that letters of formal notice and reasoned opinions are not allowed to be made public while an infringement case is underway because any disclosure could undermine the protection of the purpose of the investigations (see, for example, the answer to a request for access to the infringement procedure 2008/2186 against the Czech

[17] http://ec.europa.eu/atwork/applying-eu-law/infringements-proceedings/index_en.htm

Republic[18] or the judgement in Joined Cases C-514/11 P and C-605/11 P). However, the documents can be disclosed upon request after the case has been closed by the Commission. In order to simplify access to information and to contribute to increase transparency, DG Environment has started to publish the documents relating to closed infringement cases. The information remains incomplete, however, and can currently only be obtained for the years up to 2011[19].

Source: for infringement procedures in general: European Commission, for financial sanctions: European Commission

3.2.1. Infringement procedure - general information

The infringement cases which are currently underway (on the grounds of exceedances of air quality limit values) are the Commission´s response to a series of judgements in previous cases against Member States. In fact, several Member States were referred to the Court of Justice of the European Union (in the following addressed as “the Court”) and found to be in non-compliance with the AAQD. However, the Court simply declared that the Member States had breached PM_{10} limit values in certain years in the past, but did not rule on whether the Member States continued to be in breach of the PM_{10} limits. These judgments had no effect as they did not require the Member States to take any action to comply. For this reason, the Commission decided to launch new infringement proceedings against certain Member States[20].

3.2.2. Ongoing infringement cases (letter of formal notice, reasoned opinion)

By the end of 2015, eight Member States[21] received a letter of formal notice because of exceedances of PM_{10}. Seven of them (all except for Slovenia) also received a reasoned opinion from the Commission. Some of these Member States have received additional formal notices or reasoned opinions.

One Member State (Bulgaria) received a letter of formal notice and a reasoned opinion about exceedances of SO_2.

Eight Member States[22] received a letter of formal notice because of a breach of the AAQD as regards compliance with NO_2 limit values.

All of these cases are still ongoing and have as yet not been referred to the Court.

It is noticeable that Italy received a letter of formal notice in 2003 because of air pollution in Bari[23]; this case was closed after Italy replied that an air quality plan was established.

For an overview see Table 7 in Annex E.

If the period prescribed - generally less than two months - in the (additional) reasoned opinion has expired and a Member State still fails to abide by its obligations, the Commission may decide to refer the Member State concerned to the Court. However, for some infringement cases, Member States are able to comply with their obligations under EU law before they are referred to the Court.

[18] http://www.asktheeu.org/de/request/1623/response/6070/attach/3/CZ%20GestDem%202014%206025%20reply%2020%2001%202015%20with%20Ares%20nbr.pdf

[19] http://ec.europa.eu/environment/legal/law/infrigments_docs.htm

[20] http://legal.cleanair-europe.org/en/legal/eu/infringement-procedure/

[21] Czech Republic, Greece, Hungary, Latvia, Romania, Slovakia, Slovenia and Sweden

[22] Austria, France, Germany, Italy, Poland, Portugal, Spain, United Kingdom

[23] Infringement No. 20024517

3.2.3. Infringement cases referred to the Court of Justice of the European Union

In recent years, ten Member States[24] have been referred to the Court for exceeding the PM_{10} limit values. Of these ten cases, five[25] were still open at the end of 2015 (see also Overview Table 8 in Annex E). For the five remaining cases, it is assumed that individual judgements have already been carried out by the Court and that the cases have been closed. However, it should be noted that the respective information is not available for all cases.

One Member State (Poland) was taken to the Court concerning the implementation of the AAQD, but the case was later withdrawn[26].

For exceedances of NO_2 and SO_2 limit values none of the Member States has been taken to the Court to date.

Furthermore, six Member States[27] have been taken to the Court over non-compliance with the NEC Directive (see Table 9, Annex E). All six cases are now closed; one of them (Germany) was withdrawn.

Table 4 below provides additional information on the infringement cases that were referred to the Court:

Table 4: Infringement cases referred to the Court

Member State	Infringement actions on ambient air quality taken to the Court
Austria	**Measure to reduce NO_2 levels** (Infringement No. 20082001, Case C-28/09) The federal province of Tyrol in Austria implemented a sectoral ban on lorries of over 7.5 tonnes carrying certain goods, with the aim to reduce NO_2 levels along the Inn valley motorway. The case was referred to the Court which decided in 2012 that this measure violated the free movement of goods, especially as Tyrol had failed to implement less stringent measures beforehand. Tyrol then converted a temporary speed limit for passenger cars and light duty vehicles into a permanent one in November 2014. Also, a night time ban on heavy duty vehicles was extended to all vehicles except Euro VI. NO_2 levels have decreased in recent years but were still well above the limit value in 2014 (57 $\mu g/m^3$)
Belgium	**Exceedance of PM_{10} limit values** (Infringement No. 20082184) 3 zones and agglomerations (Brussels, the Ghent port zone and the Roeselare port zone) have shown continued failure to meet the targets. The proposed summons to the Court follows a reasoned opinion which was sent in February 2014, in a case which had first been opened in 2008. Although measures have been adopted in all the air quality zones addressed in the Commission's action, the measures so far have not been sufficient to solve the problem, and as the deadline for compliance has long expired, the Commission announced in June 2015 (see press release IP/15/5197) that the case would be referred to the Court of Justice.

[24] Belgium, Bulgaria, Cyprus, France, Italy, Poland, Portugal, Slovenia, Spain and Sweden
[25] Belgium, Bulgaria, France, Poland, Spain
[26] The reasons for withdrawing the case could not be ascertained.
[27] Germany, Greece, Ireland, Italy, Luxemburg and the Netherlands

Member State	Infringement actions on ambient air quality taken to the Court
	In 2014 the daily mean limit value for PM_{10} was exceeded in one zone (40 exceedances reported, source: EEA Dataset G). The case is still ongoing. No information has been available so far on the Curia website
Bulgaria	**Exceedance of PM_{10} limit values** (Infringement No. 20102109) Despite a number of measures and some reductions in PM_{10} since 2011, the data shows persistent non-compliance with the annual and/or daily limit values for PM_{10} in all the country's 6 zones and agglomerations except for Varna, which complied with the annual limit value once – in 2009. The decision to refer the case to the Court in June 2015 (see press release IP/15/5197) followed a reasoned opinion sent in July 2014 (Case C-488/15, September 2015). In addition to the prolonged exceedances in several zones, the Commission named the absence of more detailed information, and that Bulgaria did not keep the exceedance period as short as possible (Article 23(1) AQD). Annual mean PM_{10} levels were between 47 and 64 µg/m³ in 2014 in the 6 zones, and the number of exceedances between 105 and 171 (see Table 10 in Annex E for details). The case is still ongoing.
France	**Exceedance of PM_{10} limit values** (Infringement No. 20082190) The limit values for PM_{10} have not been respected in 16 air quality zones in France. France has applied for time extensions for meeting the targets in 2008 and in 2010, but in the Commission's view, only Strasbourg fulfilled the conditions for an exemption. Despite an earlier reasoned opinion from October 2010 in which France was requested to take action, air quality standards are still exceeded in the 15 remaining air quality zones (for 2013 levels see Table 14 in Annex E). Therefore, the Commission decided in May 2011 (see press release IP/11/596) to take France to the Court of Justice. The case is still ongoing. Meanwhile the Commission has initiated a second round of infringement actions; an additional reasoned opinion was sent in 2015 after an additional letter of formal notice had been sent in 2013. There is no information on the Court’s website on the current status of this case.

Member State	Infringement actions on ambient air quality taken to the Court
Cyprus Italy Portugal Spain	**Exceedance of PM_{10} limit values** (Infringement No. 20082185, 20082194**,** 20082200 and 20082203) The limit values for PM_{10} have not been respected in several zones in Cyprus, Italy, Portugal and Spain. While all four Member States have applied for time extensions, the Commission considers that the conditions for granting them have not been met in several non-compliant air quality zones. Therefore these Member States were taken to the Court in November 2010 (see press release IP/10/1586), Italy: Case C-68/11 , Portugal: Case C-34/11) No information is available on the Court's website on the status of the case against Cyprus. The infringement cases of Cyprus, Italy and Portugal have meanwhile been closed by the Commission, whereas Spain received another reasoned opinion in October 2014 (see press release Memo/14/589) after a second letter of formal notice. In 2014, PM_{10} limit values were not exceeded in Cyprus and Portugal. The daily mean limit value was exceeded in 31 zones in Italy on up to 115 days, the annual mean limit value was exceeded in two zones. In Spain, exceedances of daily mean values occurred in 3 zones on up to 114 days and the annual mean limit value was exceeded (48 µg/m³) in one zone (for details see Table 13 and Table 11, respectively).
Poland	**Ambient Air Quality** (Infringement No. 20100549) As the Polish authorities failed to inform the Commission of any planned measures to transpose the AQ Directive into national law by 11 June 2010, the Commission sent a letter of formal notice on 16 July 2010 and a reasoned opinion on 16 February 2011. Poland then informed the Commission that it was drafting the main transposing measure but as a relevant law had still not been adopted, the Commission took Poland to the Court of Justice in November 2011 (see press release IP/11/1434). Taking into account the seriousness and the duration of the infringement case, the Commission requested the Court to impose a financial penalty on Poland. The penalty payment imposed was EUR 71 521 per day until transposition was completed. Meanwhile the case has been withdrawn by the Commission as Poland has notified the Commission of the completion of their transposition of the AAQD into national law. Of particular note is that the Commission had not initiated a second round of infringement actions or a second referral to the Court before imposing a financial penalty. In a judgement on Poland in January 2013, the President of the Court ruled that the case be removed from the register (Case C-48/12).

Member State	Infringement actions on ambient air quality taken to the Court
Poland	**Exceedance of PM_{10} limit values** (Infringement No. 20082199) PM_{10} limit values have been persistently exceeded in 35 out of 46 air quality zones at least for the last five years, including 2014. In nine zones the annual limit values have been persistently exceeded (for details see Table 12 in Annex E). PM_{10} pollution in Poland is predominantly caused by emissions from domestic heating with solid fuels. The legislative and administrative measures taken so far to limit non-compliance have been deemed insufficient by the Commission. Hence the Commission decided in December 2015 (see press release IP/15/6225) to refer the case to the Court. This decision came after a second round of infringement actions (a second reasoned opinion was launched). No information on this case is available on the Court's website.
Slovenia Sweden	**Exceedance of PM_{10} limit values** (Infringement No. 20082203 and 20082204) At the beginning of 2009, letters of formal notice were sent to Slovenia and Sweden. Both countries had up to then not submitted notifications or had not notified the Commission of all their air quality zones exceeding the limit values for PM_{10}. As the PM_{10} limit values continued to be exceeded in both Member States, the Commission decided to refer the cases to the Court in March 2010 (see press release IP/10/315). The Court decided that Sweden and Slovenia failed to fulfil their obligations (Sweden: Case C-479/10, Slovenia: Case C-365/10). The two infringement cases were closed by the Commission in October 2011. Nevertheless, in 2014 the PM_{10} limit value was exceeded in one zone both in Slovenia and in Sweden (40 and 36 exceedances of the daily mean limit value, respectively). A letter of formal notice was therefore sent to Sweden on 25 April 2013 and a reasoned opinion on 18 June 2015, see Annex E, Table 7. A letter of formal notice was sent to Slovenia on 24 January 2013.

4. IMPLEMENTATION PROBLEMS, HOTSPOTS

KEY FINDINGS

- PM_{10} hotspots in Europe can be found in Eastern European countries, especially Poland, parts of Italy and Belgium/Netherlands.
- Trends in PM levels show some decrease in Western European countries, but have remained stable in Eastern Europe.
- Exceedances of PM are mainly caused by domestic heating (solid fuels), traffic, industry, and contributions from secondary (transboundary) particles. NO_2 limit values are mainly exceeded in large urban areas close to heavily trafficked roads.
- NO_2 levels show a decrease in some areas, but have remained stable (at high levels) in a number of areas.
- Exceedances of NO_2 are mainly caused by diesel driven vehicles.

The AAQD entered into force in 2008. However, the limit values for PM_{10} and NO_2, for which non-compliance in European Member States is most persistent, were already laid down in the 1st Daughter Directive (Directive 1999/30/EC) under the Air Quality Framework Directive (1996/62/EC). The compliance dates for PM_{10} and NO_2 were 2005 and 2010, respectively. The AAQD provides for a time extension for the compliance dates of 3 and 5 years, respectively, under specific conditions. Nevertheless, according to the most recent Europe wide analysis carried out by the EEA in 2013, PM_{10} and NO_2 limit values were found to have been breached in 22 and 19 European Member States[28], respectively. Breaches of the $PM_{2.5}$ target value were reported from seven Member States (EEA 2015a) and breaches of the SO_2 limit values in one Member State.

4.1. PM_{10}, $PM_{2.5}$, NO_2 and SO_2 hotspots in Europe

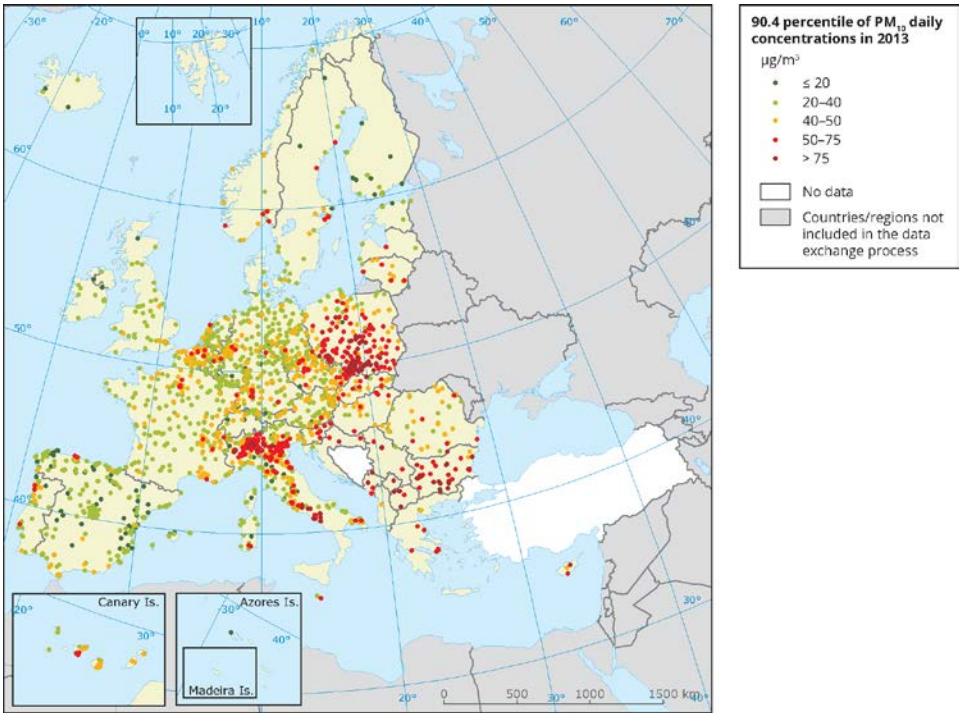
The EEA analysis shows that PM_{10} levels are rather high over wide areas in Poland, northern and southern Italy, Bulgaria, and parts of the BeNeLux countries (EEA 2015a, Map 1). In addition, there are more localized hot spots in several European countries. In 2013 more than 100 exceedances[29] of the daily mean limit value for PM_{10} were recorded in Bulgaria, Poland, France, Spain, Italy, the Czech Republic and Cyprus. Compliance throughout the territory was achieved in Denmark, Estonia, Finland, Ireland, Luxembourg and the UK (EEA 2015a).

Interpolated maps for PM_{10} and $PM_{2.5}$ for the year 2012 are shown in Annex B.

[28] PM_{10}: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden (all but Denmark, Estonia, Finland, Ireland, Luxembourg and the United Kingdom)
NO_2: Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Latvia, the Netherlands, Poland, Portugal, Romania, Spain, Sweden and the United Kingdom

[29] Data taken from AirBase, including contributions from natural sources, which are of relevance especially in southern European countries due to Saharan dust episodes

Map 1: 90.4 percentile (35th highest daily mean value) of PM_{10} daily concentrations in 2013.

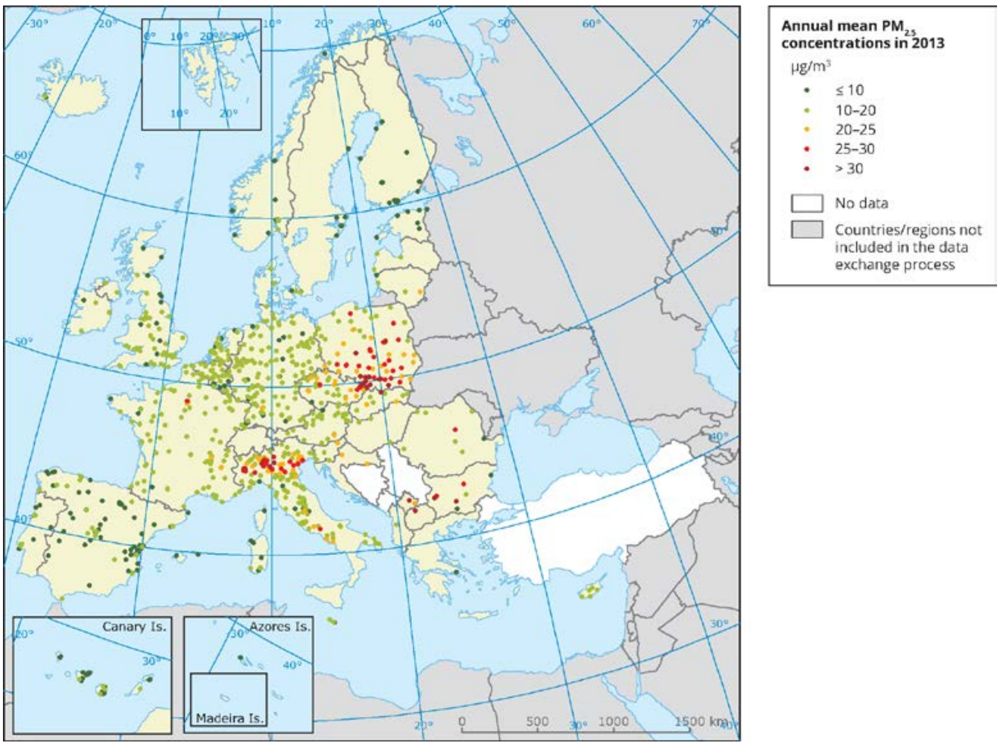


Note: The 90.4 percentile of all of the daily means corresponds to the 35th highest daily mean value. If it is above 50 µg/m³ the criteria for the daily mean limit value of PM_{10} have been breached

Source: EEA AirBase

$PM_{2.5}$ levels above the target / limit value occur mostly in Poland, the Czech Republic, Italy and Bulgaria (Map 2).

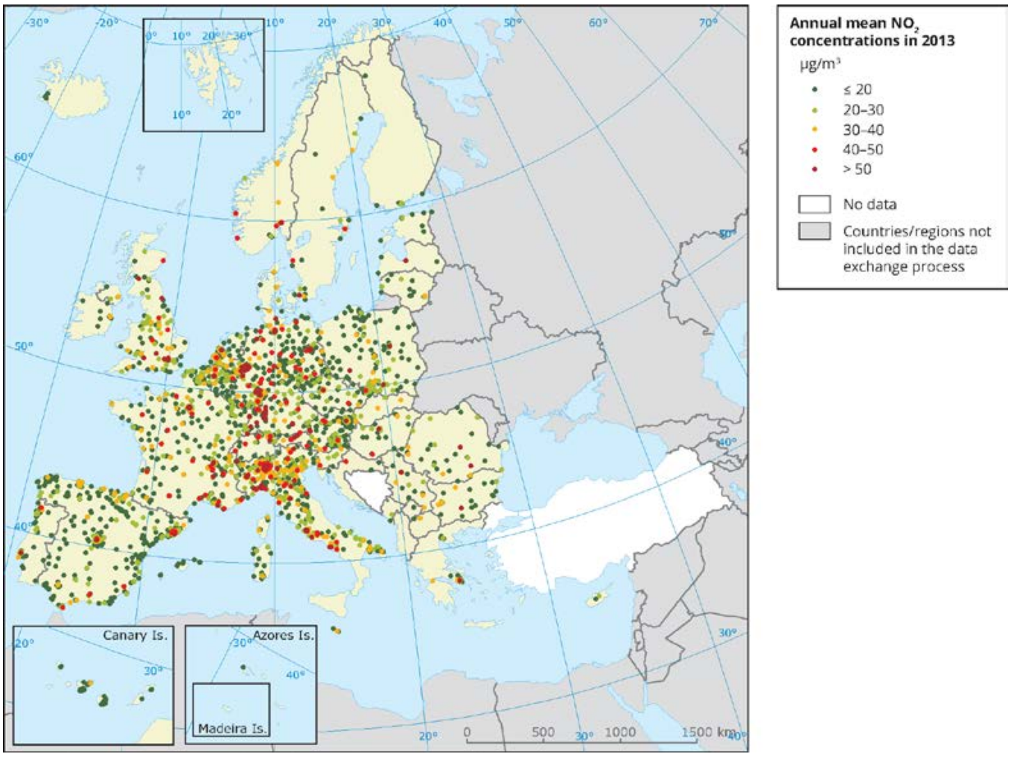
Map 2: $PM_{2.5}$ annual mean concentrations in 2013



Source: EEA AirBase

Exceedances of the NO_2 annual mean limit value[30] occur mostly[31] at monitoring stations close to traffic and in large urban areas (Map 3). In contrast to PM_{10} and $PM_{2.5}$, which tend to be higher in some larger areas in certain regions and countries, NO_2 exceedances are observed throughout Europe (in about two thirds of all Member States) within rather confined locations. Hence the pollution pattern looks rather disparate (compared to PM). This is due to the short atmospheric lifetime[32] of NO_2, which results in high levels close to the emission sources (almost exclusively traffic) and low levels in rural background areas.

Map 3: NO_2 annual mean concentrations in 2013.



Source: EEA AirBase

Model calculations (using the Copernicus atmosphere monitoring services) show elevated NO_2 levels in Northern Italy, the BeNeLux countries, the Rhine-Ruhr region, England and along the main shipping routes (Map 9 in Annex B).

Exceedances of the hourly and daily limit values (see Table 1) for SO_2 occurred in 2013 and 2014 at two sites in Bulgaria. A number of daily mean values above 100 µg/m³ in recent years were observed in Poland, Estonia and Romania.

4.2. Air quality trends at hotspots

Figure 2 shows the trends in PM_{10} annual mean[33] levels at selected stations in those regions where the highest levels were observed in recent years (average trends in Europe are shown in the Annex). In Brussels and in the agglomerations of Milan and Stuttgart PM_{10} levels declined around 2005 and stayed at more or less the same level thereafter. Amsterdam

[30] The annual mean limit value is more stringent. Hence, if compliance is achieved with the annual mean value, exceedances of the hourly mean limit value are very unlikely.

[31] In 2013 93 % of the exceedances occurred at monitoring stations characterized as traffic sites (EEA 2015a)

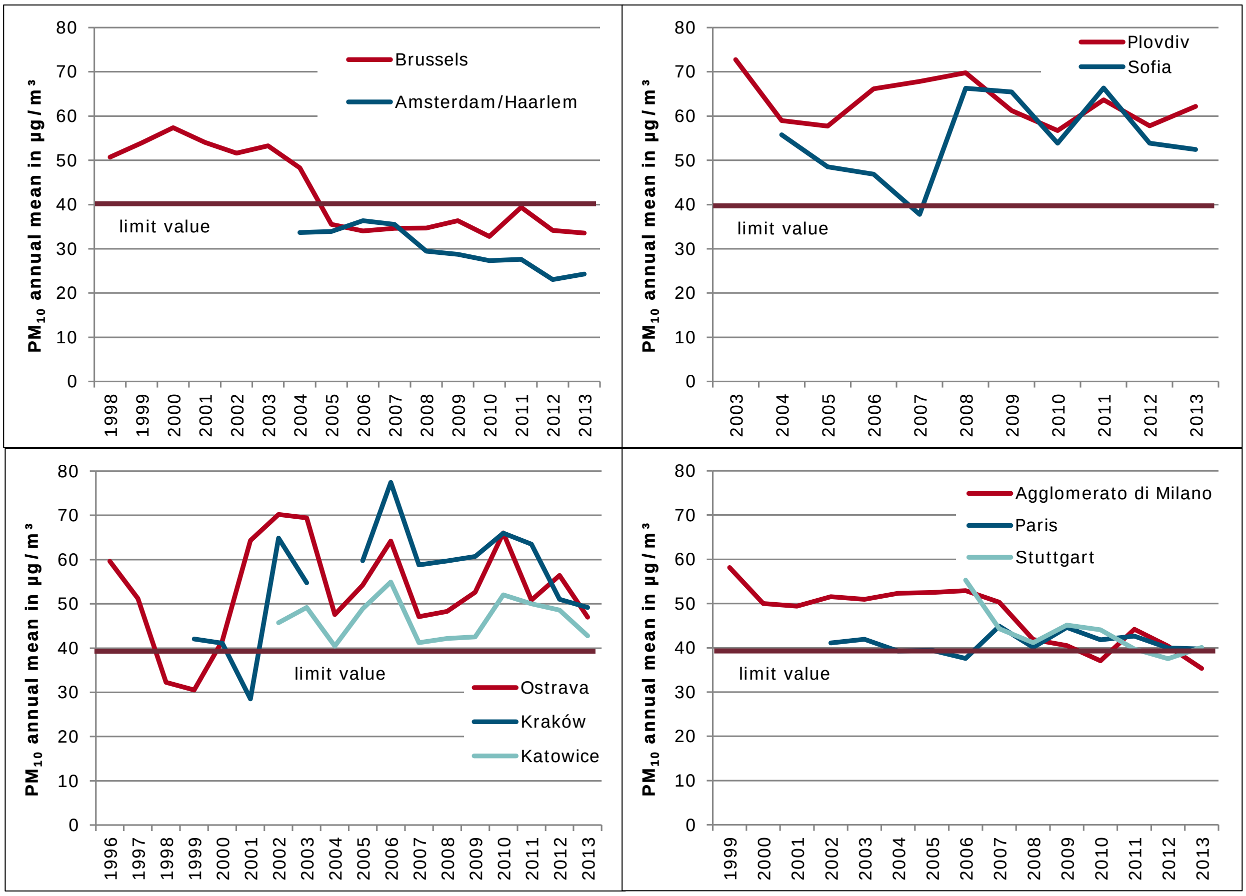
[32] i.e. the time during which the concentration is reduced to $\tau=1/e$ (i.e. to about 37 % of the original concentration)

[33] Annual mean levels are used in trend analysis as they are the most robust statistical parameter. On average more than 35 exceedances of the daily mean limit value occur where the annual mean levels are above 29 µg/m³.

shows a decline, whereas Sofia and Plovdiv in Bulgaria and Ostrava[34] (Czech Republic), Krakow[34] and Katowice (Poland) show no clear trend.

General air quality trends for the whole of Europe are shown in Annex C.

Figure 2: Annual mean levels of PM_{10} at selected sites in Europe.

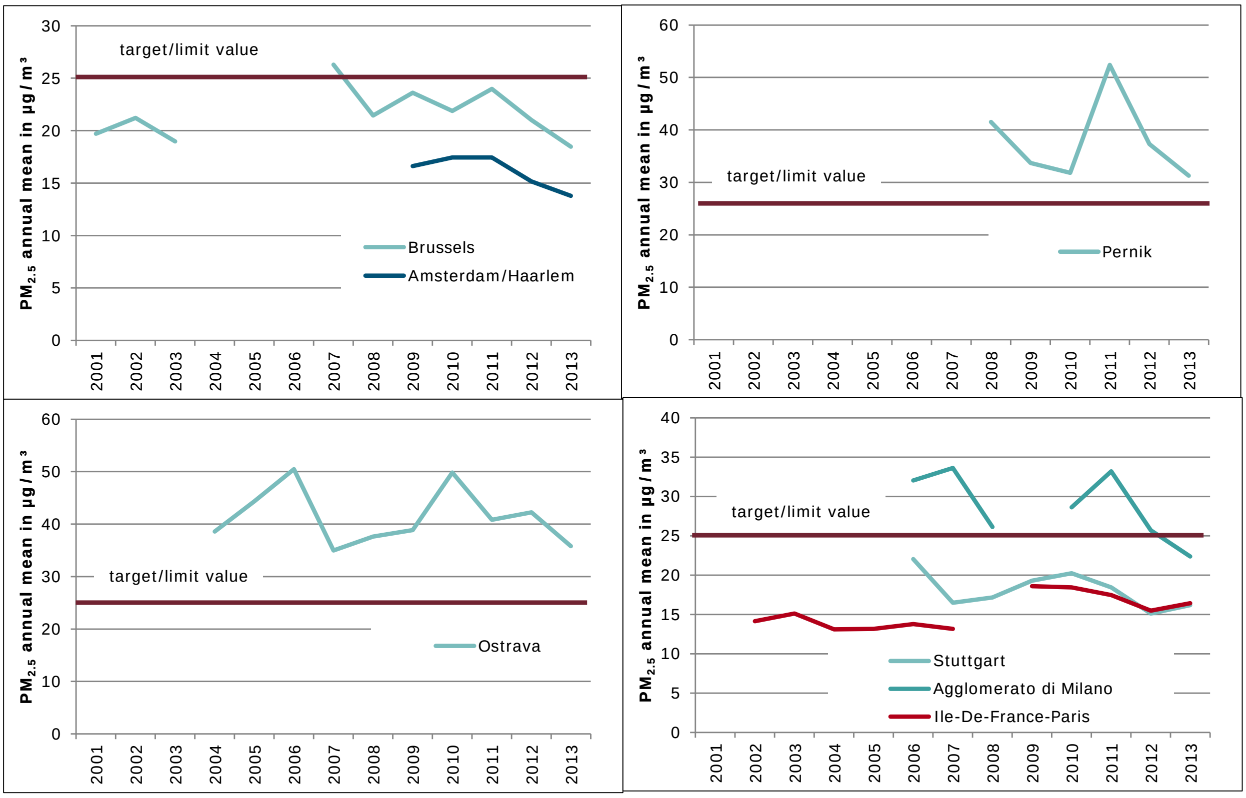


Source: EEA AirBase v8, EEA Air Quality e-Reporting

$PM_{2.5}$ monitoring started considerably later than PM_{10} monitoring. Still, there are more than twice as many PM_{10} monitoring sites as there are $PM_{2.5}$ sites. Hence, less information on $PM_{2.5}$ trends is available for the hotspots described above. Figure 3 thus shows that hardly any $PM_{2.5}$ trends can be observed in the selected regions. In addition, the data show a considerable inter-annual variability.

[34] Favourable atmospheric dispersion conditions were responsible for the relatively low levels in 1998 and 1999, and more unfavourable conditions in the years thereafter (CHMU 2013, http://portal.chmi.cz/files/portal/docs/uoco/isko/grafroc/groce/gr04e/akap22.html).

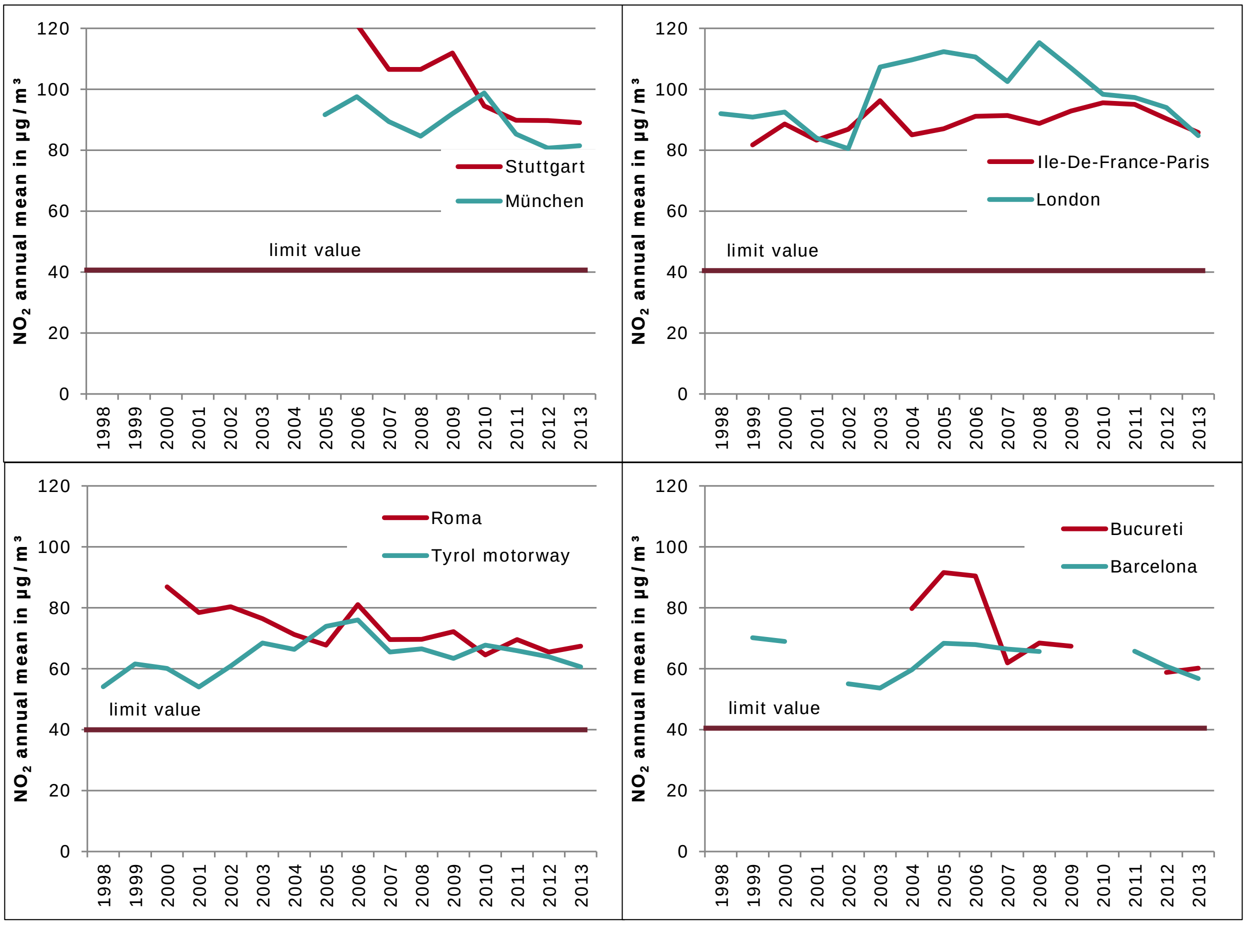
Figure 3: Trend in $PM_{2.5}$ annual means in selected regions and cities.



Source: EEA AirBase v8, EEA Air Quality e-Reporting

Figure 4 shows NO_2 annual mean trends in selected areas at sites where the highest levels were observed in recent years. A clear decline was observed in Stuttgart, a slight decline in Rome and Munich. Levels in the Ile-De-France have been more or less constant between 2000 and 2013, whereas London and the A 12 Inntal motorway in Tyrol show an increase for the years up to 2008 and 2006 respectively and a decline thereafter. Trends in Bucharest and Barcelona cannot be interpreted due to gaps in the available data.

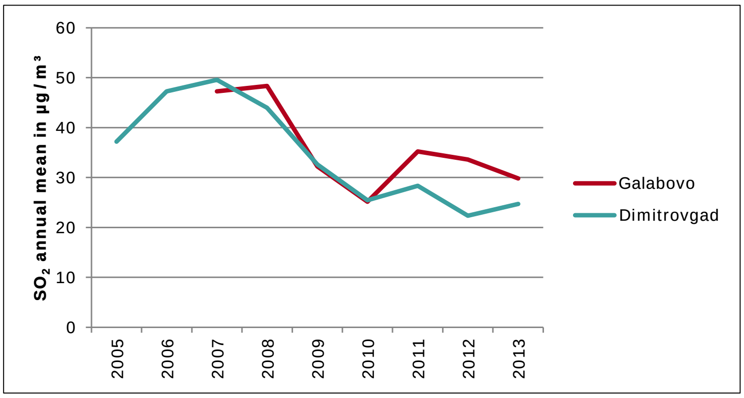
Figure 4: Trend in NO_2 annual mean levels for selected regions and cities.



Source: EEA AirBase v8, EEA Air Quality e-Reporting

Figure 5 shows SO_2 annual mean levels[35] for those two sites in Bulgaria where the highest levels were observed. After they peaked in 2007/2008, levels decreased in the years up to 2010 but remained above the hourly and daily limit values, with yet another increase at Galabovo.

Figure 5: Trend in SO_2 annual mean levels at two highly polluted sites in Bulgaria.



Source: EEA AirBase v8, EEA Air Quality e-Reporting

[35] Exceedances of the hourly and daily limit values for SO_2 were observed; however, the annual mean levels are shown as they are a robust parameter for the purpose of statistical analysis.

4.3. Main factors affecting pollutant levels

We selected four regions and cities to analyse the problems with AAQD implementation in more detail. These case studies were carried out in the following four regions/cities:

- Milan, capital of Lombardy in the Po valley (PM_{10} and NO_2 non-compliance).
- London, capital of the United Kingdom (NO_2 non-compliance).
- Krakow, capital of the Lesser Poland Voivodeship (PM_{10} non-compliance).
- Plovdiv, second largest city in Bulgaria (PM_{10} non-compliance).

4.3.1. Milan

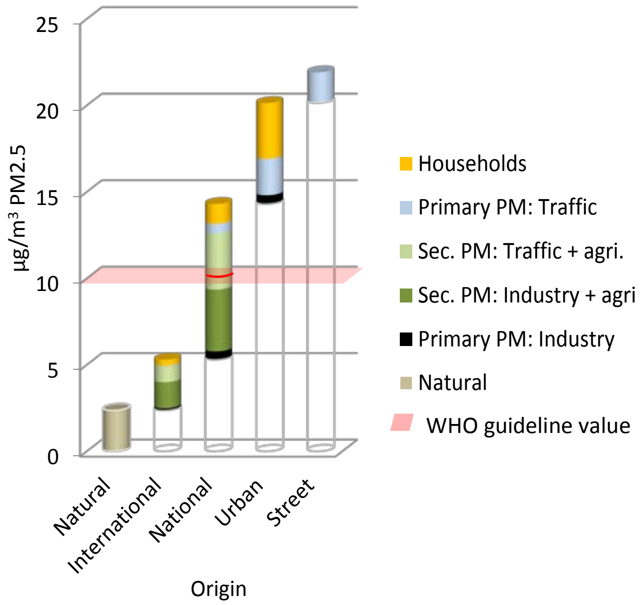
The Po valley in general and the agglomeration Milan in particular experience rather high levels of PM and NO_2. The reasons for these high levels are on the one hand emissions[36] mainly from traffic (diesel vehicles), domestic heating (biomass burning) and industry, and on the other hand adverse dispersion conditions in the Po valley - rather low wind speeds[37] especially during winter time (Umweltbundesamt 2010; Nagl et al. 2013, Benezzoli 2012a, 2012b). With respect to the car situation, Milan and Lombardy in general both have a large number of vehicles per capita[38] and a high share of diesel vehicles[39].

Biomass burning accounts for 8-10 % of the PM_{10} concentrations during winter time in the centre of Milan, for 15-25 % in the rural Po valley and for 25-30 % in pre-alpine and alpine valleys (Lanzani 2013).

A detailed analysis of the spatial origin of $PM_{2.5}$ and the main source categories of $PM_{2.5}$ was carried out by IIASA for selected $PM_{2.5}$ sites in Italy in 2009 (Figure 6, IIASA 2014b). 5 µg/m³ of a total of about 22 µg/m³ comes from natural and international sources, about 9 µg/m³ from national sources (mainly secondary PM) and about 8 µg/m³ at urban and street level mainly from households and traffic. Even though this data covers Italy as a whole, a large share of these stations is situated in Northern Italy (see Annex D, Figure 21). Therefore, it can be concluded that in the Po valley $PM_{2.5}$ levels are mainly caused by national and regional sources (primary PM: traffic, households; secondary PM: industry, traffic, agriculture).

[36] About one third of PM emissions result from diesel oil, one third from wood combustion and one third from process activities (Benezzoli 2012).
[37] Average wind speed of 0.9 m/s (Regione Lombardia 2014).
[38] Around 580 per1000 people, see http://knoema.de/atlas/Italien/Lombardy/Passenger-cars-per-1000-population
[39] 54 % of newly registered passenger cars in 2013, http://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU

Figure 6: Origin of $PM_{2.5}$ in Italy in 2009, averaged over 70 monitoring stations.



Source: IIASA 2014b

4.3.2. London (NO_2)

NO_2 levels at the most polluted traffic site in London (Marylebone Road) were well above 100 µg/m³ in 2003 – 2009 (Figure 4). In 2013 NO_2 annual mean concentrations of 85 µg/m³ were observed[40]. In Inner London levels at roadside stations were on average around 60 µg/m³ and slightly above 40 µg/m³ at urban background sites (GLA 2015). Since 2010 NO_2 levels have decreased at about 2/3 of the sites, whereas from 2005 to 2009 an increase was observed at the majority of the sites. About 1 million people were exposed to levels above the limit value in 2015, and in 2020 there will still be around 300 000 people living in locations with average NO_2 levels above the EU legal limit value. In 2013 the limit value was exceeded along around 1 000 km of road length. The main source of NO_2 exceedances in Greater London is road traffic, where the influence of different vehicles types varies between different types of roads (DEFRA 2015b). On some roads buses contribute most of the NO_x emissions. This is partly due to a previous renewal of buses (when London buses where replaced with Euro III buses to lower PM emissions) and the fact that the real driving emissions of Euro III buses and vans were higher than expected. Nevertheless, for all types of roads, NO_x emissions from diesel cars were about four times higher than the emissions from petrol cars.

4.3.3. Krakow

PM_{10} levels in Krakow were above 60 µg/m³ in 2009 – 2011 and around 50 µg/m³ in 2012 and 2013. According to the 2013 air protection programme for the Lesser Poland Voivodeship (województwo małopolskie) the main sources[41] for PM_{10} in the city of Krakow are domestic heating, local industry and traffic (Małopolska 2013a, 2013b).

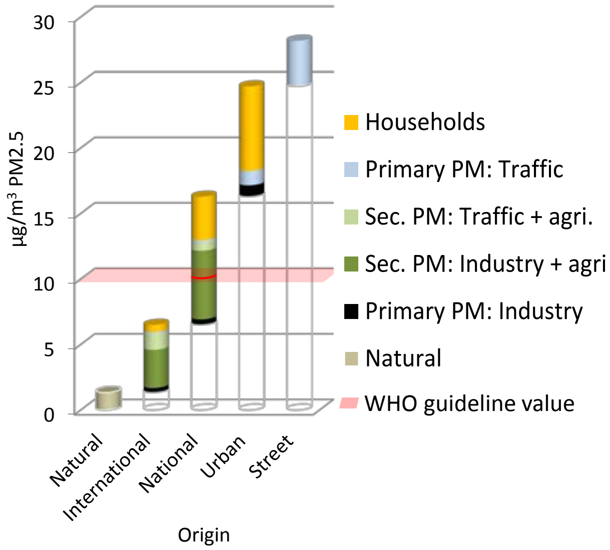
The national air protection programme published in 2015 related 88 % of PM_{10} exceedances to domestic heating and 9 % to traffic (Ministerstwo Środowiska 2015).

[40] 2014: 94 µg/m³, 2015: 88 µg/m³: http://uk-air.defra.gov.uk/

[41] In total the PM_{10} annual mean was about 60 µg/m³; 5 µg/m³ originated from background sources, 5 µg/m³ from domestic heating outside the city, 15 µg/m³ from local industry, about 8 µg/m³ from traffic and about 25 µg/m³ from domestic heating systems.

According to the IIASA's analysis for Poland, natural and international sources contribute on average about 6 µg/m³ to an overall average $PM_{2.5}$ concentration in the urban background of about 27 µg/m³ Figure 7). On the national level, the prevailing sources are secondary PM from agriculture and industry as well as households. At urban and street level, $PM_{2.5}$ is mainly caused by households and to a minor extent by traffic.

Figure 7: Origin of $PM_{2.5}$ in Poland in 2009, averaged over 142 urban monitoring stations.



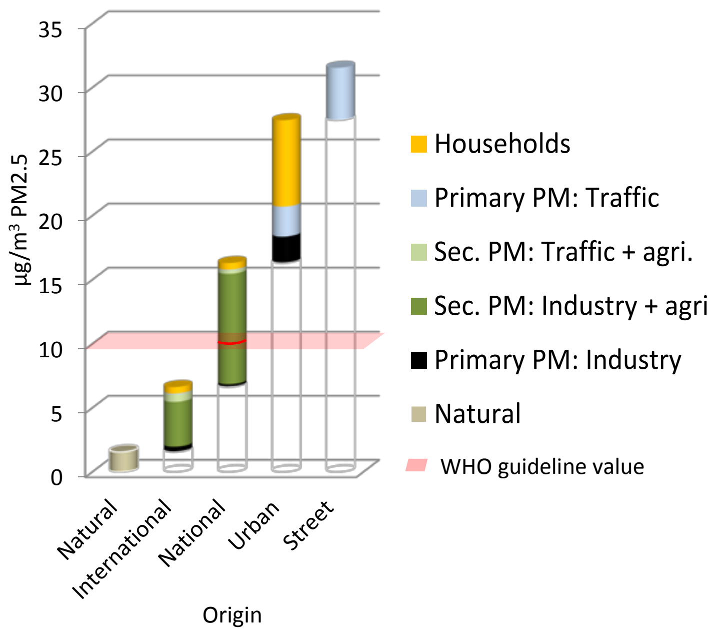
Source: IIASA 2014b

4.3.4. Plovdiv

The municipality of Plovdiv published a programme to reduce $PM_{2.5}$ and PAH levels in 2013 (Obshtina Plovdiv 2013). According to this programme 73 % of the $PM_{2.5}$ *emissions* in Plovdiv come from residential heating, 20 % from traffic, and 7 % from industry and energy production. Air quality modelling shows that almost 60 % of the $PM_{2.5}$ *concentration levels* measured at a specific site come from residential heating, 38 % from regional background concentrations and 3 % from traffic. PM_{10} modelling attributes 76 % to domestic heating, 14 % to road traffic, and 7 % to industrial sources (Obshtina Plovdiv 2014a). The prevailing meteorological conditions favour high pollutant levels – due to low wind speeds and a high frequency of temperature inversions (Obshtina Plovdiv 2011).

The IIASA analysis shows similar results for 14 urban $PM_{2.5}$ stations, where emissions from households dominate at urban level and traffic on the local level (Figure 8, IIASA 2014b).

Figure 8: Origin of $PM_{2.5}$ in Bulgaria in 2009, averaged over 14 urban monitoring stations.



Source: IIASA 2014b

4.4. Can these factors explain the observed trends?

4.4.1. PM_{10} trends

In general PM_{10} levels are influenced by:

- Anthropogenic (and to a minor extent also natural) emissions of primary PM and precursors for secondary PM;
- Meteorology and atmospheric dispersion conditions;
- Transboundary contributions of primary and secondary PM (dependent on emissions and meteorology).

Thus each of these factors contributes to the observed trends in PM levels in a different way at different locations (see also Annex D, Figure 21). In addition, these factors are at times interlinked. E.g. during episodes of very cold weather, emissions from domestic heating will increase, while adverse dispersion conditions (temperature inversion) often prevail at the same time, along with wind patterns that may be different from those prevailing during the relatively warm winter months (resulting in different transboundary contributions).

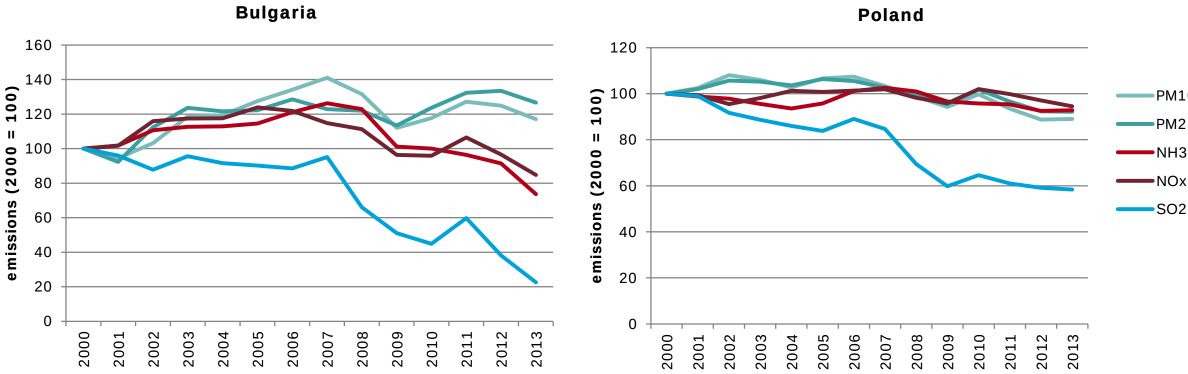
As pointed out in section 4.3.1 for Milan, pollutant levels in the Lombardy region are mainly caused by national and regional sources, combined with adverse dispersion conditions. Time series of annual average concentrations in the agglomeration of Milan (ARPA Lombardia 2015) show a decrease between 2006 and 2014 by approx. 35 % for both PM_{10} and $PM_{2.5}$. Concentrations show annual variations, including a peak in 2011. Measured NO_2 concentrations (ARPA Lombardia 2015) show a similar picture over the past decade – an overall decrease with elevated levels in 2011.

The overall trends are in line with regional emission inventory data for the Lombardy region[42], which show distinct decreases in emissions over the past decade – for NO_X, particulates and their precursors. The decrease in the observed PM and NO_2 concentrations can therefore be attributed to a reduction of anthropogenic emissions on the regional level, e.g. due to improved technologies in the energy, industry and transport sectors and due to a switch towards less polluting fuels (Regione Lombardia 2015).

In addition, the impact of atmospheric dispersion conditions is visible in the observed concentrations. E.g. elevated concentrations levels in 2011 can be attributed to stable atmospheric conditions in January/February and October/November of that year (ARPA Lombardia 2012).

For Krakow and Plovdiv no regional emissions or long-term analyses are available. Hence, we have limited our analysis to the evolvement of PM emissions and PM precursors on a national level (Figure 9). In addition, we have analysed PM_{10} concentration levels averaged over all of the available stations (Figure 10)

Figure 9: Total national emissions of PM_{10} and $PM_{2.5}$, and precursors of secondary inorganic particles, 2000 to 2013 (officially reported data).



Source: CEIP

National total PM_{10} and $PM_{2.5}$ emissions show an overall increase in Bulgaria for the period 2000 - 2013, with a decline around 2009. Also, precursors of secondary inorganic particles remained on the same level as in 2000 until 2012, except for SO_2. PM and precursor emissions have been stable in Poland since 2000 with the exception of SO_2, which show a decrease until 2009.

National total emissions can of course not explain developments at urban level; however, they can provide an indication of the overall trend. Besides, as one can see from Figure 7 and Figure 8, a relatively large share of $PM_{2.5}$ is made up by national emissions. Taking this into account, the national emissions correspond fairly well to the overall development of average PM_{10} levels, as shown in Figure 10, which show no trends for urban background stations in Poland, apart from a small decrease for Bulgaria.

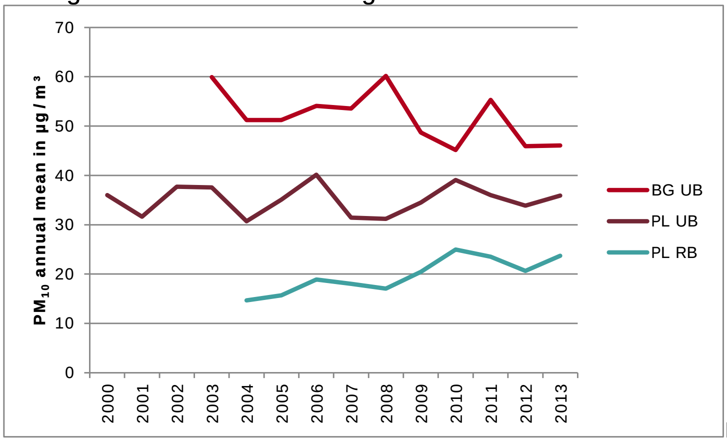
However, it has to be kept in mind that there are still substantial uncertainties in emission inventory calculations[43] (IIASA 2014c) on the one hand and that there is a significant non-proportionality between precursor emission reductions and secondary particle concentrations on the other hand (Fuzzi et al. 2015). Additionally, a large share of PM is made up of organic aerosol, whose sources and formation mechanisms are still rather poorly understood, and

[42] INENAR – Inventario Emissioni Aria – Regione Lombardia, http://www.inemar.eu/xwiki/bin/view/InemarDatiWeb/Inventario+delle+emissioni+in+atmosfera

[43] E.g. the national inventory for Poland does not include the use of non-commercial coal in households, which might amount to 50 kt of $PM_{2.5}$ (IIASA 2014c). By comparison: the national total $PM_{2.5}$ emissions are about 150 kt (CEIP).

which are strongly dependent on natural sources and meteorology (Fuzzi et al. 2015). Hence, precursor emission reductions cannot be directly translated into reduced concentrations.

Figure 10: Average PM_{10} concentrations at urban, suburban and rural background stations in Bulgaria and Poland

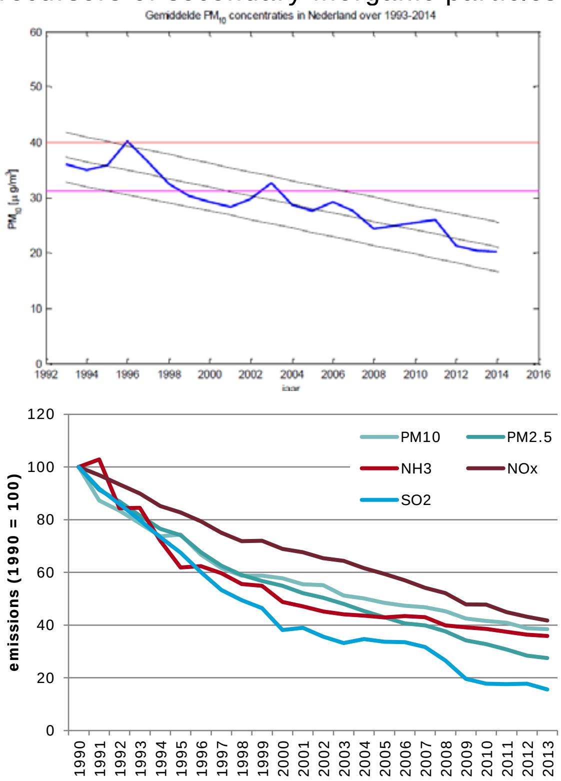


Note: UB: urban and suburban background. RB: rural background

Source: EEA AirBase v8, EEA Air Quality e-Reporting

When conducting a similar analysis with the Netherlands, it can be clearly shown that the decline in national emissions corresponds well to the observed decline in PM_{10} levels (RIVM 2015).

Figure 11: Average PM_{10} concentrations (left) and national emissions of PM and precursors of secondary inorganic particles in the Netherlands



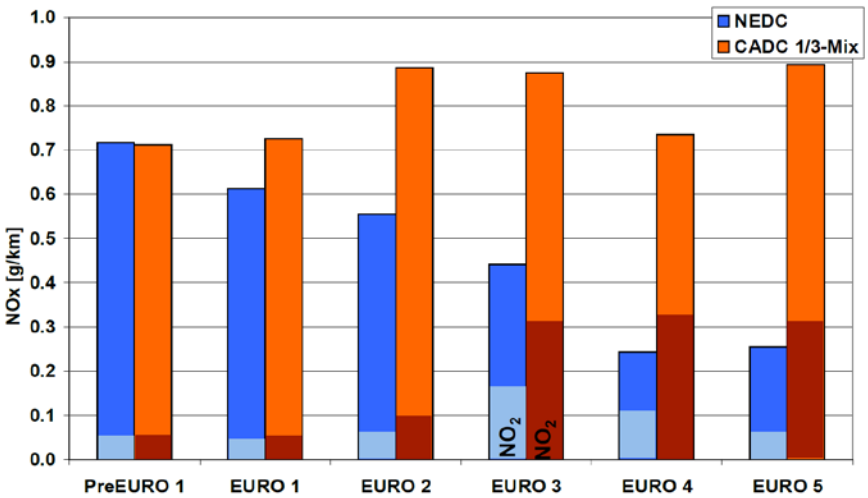
Source: RIVM 2015, CEIP

4.4.2. NO_2 trends

NO_2 levels in cities are mainly caused by diesel driven vehicles. Hence, the observed trends (as shown in Figure 4) are mainly influenced by changes in NO_x (NO and primary NO_2) emissions from vehicles. Meteorology is of minor importance[44] in the case of NO_2. The emissions themselves are a product of activity data (i.e. number of vehicles and mileage) and specific emission factors (which are dependent on the type of vehicle and the traffic situation). Of general importance is how the NO_x (and NO_2) emission factors of diesel vehicles have evolved in recent years. NO_x emission factors for diesel passenger cars and light duty vehicles are more or less the same for pre-Euro 1 to Euro 5 vehicles, whereas primary NO_2 emissions increase for Euro 3 vehicles and beyond (Figure 12, Sturm et al. 2015). The main reasons for these discrepancies are the outdated test cycle, which does not reflect current driving characteristics, and the generous flexibilities allowed in the testing procedure (EEA 2016).

Thus, NO_2 levels have remained the same or have even increased at traffic sites where no stringent measures were applied (Figure 4). At sites with a large share of heavy duty vehicles, a decline can be observed due to the lower NO_x emissions from Euro V and Euro VI vehicles.

Figure 12: NO_x and NO_2 emissions of diesel passenger cars in two test cycles dependent on Euro standards.



Note: NEDC: New European Driving Cycle. CADC: Common Artemis Driving Cycles

Source: Sturm et al. 2015

4.5. Deviation from anticipated trends

The most comprehensive comparison of ex-ante and ex-post assumptions on EU level was carried out by IIASA during the AAQD review (IIASA 2012a). The IIASA report compared the baseline projections developed for the CAFE process in 2005 against projections for the revision in 2012. It showed that in the EU-15[45] SO_2, NH_3 and VOC were below the projections, while NO_x and $PM_{2.5}$ were above them. In the EU-12[46] SO_2 and NH_3 were below the projections, while NO_x, and especially $PM_{2.5}$ and VOC were considerably higher.

[44] Due to the averaging period of one calendar year, relatively constant emissions of traffic throughout the year, and relatively short atmospheric lifetime.
[45] Member States that constituted the EU before 2004
[46] Member States that joined the EU after 2004

These higher-than-projected NO_x emissions can be clearly attributed to the higher-than-expected real-driving emissions of diesel vehicles (see Figure 12). In addition, the use of coal has not declined as anticipated in the EU-12.

For $PM_{2.5}$ the main reasons are the growth in biomass combustion and the larger share of diesel vehicles in the fleet which has not been compensated by the introduction of diesel particle filters.

5. MEASURES TAKEN IN CASE OF NON-COMPLIANCE

KEY FINDINGS

- Stringent measures for traffic have been implemented in Milan and London.
- They have led to an improvement in air quality already, even though the limit values for PM_{10} (Milan) and N_{O2} (Milan and London) are still exceeded.
- In Krakow the focus lies on domestic heating measures, which foresee a solid fuel ban from 2019 onwards.
- In one of the case studies (the city of Plovdiv, Bulgaria) some effort is still necessary to implement measures for domestic heating and to solve administrative issues.

According to Article 23 of the AAQD, Member States are required to draw up air quality plans and programmes in case of an exceedance of limit or target values. The information to be reported (at least within these plans) is laid down in Annex XV of the AAQD. Member States have to report specific elements of these programmes to the European Commission. Until 2012 this was done with the help of a questionnaire as specified in Commission Decision 2004/224/EC. Since 2013, an e-reporting system (established under the Implementing Decision 2011/850/EU) has been in place for this purpose

The AAQD does not explicitly require Member State to update their plans and programmes. However, many Member States (and/or local authorities depending on the administrative level that is responsible) usually update their plans regularly to account e.g. for changes in pollutant levels or for the necessity to amend measures or to implement new measures. This information is partly reported under the same mechanism as the original plans and programmes.

For the air quality hotspots described in section 4.3 the most recent air quality plans and programmes are summarized below.

5.1. Main measures implemented

5.1.1. Milan

The main measures implemented in Milan to improve air quality are (ETC/ACM 2013a, 2013b):

- Low emission zone for Milan and Milan province (Lombardy).
- Charging scheme for vehicles.
- Access regulations for vehicles.
- Regulation for biomass burning.

The low emission zone (LEZ) and the congestion scheme are combined in the Milano Area C[47]. This area is the historical centre of Milan, where an entrance ticket of 5 € has to be activated during certain time periods on working days[48]. However, diesel vehicles prior to

[47] http://www.comune.milano.it/wps/portal/ist/it/servizi/mobilita/Area_C/AREA_C, http://www.comune.milano.it/wps/portal/ist/en/area_c

[48] Monday, Tuesday, Wednesday and Friday from 7.30 to 19.30, and Thursday from 7.30 to 18.00

Euro 4 and petrol vehicles prior to Euro 1 are not allowed to enter Area C at all during these time periods. There are also access restrictions[49] to "I Navigli" southwest of Area C.

There are further LEZs in certain regions in Lombardy[50].

Since 2006 biomass burning in low efficiency stoves and fireplaces has been prohibited between 15 October and 15 April in Milan, Bergamo, Brescia, and all regions of Lombardy that are below 300 m above sea level. Since August 2014 a requirement has been in place to have wood-burning appliances (stoves and fireplaces) installed by certified experts, regularly maintained and registered (Regione Lombardia 2014). Burning of coal and high Sulphur content fuel oils in small appliances has been prohibited[51] since 2002.

Further measures and interactions with other plans are described in the regional action plan to improve air quality in Lombardy (Piano Regionale degli Interventi per la qualità dell'Aria, PRIA[52]).

5.1.2. London

Following a judgement by the UK Supreme Court after a legal challenge by NGO Client Earth the Department for Environment Food & Rural Affairs (DEFRA) had to update the NO_2 air quality plans for 38 zones, including the air quality plan for Greater London (DEFRA 2015a, 2015b).

The main measures which have already been implemented or have to be implemented in the near future in London (next to national levels) are:

- A so-called Ultra Low Emission Zone (ULEZ): The ULEZ will be implemented in central London in 2020 in addition to the congestion charge and the London-wide low emission zone. Within the ULEZ diesel vehicles will have to comply with Euro 6/VI standards or diesel vehicle owners will be charged with £ 12.50 for cars and £ 100 for heavy duty vehicles and buses.
- Renewal of bus fleet: Euro VI buses replacing Euro III as well as 1 700 hybrid-electric buses by 2016 and 3 000 by 2020.
- Renewal of taxi fleet: All newly licensed taxis will have to be zero emission capable from 2018. Funds will be provided for decommissioning taxis older than ten years. Requirements will be introduced for private hire vehicles.
- Promotion of cycling, walking, car sharing. Krakow

The main measures to improve air quality in Krakow and the Lesser Poland Voivdodeship for domestic heating are (Małopolska 2013a, 2013b):

- Restrictions on the use of solid fuels for domestic heating.
- Replacement of low-efficiency solid fuel appliances.
- Expansion and modernization of the district heating network.
- Expansion of gas network.

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[49] http://www.urbanaccessregulations.eu/countries-mainmenu-147/italy-mainmenu-81/milano-ar

[50] http://www.regione.lombardia.it/cs/Satellite?c=Redazionale_P&childpagename=Ambiente%2FDetail&cid=1213374630533&pagename=MBNTWrapper, http://urbanaccessregulations.eu/countries-mainmenu-147/italy-mainmenu-81/lombardia/milano

[51] http://www.misureprqa.sinanet.isprambiente.it/misure_prqa_anonimusview.php?Anno=2011&IDMisura=I03_D1T_04**

[52] http://www.reti.regione.lombardia.it/cs/Satellite?c=Redazionale_P&childpagename=DG_Reti%2FDetail&cid=1213538141708&packedargs=NoSlotForSitePlan%3Dtrue%26menu-to-render%3D1213277017319&pagename=DG_RSSWrapper

- Renovation of existing buildings and energy efficient construction of new buildings.
- Increased use of renewable energy sources for domestic heating.
- Ban on (agricultural) waste burning.

For industry:

- Obligation for new or modified installations to compensate for emissions in the same municipality (or neighbouring if appropriate).
- Requirements for measures to reduce fugitive emissions
- Enforcement of inspections of industrial facilities.

For traffic:

- Extension of parking restrictions, driving restrictions, park & ride.
- Improvement of public transport and cycling.

The first four measures which apply to domestic heating and all the measures for industrial facilities mentioned above are the most efficient ones under the programme. The restrictions on the use of solid fuels were introduced by adopting a resolution[53] which limits the fuels used for domestic heating to gas and light fuel oil in the city of Krakow. After tackling legal challenges, this resolution will enter into force on 1 September 2019. Thus, in principle, the resolution bans solid fuel appliances in both new and existing buildings. The households affected by this resolution have to switch to gas, light fuel oil or district heating systems or to electric heating appliances.

Under the air quality programme and the resolution adopted by the City of Krakow, grants will be provided for replacing old solid fuel appliances as well as subsidies for fuels (Małopolska 2013a, 2013b, Uchwała Nr XXXIV/571/15, Uchwała Nr XC/1355/13).

5.1.4. Plovdiv

For the Bulgarian city of Plovdiv the main measures will be implemented in the transport sector, as well as fuel switching in municipal buildings (ETC/ACM 2013a, 2013b). The measures in the transport sector are, in particular, an optimization and an increase of the attractiveness of public transport, the creation of bicycle lanes and the establishment of a centre for urban mobility management (Obshtina Plovdiv 2013). The environmental planning programme, however, shows that the measures for domestic heating at municipal level are not sufficient to achieve compliance, due to a number of financial and organisational obstacles which would also require action on the national level (Obshtina Plovdiv 2014a). The programme addresses necessary key actions at national level:

- Targeted national policy for granting support to economically vulnerable households;
- Additional incentives for natural gas in the industrial, public and residential sectors;
- Better control of emissions from industrial plants.

[53] http://bip.malopolska.pl/umwm/Article/get/id,1159347.html

The programme also states that the current legal framework limits the possibilities for local administrations to implement measures and thus proposes the following changes:

- Emission standards for heating appliances and standards for fuels;
- Requirements for solid fuel heating appliances (stoves and boilers);
- Modernization and replacement of heating appliances in public buildings

According to the programme, these measures should be accompanied by an information campaign.

5.2. Impact of the main measures

5.2.1. Milan

The implementation of measures in the region of Lombardy was summarized in a comprehensive study in 2015 (Regione Lombardia 2015). In this study, recent developments in emissions and ambient air concentrations of pollutants were also analysed. For traffic-related measures, an additional study is available, which summarizes the development of traffic-related emissions in the Milan Area C (AMAT-MI 2015).

For this study a transport model was used which combined detailed vehicle data and emission factors on monthly and annual timescales. From 2010 to 2014, PM_{10} exhaust emissions from traffic in Milan's Area C were reduced by almost 60 % and total PM_{10} emissions (including diffuse emissions) were reduced by 36 % (AMAT-MI 2015).

The study also shows that there was a marked decrease in PM_{10} emissions from 2011 to 2012, which is attributed to the introduction of the low emission zone and the charging scheme in Milan's Area C. Additional emission reductions from year to year are explained by a shift in the car fleet over time, in particular towards Euro 5 and Euro 6 vehicles (both petrol and diesel).

Emission data from other sectors are available for the years up to 2012 only. According to the regional inventory for Lombardy[54], PM_{10} emissions from non-industrial stationary sources decreased by 16 % between 2010 and 2012. However, no information is available on the effect of specific measures addressing biomass burning. Concerning ambient air quality in Milan, a decrease in annual average PM_{10} concentrations was observed each year from 2011 to 2014. Concentrations in 2013 and 2014 were lower than in all years prior to 2011 (Regione Lombardia 2015). A decreasing trend was also observed in the number of days in exceedance of the daily limit value for PM_{10}. Trends in annual average $PM_{2.5}$ and NO_2 concentrations were less marked, but also showed a decrease between 2012 and 2014.

In the study mentioned above, the status of implementation of all measures from the air quality plan of Lombardy is summarized, with the vast majority of measures having been implemented as foreseen in the air quality plan. However, information on any observed effects of specific measures on ambient air quality is not available.

It has to be noted that despite the implementation of measures and an overall decrease in emissions and ambient air concentrations, air quality standards are still exceeded in Milan. In 2014, the limit values for NO_2 (annual average) and PM_{10} (annual average and number of exceedances of the daily limit value) and the target value for $PM_{2.5}$ were exceeded in Milan.

Among the reasons for these exceedances are adverse dispersion conditions, with low average wind speeds and high pressure areas in the Po river basin (Regione Lombardia 2015). However, it is pointed out that the year 2014 was characterised by exceptionally

[54] http://www.inemar.eu/xwiki/bin/view/Inemar/HomeLombardia

favourable dispersion conditions, which explains in part why ambient air concentrations were comparatively low in that year.

5.2.2. London

The air quality plan for London does not specify the impact of individual measures; however, the overall development of NO_2 was modelled including the implemented and some of the planned measures (DEFRA 2015a, 2015b).

According to the model calculations, the road length where the NO_2 limit value is exceeded will be reduced from about 1 080 km in 2013 to 240 km in 2020 and 22 km in 2025. Complete compliance is expected for 2030. The maximum modelled NO_2 concentration is 126 µg/m³ for 2013, 71 µg/m³ for 2020, 48 µg/m³ for 2025 and 40 µg/m³ for 2030.

5.2.3. Krakow

Emissions of PM_{10} and $PM_{2.5}$ in the Lesser Poland Voivodeship amounted to 32 kt and 28 kt respectively in 2011 (Małopolska 2013a). Emissions within Krakow amounted to 4.1 kt and 3.2 kt respectively (Małopolska 2013b). The largest share comes from domestic heating. The programme for the Lesser Poland Voivodeship provides emission reductions through the following main measures:

- The restrictions on solid fuel use in the agglomeration of Krakow are expected to have reduced PM_{10} and $PM_{2.5}$ emissions by about 370 t in 2015 and to reduce them by 930 t and 920 t respectively in 2018.
- The replacement of low-efficiency solid fuel appliances is expected to have reduced PM_{10} and $PM_{2.5}$ emissions by about 350 t in 2015 and to reduce them by 880 t and 870 t respectively in 2023.
- The expansion and modernization of the district heating network is expected to have reduced PM_{10} and $PM_{2.5}$ emissions by about 175 t in 2015 and to reduce them by 440 t in 2023.
- The expansion of the gas network is expected to have reduced PM_{10} and $PM_{2.5}$ emissions by about 170 t in 2015 and to reduce them by 420 t in 2023.
- The use of renewable energy sources for domestic heating is expected to have reduced PM_{10} and $PM_{2.5}$ emissions by about 5.5 t in 2015 and to reduce them by 14 t in 2023.
- Insulation for buildings is expected to have reduced PM_{10} and $PM_{2.5}$ emissions by about 14 t in 2015 and to reduce them by 35 t in 2023.
- Measures in the industrial sector are expected to reduce PM_{10} and $PM_{2.5}$ emissions by about 520 t and by 470 t respectively (no date provided).

As the measures in the domestic heating domain might be interlinked, the emission reductions cannot be simply added up and compared with 2011 emission levels.

5.2.4. Plovdiv

The $PM_{2.5}$ and PAH programme for Plovdiv describes the expected estimated impact of certain measures in the domestic heating sector on emissions and $PM_{2.5}$ levels (Obshtina Plovdiv 2013). The most effective ones are:

- Information on the benefits of building renovations and on grants for renovations;
- Emission reduction in a prison labour facility;
- Installation of a telephone hotline to report on excessive emissions;
- Developing a strategy and an action plan to reconnect former users of district heating;

- Developing a strategy and action plan to attract the use of gas for domestic heating.

The estimated reduction of $PM_{2.5}$ levels is between 0.6 and 0.9 µg/m³ for each of these measures[55] in 2015. The reduction achieved due to general trends in the use of energy is estimated to be 1.6 µg/m³. From the programme it is not clear how these reduction potentials have been derived. It is thus assumed that these numbers are estimates.

However, the programme also states that these measures are not sufficient to achieve compliance with $PM_{2.5}$ and BaP standards.

5.3. Pursuing the main measures

5.3.1. Milan

The status of implementation of air quality measures in the Lombardy region was evaluated in 2015 (Regione Lombardia 2015). Of the 66 measures which were listed as high priority measures in the air quality plan, 58 had been implemented at the time of the evaluation. Most of them are still ongoing, but 20 had already been completed. In particular, all of the measures foreseen for the transport sector had been implemented. Where measures had not been implemented, the following reasons were given:

- Adjustment of the time schedule (this concerns measures that had been labelled as "medium-term" in the air quality plan).
- Unavailability of financial resources (a fund was mentioned from which the resources were expected to be received).
- One measure in the area of stationary sources was not implemented because it was replaced by a national measure.
- One measure in the area of agriculture had not yet been implemented due to a lack of funding, but an application was ongoing for funds to be obtained under the EU's rural development programmes.

In addition to the high priority measures, five medium/long-term measures had been implemented in the transport and buildings sector. One of these measures, a resolution on a temporal traffic ban for Euro 1 motorcycles and mopeds, had already been completed. Other medium- to long-term measures face difficulties or may be delayed, due to the following reasons:

- Changes in the national institutional, financial and socio-economic framework due to the continuing economic crisis.
- In the context of social and economic difficulties, it becomes harder to impose additional restrictions or obligations on citizens and businesses.

To summarize, the evaluation carried out in 2015 shows that the majority of the planned measures are on track while also providing reasons for delays - which are in many cases related to financial difficulties.

5.3.2. London

Local authorities are required in general to report annually on progress with the implementation of their air quality plans to DEFRA (DEFRA 2015a, 2015b). In addition, the Greater London Authority publishes progress reports on the delivery of the London Mayor's

[55] In the programme the overall impact is stated to be 8.7 µg/m³, which is, however, the sum of the reductions achieved for all of the measures over three years and therefore does not make sense here.

air quality strategy. The second progress report was published in summer 2015 (GLA 2013, 2015). The reports describe developments in air quality and exposure to pollutant levels above the limit values. More importantly, they describe the progress achieved in each of the 15 policies that constitute the strategy. According to the second progress report, all policies are on track. In addition, further measures will be looked at such as an expansion of the so-called “Ultra Low Emission Zone”. The progress report also announces two new strategies for London’s transport authority TfL (Transport for London), namely an “Ultra Low Emission Vehicle Delivery Plan” and a freight transport strategy.

5.3.3. Krakow

For the Lesser Poland Voivodeship annual reports[56] are published that describe the implementation of the main measures and their impact on emissions (Małopolska 2015). The most recent report states that even though about 3 100 solid fuel boilers were replaced in 2014 in the Voivodeship, this is by far not sufficient in view of the fact that the aim is to replace about 150 000 boilers until 2023 as laid down in the air quality programme (Małopolska 2013a, 2013b).

For the city of Krakow the implementation of the resolution for domestic heating[57] should ensure that by 2019 all solid fuel appliances are replaced by gas, oil or district heating.

For industry a number of permits were issued and inspections were conducted for several facilities (Małopolska 2015).

In addition, the implementation of the air quality plan for the Małopolska Region was supported by a LIFE project[58] in 2015.

5.3.4. Plovdiv

The $PM_{2.5}$ and PAH programme is an integral part of the general environment programme and thus adopted and supervised by the City Council (Obshtina Plovdiv 2013, 2014b). Thus annual reports are required that describe:

- Air quality assessments and air quality trends.
- The current status of the implementation of measures and funding of measures.
- Additional measures.

The annual reports are however not yet available on the website of the municipality of Plovdiv.

The $PM_{2.5}$ and PAH programme needs to be updated in 2016.

56 http://www.malopolskie.pl/Srodowisko/Powietrze/
57 Uchwała Nr XXXIV/571/15
58 http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=5440

6. TRENDS AND FUTURE PROSPECTS OF $PM_{2.5}$

KEY FINDINGS

- $PM_{2.5}$ levels exceeded the target value in 2014 in 6 Member States, where the highest levels were observed in the Czech Republic, Poland and Bulgaria.
- For these three countries it is doubtful whether compliance with the limit value and the exposure concentration obligation was achieved in 2015 (official data will be available in autumn 2016).
- $PM_{2.5}$ impacts on human health will be reduced by 50 % under the clean air policy package until 2030, and average urban $PM_{2.5}$ levels will reach levels close to the WHO guideline value in most Member States.

$PM_{2.5}$ is the air pollutant with the most severe impacts on human health in the EU. Within the review of the European air quality policy[59] it was estimated that about 400,000 premature deaths can be attributed to $PM_{2.5}$ annually (European Commission 2013a). Therefore it is important that Member States comply with the target and limit value for $PM_{2.5}$ of the AAQD. The Directive sets a target and limit value of 25 µg/m³ as annual mean concentrations for $PM_{2.5}$. The target value had to be meet in 2010, the limit value for $PM_{2.5}$ became binding from 2015 onwards.

In addition, Member States are required to reduce exposure to $PM_{2.5}$ in urban areas for the periods 2013-2015 and 2018-2020 based on 2008-2010 (or 2009-2011) levels.

6.1. Compliance with $PM_{2.5}$ limit and target values

In 2010 the target value for $PM_{2.5}$ was exceeded in the following Member States:

Table 5: Exceedance of the $PM_{2.5}$ target value in 2010.

Bulgaria	4 out of 6 zones
Czech Republic	4 out of 15 zones
Germany	1 out of 78 zones
France	4 out 71 zones
Hungary	1 out of 5 zones
Italy	15 out of about 130 of zones
Latvia	1 out 3 of zones
Poland	28 out 46 of zones
Slovakia	2 out 10 of zones

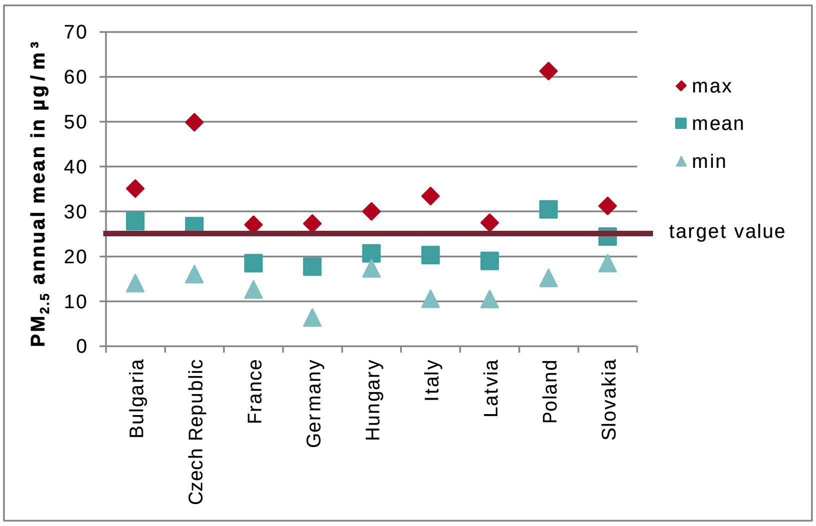
Note: No information is available for Romania and some zones in Italy and France, and both one zone in Germany and Ireland. There are some discrepancies between the data reported in the questionnaire compiled according to Commission Decision 2004/461/EC, the report from ETC/ACM (ETC/ACM 2012a) and AirBase

Source: ETC/ACM 2012a.

[59] http://ec.europa.eu/environment/air/review_air_policy.htm

Figure 13 shows that the target value was exceeded only to a minor extent in France, Germany, Hungary and Latvia, whereas in the Czech Republic and Poland concentrations were up to twice the target value. In these countries (and in Bulgaria) even the mean value of all the stations was above the target value.

Figure 13: Minimum, average and maximum $PM_{2.5}$ levels in EU countries that reported exceedances of the $PM_{2.5}$ target value in 2010.



Source: ETC/ACM 2012a, AirBase v8, CDR

In 2014 exceedances of the target value occurred in six countries (see also Figure 1). Slovakia reported eight exceeding zones were levels were between 21 and 25 µg/m³.

Table 6: Exceedance of the $PM_{2.5}$ target value in 2014.

Bulgaria	4 out of 6 zones
Czech Republic	4 out of 10 zones
France	1 out 76 zones
Hungary	1 out of 5 zones
Italy	1 out of about 130 zones
Poland	24 out 46 of zones

Note: number of zones in Hungary from 2010. For three exceeded zones in Poland levels are between 23 and 25 µg/m³.

Source: EEA Dataset G. Data for Italy from Ministry website.

Still rather high levels[60] were observed in the Czech Republic, Poland and Bulgaria. Thus it seems very doubtful that these three countries complied[61] with the $PM_{2.5}$ limit value in 2015.

For France, Hungary and Italy compliance in 2015 will be dependent on the meteorological conditions.

The $PM_{2.5}$ AEI for Bulgaria, the Czech Republic and Poland for the years 2009-2011 were well above the ECO of 20 µg/m³ (see section 2.2.2, Table 2). Hence, it is also doubtful that these three countries complied[61] with the ECO in 2015.

[60] Bulgaria: 30 µg/m³, Czech Republic: 36 µg/m³, Poland: 45 µg/m³

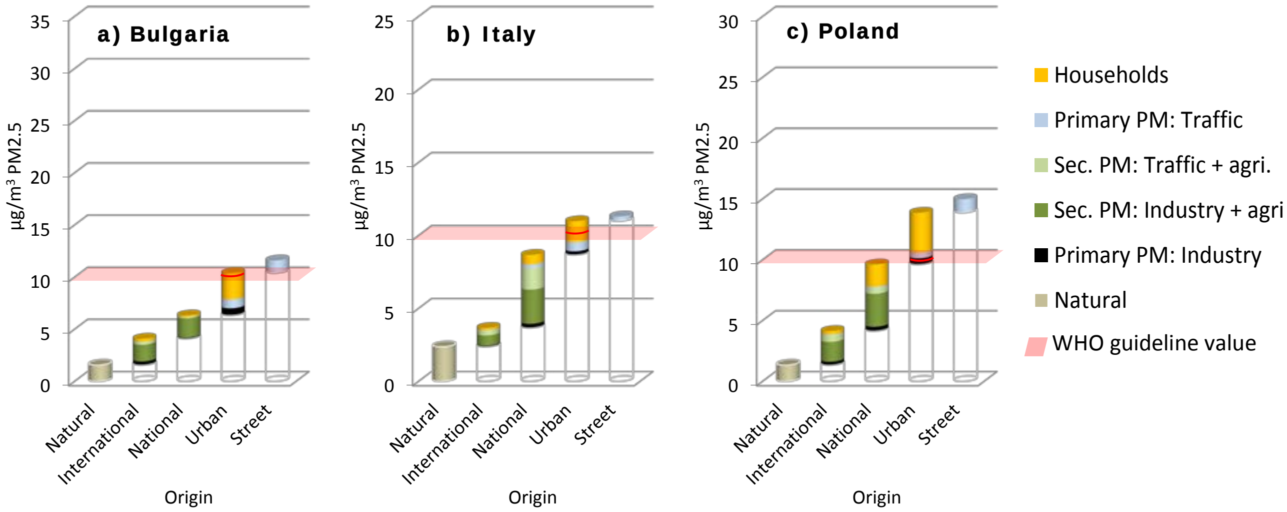
[61] The officially reported air quality data for 2015 will not be available before October 2016.

6.2. Future prospect for $PM_{2.5}$ levels

The expected effect of the measures suggested in the Clean Air Policy Package on the $PM_{2.5}$ concentrations in 21 Member States[62] was determined by IIASA. Urban $PM_{2.5}$ levels are expected to be reduced by 50% or more in most Member States by 2030 (IIASA 2014b).

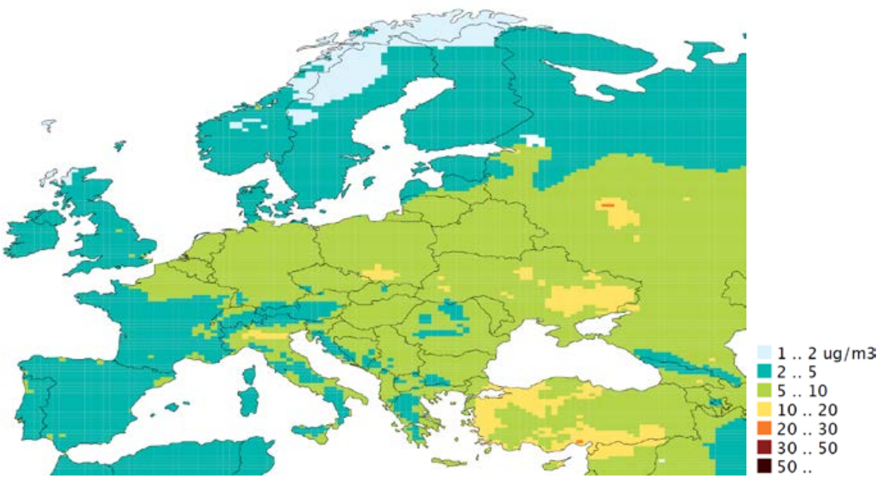
Figure 14 and Map 4 show that the average urban $PM_{2.5}$ levels will decrease to levels close to the WHO guideline by 2030 in most Member States, assuming that the measures suggested in the Clean Air Policy Package are implemented. According to the more detailed analysis by IIASA at urban and street level, exceedances of the WHO guideline level might still occur in 11 Member States[63] (IIASA 2014b).

Figure 14: Origin of $PM_{2.5}$ in Bulgaria (a), Italy (b) and Poland (c) in 2030 under the EU Clean Air Policy Package.



Source: IIASA 2014b

Map 4: $PM_{2.5}$ levels in 2030 under the Commission's proposal scenario



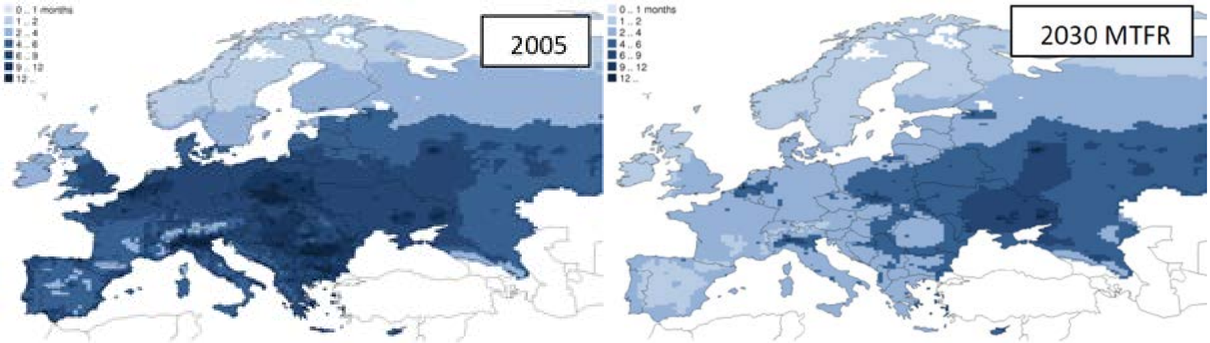
Source: IIASA GAINS Europe

[62] Austria, Belgium, Bulgaria, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, the Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden, United Kingdom. For the other Member States insufficient data were available.

[63] Austria, Belgium, Bulgaria, Czech Republic, France, Greece, Hungary, Italy, Poland, Romania, Slovakia

In addition, IIASA analysed the health impact from exposure to $PM_{2.5}$ (IIASA 2014a). Loss of life expectancy due to exposure to $PM_{2.5}$ could be reduced from 8.5 months in 2005 to about 3.6 months on average in 2030 when implementing the maximum technically feasible measures in the EU. In some Member States (Belgium, the Czech Republic, Hungary, Poland and Romania) premature mortality will still be about 6 or more months in 2030 (Map 5).

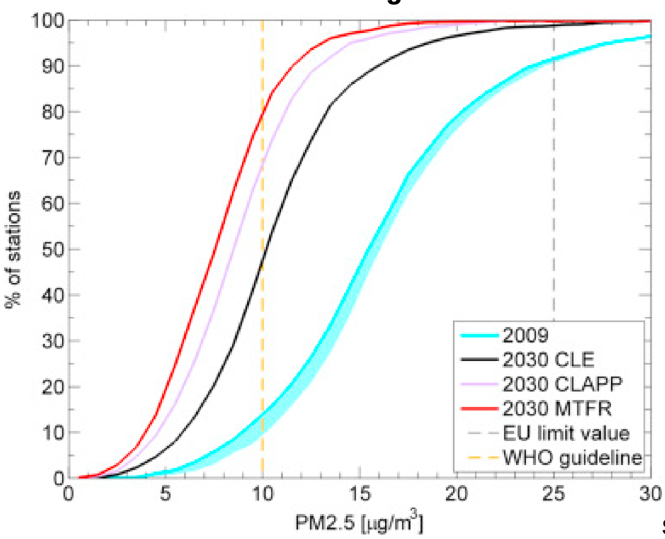
Map 5: Loss of statistical life expectancy from exposure to $PM_{2.5}$ in 2005 (left) and 2030 MTFR scenario (right).



Source: IIASA 2014a

Assessments of future $PM_{2.5}$ levels under different policy scenarios have been carried out under the revision of the AAQD (Kiesewetter et al. 2015b). Figure 15 shows that in 2030 almost all stations are expected to comply with the EU limit value of 25 µg/m³. To comply with the WHO guideline value of 10 µg/m³ further measures are required. Under the Clean Air Policy Package around 63 % of the stations are expected to meet the WHO guideline value in 2030.

Figure 15: Cumulative distributions of $PM_{2.5}$ concentrations for 2009 and for 2030 under current legislation (CLE), the Clean Air Policy Package (CLAPP) and the maximum technically feasible reductions (MTFR), modelled for all monitoring stations covered by GAINS.



Source: Kiesewetter et al. 2015b

7. POLICY OPTIONS TO ACHIEVE FULL COMPLIANCE

KEY FINDINGS

- Measures to reduce the impact of domestic heating on PM levels should aim at reducing solid fuel burning, with a complete ban as a last resort.
- Industrial sources should be tackled by issuing permits that go beyond BAT levels[64], and inspections should be carried out more often.
- Agricultural waste burning should be banned to reduce PM levels on the suburban and regional scale. This measure should be accompanied by efficient waste collections.
- Regional background PM concentrations are in many areas most efficiently reduced by cutting NH_3 emissions so as to reduce secondary inorganic particle formation.
- Measures aimed at achieving NO_2 compliance have to address diesel vehicles e.g. by introducing progressively stringent low emission zones and thus banning diesel vehicles from inner city areas in the near future, or by progressively increasing the taxation of diesel fuel
- Traffic measures should address the transport system as whole, i.e. public transport, pedestrians, cyclists, and also take into account transport demands via the implementation of Strategic Urban Mobility Plans.

The extent of exceedance of PM_{10} and NO_2 limit values in some countries prevented the European Commission from proposing new or more stringent limit values e.g. for $PM_{2.5}$ during the review of the European Air Quality Policy. Also, some Member States claimed in their time extension notifications that compliance would not be achieved before 2020. Hence, for the Clean Air Programme for Europe[65], which was presented as the outcome of the review process, the main goal is to achieve full compliance in 2020 at latest. This should be achieved by source related measures on European level and through the revised NECD, by further supporting Member States as well as through national, regional and local measures undertaken by the Member States.

The main policy options through which compliance might be achieved are listed below.

7.1. Main policy options

7.1.1. Compliance with PM_{10} limit values

PM_{10} levels at air pollution hot spots are up to twice the annual mean value, which corresponds to 35 exceedances of the daily mean limit value (section 4.2, Figure 2). Due to the long atmospheric lifetime and secondary particle formation, PM_{10} and precursor emission reductions need to be achieved at all spatial levels, from the local to the European level (see Figure 6, Figure 7 and Figure 8). Measures on the local and urban scale only will not be sufficient.

[64] see as an example: https://luft.umweltbundesamt.at/measures/query/show/45
[65] COM(2013) 918 final

The main measures[66] in the domestic heating sector are the following ones:

- Ban on burning coal for domestic heating as e.g. implemented in Dublin[67] in 1990 and planned for Krakow in 2019 (also including wood burning, see section 5.1.3).
- Either a ban on wood burning in city areas or stringent emission limit values for heating appliances (see 1. BImSchV).
- Ecodesign Commission Regulations (EU) set emission thresholds for putting new heating appliances on the market. However, due to market harmonization, more stringent national limits or additional parameters for conformity testing and the operating stage (or bans on new heating appliances which fulfil all the - possibly less ambitious - Ecodesign requirements), cannot be defined by the Member States. Regional opting-out for environmental and health reasons is possible on a case-by-case basis only.
- In case of a change of appliances: renovation of buildings to improve thermal insulation and thus reduce energy consumption.
- Grants and subsidies might be required to avoid fuel poverty, overcome investment hurdles, and avoid illegal (waste) burning.

The main measures to tackle traffic emissions are the following ones:

- Stringent low emission zones, with a future ban on diesel vehicles in (inner) city areas altogether.
- Promotion of slow transport modes (cycling, walking) and public transport.
- Implementing long-term Sustainable Urban Mobility Plans (SUMPs; European Parliament 2015).

Industrial sources should be addressed by issuing permits that go beyond BAT levels[68], and enforcing inspection.

Agricultural waste burning should be banned to reduce PM levels on the suburban and regional scale. This measure should be accompanied by efficient waste collections.

Regional background PM concentrations are in many areas most efficiently reduced by cutting NH_3 emissions so as to reduce secondary inorganic particle formation (ETC/ACM 2013c, 2013d; Umweltbundesamt Dessau 2014a, Bessagnet & Rouil 2014). To cut NH_3 emissions the main measures are: integrated nitrogen management (which takes into account the whole nitrogen cycle), low emission manure application techniques, low-emission manure storage systems, livestock feeding strategies, and to limit ammonia emissions from the use of mineral fertilizers (UNECE 2015).

The results obtained with the GAINS[69] model for the Clean Air Policy Package include cost efficient optimizations of measures, which can be used as guidance for choosing and implementing measures on the national level.

[66] Further examples can be found in a draft catalogue of measures: https://luft.umweltbundesamt.at/measures/
[67] Dublin coal ban ("ban on the marketing, sale and distribution of bituminous fuel"). http://www.environ.ie/en/Environment/Atmosphere/AirQuality/SmokyCoalBan/
[68] see as an example: https://luft.umweltbundesamt.at/measures/query/show/45
[69] Greenhouse Gas - Air Pollution Interactions and Synergies, http://www.iiasa.ac.at/web/home/research/researchPrograms/GAINS.en.html

7.1.2. Compliance with NO_2 limit values

At the air pollution hotspots in Europe NO_2 values exceed the limit value by a factor of 2 and more (section 4.2, Figure 4). Under current legislation it is still uncertain whether compliance will be achieved in 2030 in some places (Kiesewetter et al. 2014). Due to the non-linear relationship between NO_x and NO_2, emissions have to be reduced even more (Düring et al. 2011). Thus, at these hotspots, local and urban NO_x emissions will have to be more than halved in order to reach compliance.

Several studies have shown that non-compliance with NO_2 limit values is mainly caused by diesel vehicles (EEA 2015a, Degraeuwe 2016). Due to the higher than expected NO_x emissions of Euro 6 type approved diesel vehicles under real-driving conditions compliance cannot be achieved in the near future at heavily polluted sites (Umweltbundesamt Dessau 2015, see also press release[70]). The large so-called conformity factors (difference between laboratory conditions and real driving emissions) for future Euro 6 vehicles that the Member States agreed on[71] in October 2015 (and which the European Parliament[72] decided not to veto in February 2016) will further delay compliance.

A substantial reduction can only be achieved by either introducing a stringent real-driving emissions on-road test procedure[73] or through a shift in the fleet composition in city areas towards gasoline or electric cars. The latter can be achieved e.g. by introducing progressively stringent low emission zones and thus banning diesel vehicles from inner city areas sooner or later altogether, or by progressively increasing the taxation of diesel fuel.

While these measures focus mainly on motorized traffic, it is essential to address the transport system as whole, i.e. public transport, pedestrians and cyclists, and also to take into account transport demands via the implementation of SUMPs (European Parliament 2015). A recent EEA report under the Transport and Environment Reporting Mechanism (TERM) named key challenges for reducing the environmental impact of transport in the future (EEA 2015b):

- Achieving the goals concerning the modal shift of the 2011 Transport White Paper[74].
- Reducing greenhouse gas emissions from road freight;
- Promoting alternative fuels for transport;
- Implementing new technologies that address transport supply and demand.

7.2. Possible support to Member States

The EU Commission proposes several support options for the Member States in the Clean Air Policy Package. These options include two funding instruments: the European Structural and Investments Funds (ESIF)[75] 2014-2020 and LIFE[76] 2014-2020. Under ESIF, regions and cities will be supported in the implementation of measures and the promotion of innovative technologies to reduce air pollution. The LIFE programme includes co-funding projects to implement air quality policies and legislation by supporting national, regional and local

[70] http://www.umweltbundesamt.de/presse/presseinformationen/alte-diesel-muessen-schrittweise-raus-aus-der
[71] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8531&lang=en&title=Commission-welcomes-agreement-on-robust-testing-of-air-pollution-emissions-by-cars
[72] http://www.europarl.europa.eu/news/en/news-room/20160129IPR11905/Parliament-decides-not-to-veto-car-emissions-test-update
[73] The Commission has recently proposed new rules for vehicle testing, see press release on 27 January 2016: http://europa.eu/rapid/press-release_IP-16-167_en.htm
[74] http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en.htm
[75] http://ec.europa.eu/regional_policy/en/funding/
[76] http://ec.europa.eu/environment/life/index.htm

authorities in capacity building. In addition, the new LIFE Programme contains so-called 'Integrated Projects' to support the development and implementation of Air Quality Plans across Regions at national or transboundary level. LIFE projects have already addressed issues like sustainable mobility and transport, air pollution monitoring and modelling, capacity building, encouragement of behavioural change and awareness raising (European Union 2014).

Horizon 2020[77], the EU's research and innovation programme 2014-2020, supports the development of innovative technologies and strategies for improving air quality. In 2015, the European Commission launched the "Horizon Prize on materials for clean air" to stimulate innovation aimed at the reduction of PM concentrations in urban areas[78].

The vision of an Energy Union, as set out in the Energy Union Framework Strategy (COM(2015) 80final), shall enable all consumers to contribute to an overall reduction of energy consumption. The European Commission presented the necessary steps to achieve this aim, which are as follows (European Commission 2015):

- Better information for consumers on consumption, related costs and energy sources.
- Making the switching process between suppliers quick and simple.
- Providing consumers with possibilities to become active energy players.
- Making smart homes and networks a reality.

Energy poverty is an issue related to domestic heating and should thus be taken into account when addressing solid fuel heating appliances. The European Commission recently[79] proposed several options to support the Member States and measures on the European level in the field of energy poverty (European Commission 2015, VCWG 2013, INSIGHT_E 2015).

[77] http://ec.europa.eu/programmes/horizon2020/en
[78] http://ec.europa.eu/research/horizonprize/index.cfm?prize=clean-air
[79] http://europa.eu/rapid/press-release_SPEECH-16-164_en.htm

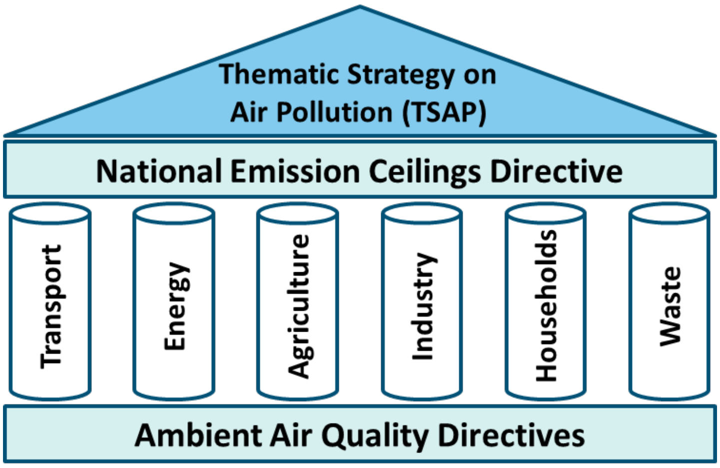
8. RELATIONSHIP AND INTERACTION WITH NECD AND SOURCE LEGISLATION

KEY FINDINGS

- The National Emission Ceilings Directive, currently under revision, limits emissions from air pollutants in the Member States with the aim to reduce transboundary pollution.
- The Industrial Emissions Directive limits emissions from industrial installations based on the application of best available techniques.
- Combustion plants between 1 and 50 MW are covered by the Medium Combustion Plant Directive.
- Emissions from domestic heating devices are partly regulated in the Ecodesign Directive. However, moderate ambition levels, along with the long transition periods of the Ecodesign Regulations and the long lifespan of heating appliances tend to limit the impact of these measures in the near future.
- Differences in emission levels for NO_x between type approval tests and real-world emissions of vehicles lead to exceedances of NO_2 limit values in cities in Europe. Diesel particle filters have reduced PM exhaust emissions from vehicles considerably.
- A coordinated strategy for climate change and air pollution policies can lead to benefits for both areas.

The following chart illustrates the interrelationships between different air quality related legislation in Europe:

Figure 16: Schematic representation of European air quality policy.



Source: Environment Agency Austria (Umweltbundesamt) based on DG ENV

Whereas the National Emission Ceilings Directive (NECD, Directive 2001/81/EC) reduces the overall emissions of several air pollutants in the Member States and thus also contributes to a reduction of transboundary pollution, the AAQD aims at protecting human health and reducing exposure. Source- and product-related legislation and regulations support the achievement of both the targets of the NECD and the AAQD. The main source-related instruments of legislation are the Industrial Emissions Directive 2010/75/EU (IED), the Ecodesign Directive 2009/125/EC and the Medium Combustion Plant Directive 2015/2193/EU.

Apart from the source-related legislation mentioned above, there are also several product-related Directives and standards. Most relevant for air quality are the Paints Directive 2004/42/EC, Directive on sulphur content of liquid fuels 1999/32/EC, Directive on the quality of liquid fuels 2003/17/EC, and Directives to reduce VOC from petrol storage (Council Directive 1999/13/EC and European Parliament and Council Directive 94/63/EC).

8.1. Interlinkages with the NECD

The NECD limits the emissions of several air pollutants and ozone precursors with the aim to reduce transboundary pollution contributing to acidification, eutrophication and ground-level ozone. In the proposed NECD[80], Member States are required to draw-up, adopt and regularly update a national air pollution control programme (NAPCP) describing how they will meet their reduction commitments. According to the proposal, NAPCPs shall be developed in the context of the overall air quality policy framework and shall take into account the transboundary impacts of air pollution, the requirements of the air quality objectives stipulated in the AAQD and coherence with other relevant national plans or programmes, e.g. air quality plans according to the AAQD.

Box 4: National Emissions Ceilings Directive (NECD)

Directive 2001/81/EC of the European Parliament and the Council on National Emissions Ceilings for certain pollutants (NECD) sets upper limits for each Member State for the total emissions of four pollutants responsible for acidification, eutrophication and ground-level ozone pollution (sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia).

This Directive is currently under revision. The revision of the NECD is part of the implementation of the Clean Air Policy Package proposed by the European Commission. In the proposal[80] new national emission reduction commitments applicable from 2020 and 2030 are established for SO_2, NO_x, NMVOC, NH_3, fine particulate matter ($PM_{2.5}$) and methane (CH_4). Until 2020 the emission ceilings set in the current NECD continue to apply. Under Article 6 of the proposal for a new NECD the Member States are required to draw up, adopt and regularly update a National Air Pollution Control Programme describing how they will meet their reduction commitments. Member States are required to provide information on policies and emission to stay below their emission limits.

8.2. Interlinkages with main source legislation

Emissions from stationary sources in the industrial sector are limited under the Industrial Emissions Directive (IED). Included are emissions from industrial installations like large combustion plants, waste incineration plants and installations using organic solvents.

In 2015, the Medium Combustion Plant Directive (MCPD) entered into force which addresses emissions from combustion plants between 1 and 50 MW not covered in the IED. There are about 143 000 medium combustion plants[81] in the EU. They are an important source of emissions of sulphur dioxide, nitrogen dioxide and PM. In areas not complying with the air

[80] COM(2013)920final, available at: http://eur-lex.europa.eu/legal-content/EN/HIS/?uri=CELEX:52013PC0920&qid=1408612908289
[81] http://ec.europa.eu/environment/industry/stationary/mcp.htm

quality limit values of the AAQD, Members States can apply stricter emission limit values than those set out in the MCPD for individual combustion plants.

Domestic heating is a main source of PM and black carbon emissions in the EU. Emissions from new boilers and stoves are partly addressed by the Ecodesign Directive. Moderate ambition levels and the long transition periods of the Ecodesign Commission Regulations (EU; No 813/2013, No 814/2013, 2015/1185, 2015/1188, 2015/1189) as well as the long lifespan of heating appliances (fewer turnovers) may interfere with AAQD goals.

Box 5: Main source legislation

The Industrial Emissions Directive 2010/75/EU (IED) sets out the main principles for the permitting and control of installations based on an integrated approach and the application of best available techniques (BAT). BAT means the most effective techniques to achieve a high level of environmental protection as a whole which can be implemented under technically and economically viable conditions and take the costs and benefits into consideration.

The Ecodesign Directive 2009/125/EC sets minimum eco-design requirements for specific energy-using products. The amended Directive extends the scope to services and industries, such as heating systems, ventilation and air conditioning, machines, pumps and transformers. It also sets emission limits for solid fuel local space heaters and solid fuel boilers.

The Medium Combustion Plant Directive 2015/2193/EU (MCPD) was presented by the European Commission in December 2013 as part of the Clean Air Package and published in November 2015. The MCPD sets emission limit values for certain pollutants, namely sulphur dioxide, nitrogen oxide and dust. These limits will be applied for new and existing medium combustion plants. The new Directive covers medium combustion plants with a rated thermal input between 1 and 50 MW, thus filling that gap to complete the regulatory framework for the combustion sector (smaller and bigger plants are already covered by the respective EU Directives – namely the Ecodesign Directive and the IED, respectively).

The MCPD foresees the possibility of granting exemptions to some plants, in particular district heating systems, plants using biomass as the main fuel and plants being part of small isolated systems (for instance, on islands). The MCPD also includes rules to monitor emissions of carbon monoxide.

8.3. Interlinkages with regulations for vehicles

Commission Regulation (EC) No 692/2008 on Euro 5 and Euro 6 standards of light vehicles and Regulation (EC) No 595/2009 on the Euro VI standard for heavy duty vehicles introduce minimum requirements for air pollutant emissions from vehicles. The implementation of these regulations is expected to reduce NO_x and PM emissions from vehicles significantly. However, differences in NO_x emission levels between type approval tests and real-world emissions lead to the current (and prolonged) NO_2 exceedance situations in cities in Europe (IIASA 2012b, 2014a; Kiesewetter et al. 2014, Degraeuwe 2016). The high conformity factors for Euro 6 vehicles will further delay compliance with NO_2 limit values (partly relevant also for PM compliance due to secondary particle formation).

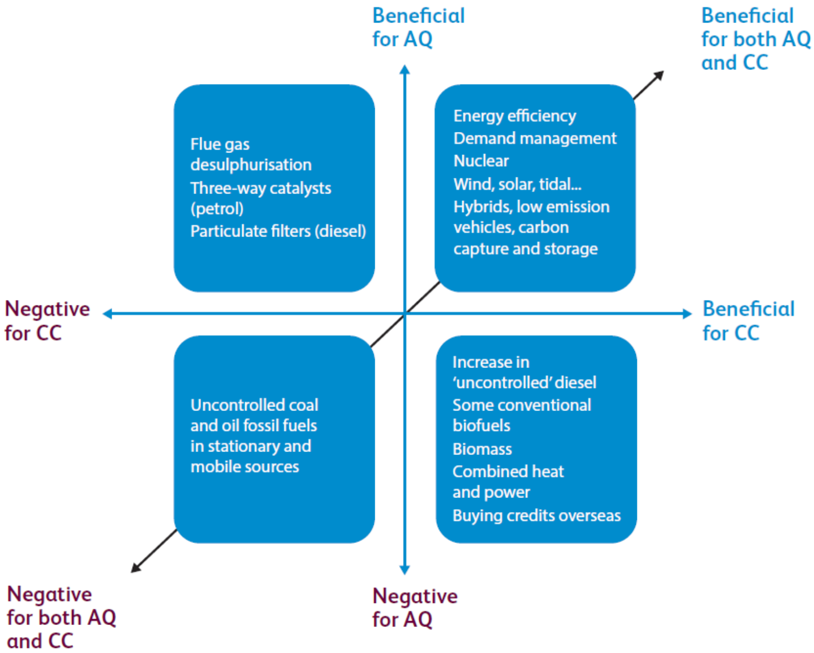
By contrast, PM exhaust emissions have considerably declined since the widespread introduction of diesel particle filters. Nevertheless, non-exhaust emissions (mainly particles from tyre wear, brake wear, road surface abrasion and resuspension of road dust) are currently not regulated and can only be tackled by a reduction of traffic volumes and improvements to road surfaces.

The Non-Road Mobile Machinery (NRMM) Directive 97/68/EC, which tackles emissions from combustion engines installed in mobile machines such as construction machinery, generator sets, chain saws, trimmers etc., is currently under revision[82].

8.4. Interlinkages with climate change policies

Synergies and trade-offs between policies addressing climate change and air quality are shown in Figure 17.

Figure 17: Interaction of Air Quality (AQ) and Climate Change (CC) policies



Source: Royal College of Physicians 2016

In support of the air quality policy review, the European Commission has presented a report which summarizes *inter alia* the findings of the main EU-funded research projects concerning the interaction between air quality and climate change (European Commission 2013b):

- In many countries, climate mitigation policies are quite separate from air quality policies and therefore ignore the relationship (as shown in Figure 17) between them.
- Major greenhouse gases originate from the same sources as air pollutants, and a coordinated abatement strategy could provide an effective way of securing benefits for both policy areas.
- Reduction in the emissions of methane, and of absorbing aerosols, in particular black carbon, should contribute to an improvement of air quality, specifically to a reduction in ozone concentration. Reduction of SO_2 emissions, however, will increase global warming.
- Climate change affects air quality. However, dedicated air quality mitigation measures will be more effective in improving air quality than variations induced by climate change and natural variability in the climate.

[82] COM/2014/0581 final - 2014/0268 (COD), available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014PC0581

9. CONCLUSIONS AND POLICY OUTLOOK

KEY FINDINGS

- About two thirds of the Member States are currently in non-compliance with PM_{10} and NO_2 limit values; one fifth exceeds the $PM_{2.5}$ target value.
- Infringement procedures were launched by the European Commission against a high number of Member States and several cases were referred to the Court of Justice of the European Union. However, no judgement was passed so far that might lead to accelerated compliance.
- Domestic heating, traffic and industry are major sources of PM_{10} and $PM_{2.5}$, whereas NO_2 is mainly caused by emissions from (diesel) vehicles, which have not decreased in recent years for passenger cars and light-duty vehicles.
- Stringent measures to achieve compliance have been implemented and will be implemented in some but not all the cities.
- Except for some local hotspots, full compliance is expected for 2030 on a European level, which is considerably later than envisaged in the Clean Air Policy Package.

9.1. Status of compliance with limit values

In 2014 the limit value for the annual mean of NO_2 was exceeded in 18 Member States[11], the hourly limit value for NO_2 in five Member States[12]. The highest levels were observed in large urban areas in Germany, France and UK.

The limit value for the daily mean of PM_{10} was exceeded in 17 Member States[13], the annual mean limit value in six Member States[14]. The highest levels were observed in Bulgaria, France and Poland.

The target value for $PM_{2.5}$ (which became a limit value in 2015) was exceeded in six Member States[15].

The SO_2 limit values for the protection of human health were exceeded in Bulgaria and Slovakia at specific hotspots; the critical levels for the protection of vegetation were exceeded in the Czech Republic.

Currently the European Commission has launched infringements procedures against 23 of 28 Member States. Ten Member States have been referred to the Court of Justice of the European Union for exceeding the PM_{10} limits values. For exceedances of NO_2 and SO_2 no Member State has been taken to the Court so far.

9.2. Main implementation problems

Domestic heating is the major source of PM in the Eastern European hotspots that have been analysed in this study. Tackling solid fuel burning requires changes in heating appliances in a large share of households and building; and often in low-income households. These changes either take a long time or require support – i.e. subsidies or grants - often to cover up to 100 % of the renewal cost. Cooperation at different administrative levels is therefore crucial but cannot always be guaranteed in all the air quality hotspots.

Cooperation on a regional, national and international level is also necessary to reduce contributions from secondary particles on a regional scale, which limits the effectiveness of local measures.

NO_2 compliance is hampered by the persistent non-delivery of Euro standards for diesel passenger cars and light duty vehicles under real-world driving conditions. Thus a complete ban on diesel vehicles in inner cities areas would be necessary to achieve compliance at the most polluted sites. Such a drastic measure would require a huge political effort, as diesel fuel has up to now been taxed at a lower (privileged) rate than gasoline in many Member States[83] where diesel vehicles have been promoted over many years (see e.g. Umweltbundesamt Dessau 2014b). The difficulties of the implementation of stringent traffic measures apply to PM as well.

9.3. Adequacy of implemented measures for air quality improvement

With respect to the four cases analysed in this study, adequacy of implemented measure for air quality improvement can be summarized as follows:

The measures already implemented in London, as well as the planned ones, represent in principle the main measures that are available to tackle NO_2 exceedances[84]. The main problem for London as well as for many other cities in Europe, however, is that the real-world driving emissions of diesel vehicles are much higher than anticipated, even those of Euro 5 vehicles, which has lowered the impact of the measures in place and will delay full compliance.

In Milan stringent measures were implemented, but these measures were not sufficient to achieve compliance. Given the adverse dispersion conditions in the Po valley, even more drastic measures would be required.

The ban on solid fuel burning in Krakow, effective from September 2019 onwards, along with ongoing measures to promote the renewal of appliances and the insulation of buildings, can be regarded as an adequate response, similar to the policies implemented in Dublin in 1990.

For the city of Plovdiv the measures foreseen and already implemented can be regarded as a first step towards compliance but they will not be sufficient to achieve compliance in the next few years.

9.4. Outlook to future compliance

The Clean Air Policy Package of the European Commission of 2013 aims at compliance with existing limit values by 2020 (European Commission 2013a). However, these objectives will most probably not be achieved for PM_{10}, $PM_{2.5}$ and NO_2 in certain air quality hotspots in Europe, especially when looking at a current legislation scenario (Kiesewetter et al. 2014, 2015a). If maximum technically feasible emission reduction technologies are fully implemented, full compliance with PM_{10} limit values might be achieved at almost all air quality stations by 2030.

The large difference between the laboratory conditions and real driving emissions - even for Euro 6 diesel vehicles - will further delay compliance with NO_2 limit values.

[83] see e.g. the tax rates available: https://ec.europa.eu/energy/en/statistics/weekly-oil-bulletin

[84] Passenger cars (except light 4x4 utilities and pickups) are currently not affected by the LEZ (see https://tfl.gov.uk/modes/driving/low-emission-zone/check-if-your-vehicle-is-affected?intcmp=2266), but will be included in the ULEZ from 2020 onwards (https://tfl.gov.uk/modes/driving/ultra-low-emission-zone). The ULEZ, however, will only cover the area of central London.

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ANNEX A OBJECTIVES OF AAQD AND 4DD

The limit values for the protection of human health of the AAQD can be found in section 2.2.1, the obligations for $PM_{2.5}$ in section 2.2.2.

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

Alert thresholds for SO_2 and NO_2

To be measured over three consecutive hours at locations representative of air quality over at least 100 km² or an entire zone or agglomeration, whichever is the smaller.

SO_2	500 µg/m³
NO_2	400 µg/m³

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/m^3
Alert	1 hour	240 µg/m^3

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

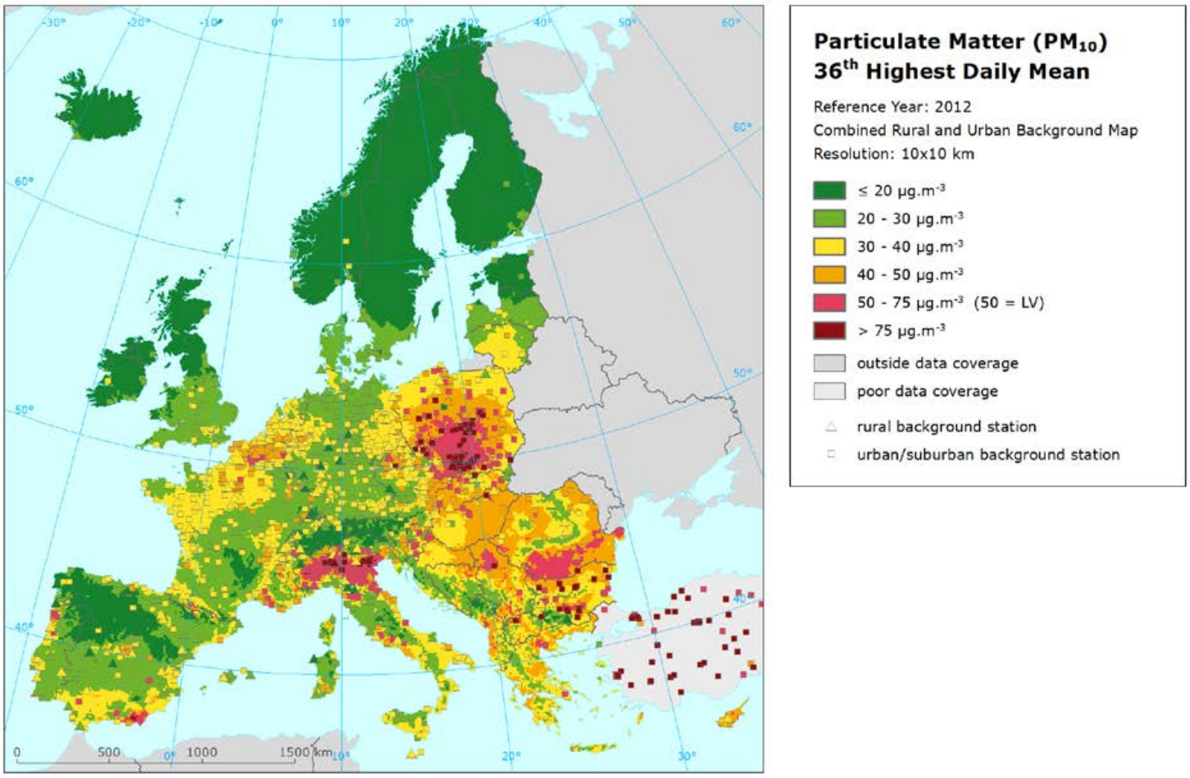
Total content in PM_{10} averaged over a calendar year.

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

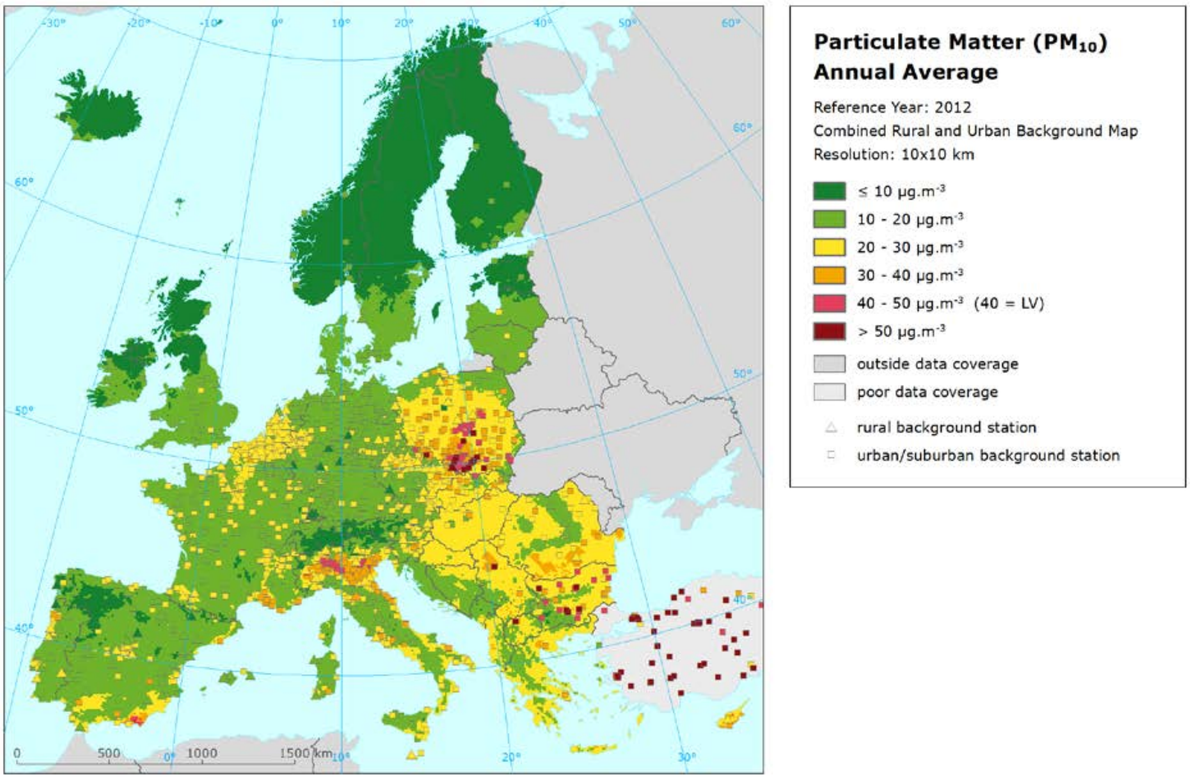
Source: 4DD.

ANNEX B AIR QUALITY MAPS

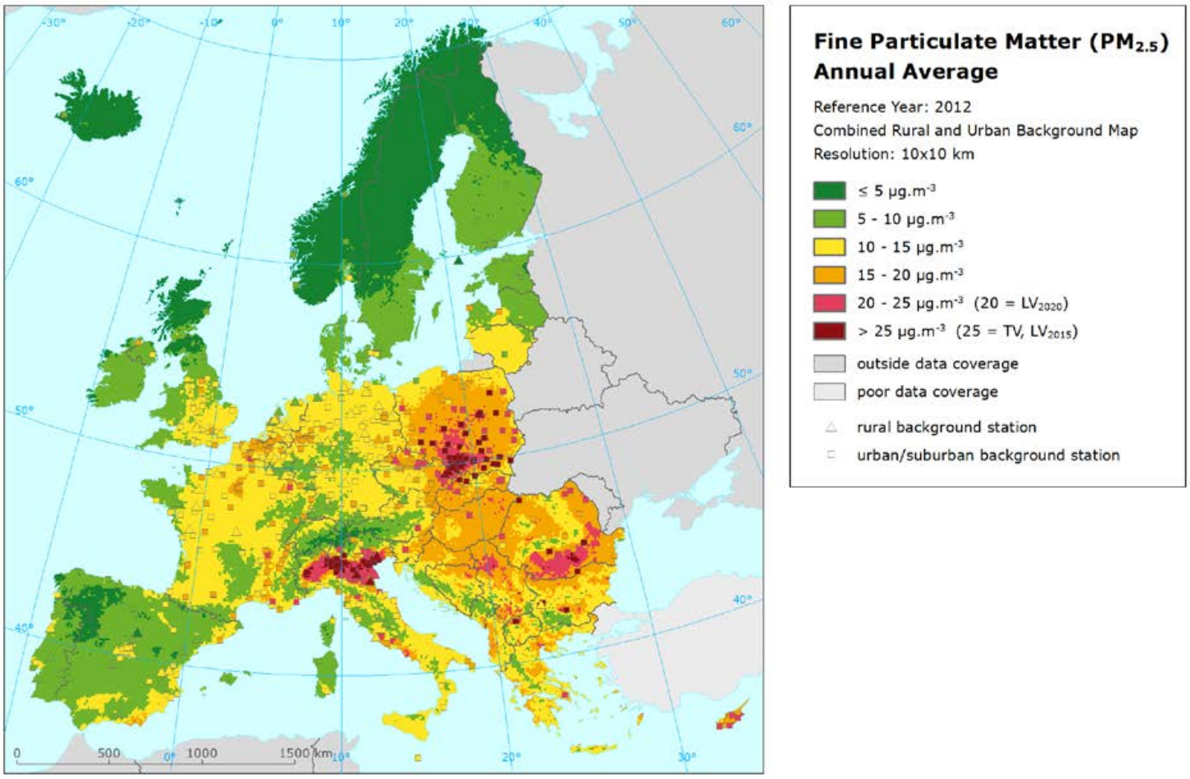
Map 6: 36th highest PM_{10} daily mean of 2012.



Map 7: PM_{10} annual mean in 2012.

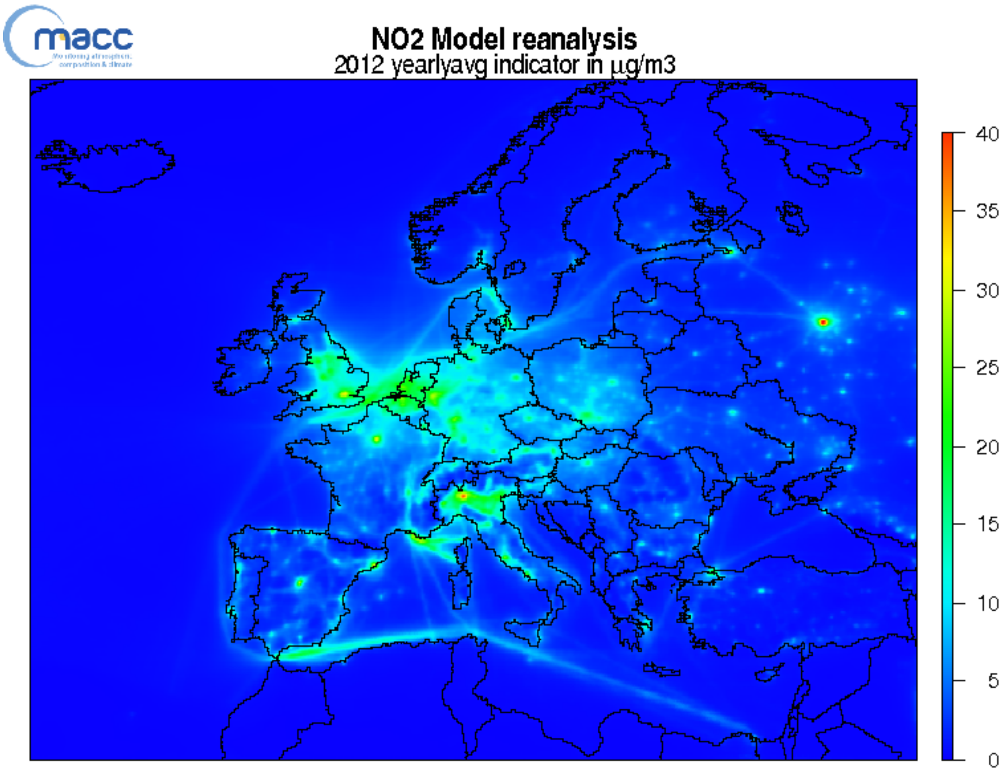


Map 8: $PM_{2.5}$ annual mean in 2012.



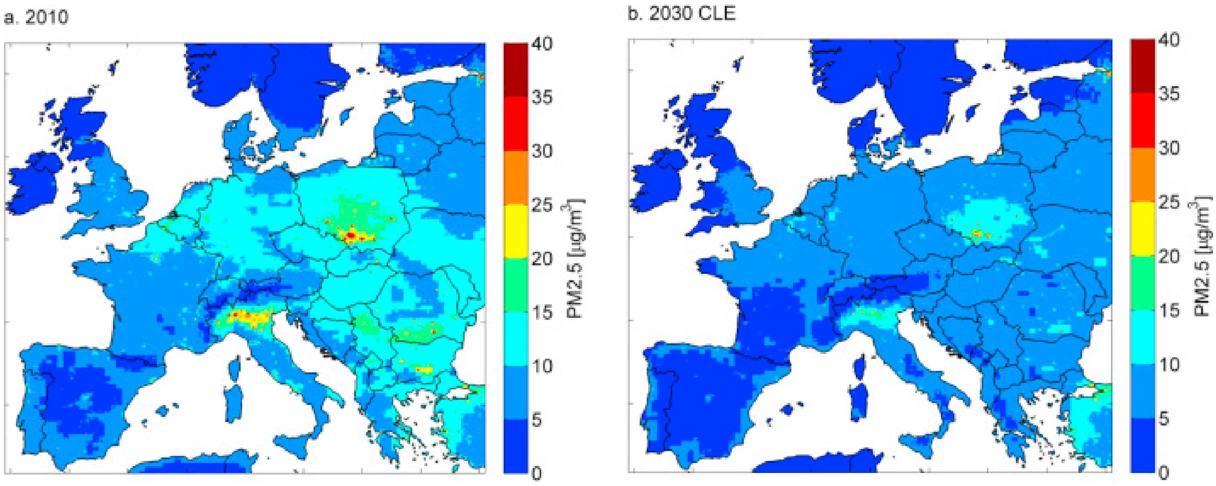
Source: [ETC/ACM]

Map 9: Model calculations of the annual mean NO_2 concentration for 2012.



Source: [MACC]

Map 10: Ambient urban background $PM_{2.5}$ concentrations from anthropogenic emissions as modelled in GAINS for 2010 and 2030, assuming current legislation (CLE).



Source: Kiesewetter et al. 2015b

ANNEX C GENERAL AIR QUALITY TRENDS

Figure 18: PM_{10} annual mean trend average of about 800 monitoring sites in EU28

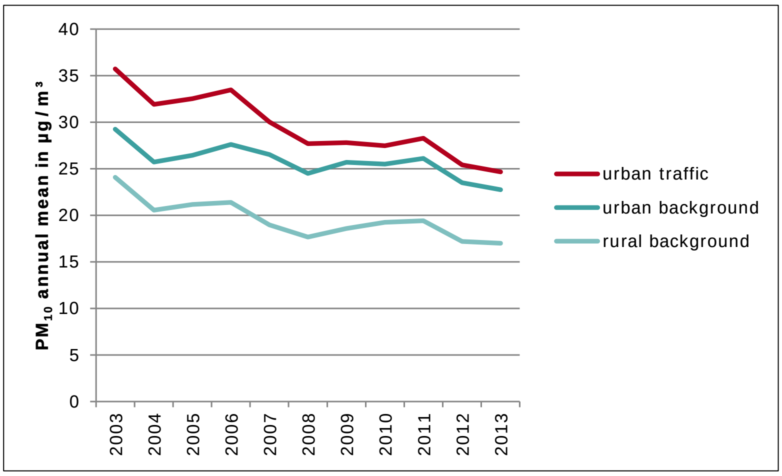


Figure 19: NO_2 annual mean trend average of about 640 monitoring sites in EU28

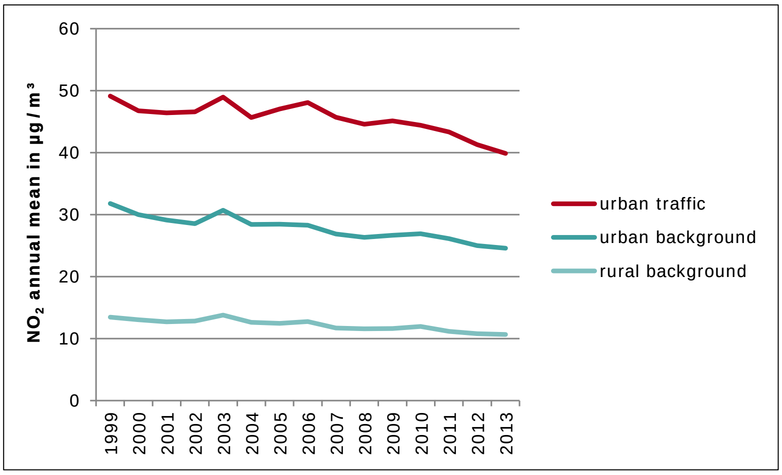
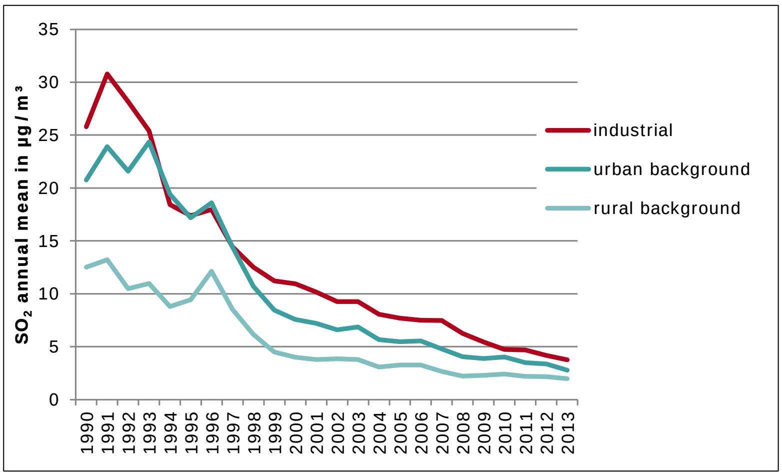


Figure 20: SO_2 annual mean trend average of about 550 monitoring sites in EU28

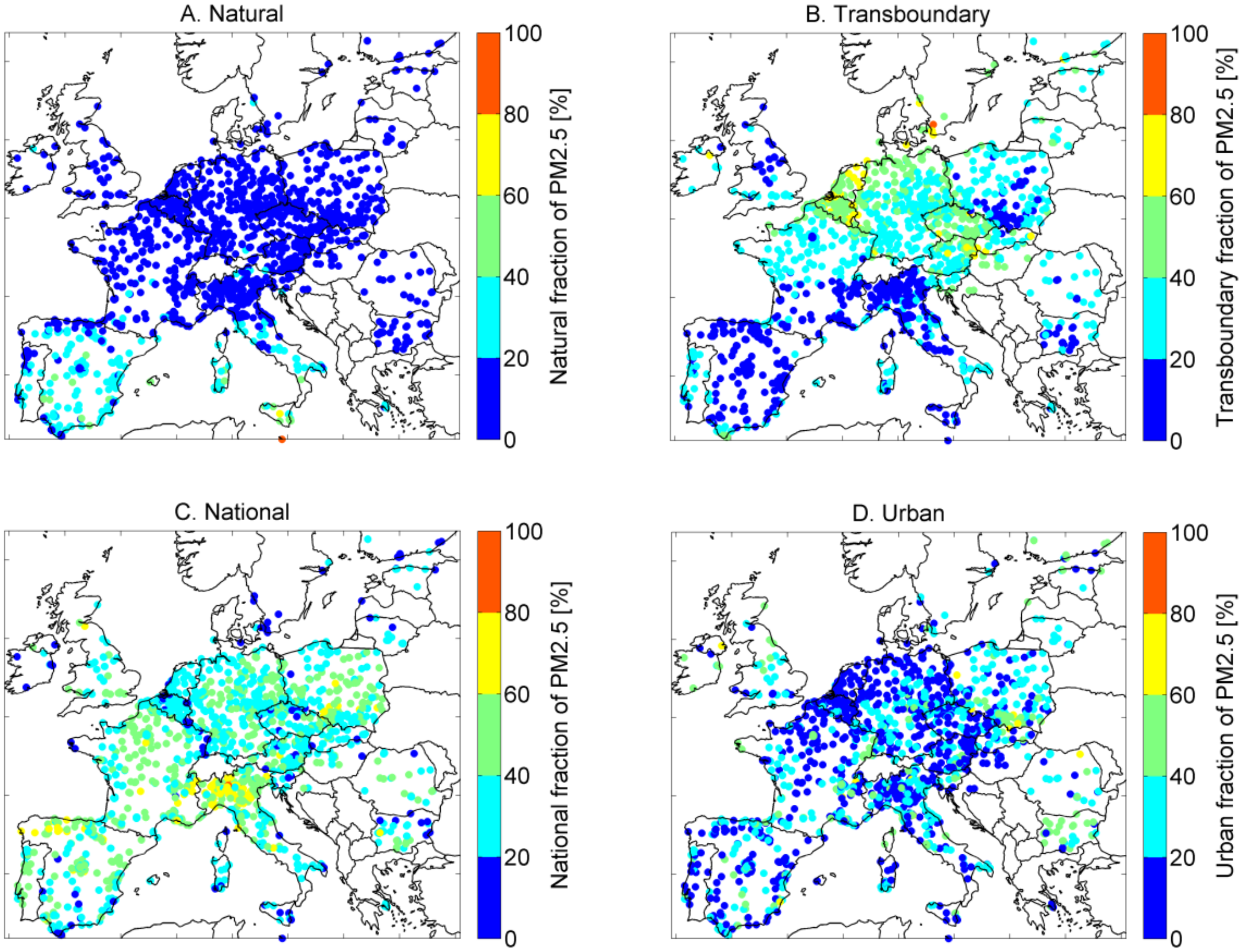


Source: EEA

ANNEX D SPATIAL ORIGINS OF $PM_{2.5}$

Spatial origins of $PM_{2.5}$ at background monitoring stations covered by the GAINS model of IIASA, given as relative fractions of total modelled $PM_{2.5}$ at each station in 2009.

Figure 21: Relative fraction of different spatial origins at $PM_{2.5}$ AIRBASE monitoring sites.



Source: IIASA 2014b

ANNEX E INFRINGEMENT CASES

Table 7: Ongoing infringement cases

Member State	Infringement Nr.	Reason	Formal notice	Reasoned opinion
Austria	20162006	NO_2	2016-02-25	
Bulgaria	20092135	SO_2	2009-06-25 2013-11-20	2010-03-18 2014-11-26
Czech Republic	20082186	PM_{10}	2010-01-28 2013-02-21	2010-09-30 2015-03-26
France	20152074	NO_2	2015-06-18	
Germany	20152073	AAQD NO_2	2015-06-18	
Greece	20082192	PM_{10}	2009-11-20 2013-02-21	2010-06-24 2014-10-16
Greece	20032097	NEC	2003-07-09 2003-07-11	
Hungary	20082193	PM_{10}	2009-11-20 2013-02-21	2010-10-28 2014-03-28
Italy	20024517	Air pollution in Bari	2003-10-15	
Italy	20152043	AAQD NO_2	2015-05-28	
Latvia	20082195	PM_{10}	2010-01-28 2013-01-24	2011-02-16 2014-07-10
Poland	20162010	NO_2	2016-02-25	
Portugal	20152045	AAQD NO_2	2015-05-28	
Romania	20092296	PM_{10}	2009-11-20 2013-02-21	2010-06-24 2011-04-06
Slovakia	20082201	PM_{10}	2009-11-20 2013-02-21	2010-09-30 2014-11-26
Slovenia	20122212	PM_{10}	2013-01-24	

Member State	Infringement Nr.	Reason	Formal notice	Reasoned opinion
Spain	20152053	NO_2	2015-06-18	
Sweden	20122216	PM_{10}	2013-04-25	2015-06-18
United Kingdom	20144000	NO_2	2014-02-20	

Source: Commission decisions on infringements

Table 8: List of infringement cases of the AAQD referred to the Court

Member State	Infringement Nr.	Reason	Formal notice	Reasoned opinion	Referral to Court	Closing
Belgium	20082184	PM_{10}	2009-11-20 2009-11-23 2012-11-21	2010-06-24 2014-02-20	2011-04-06	
Bulgaria	20102109	PM_{10}	2010-09-30 2013-01-24	2014-07-10	2015-06-18	
Cyprus	20082185	PM_{10}	2009-01-29 2009-02-02	2010-03-18	2010-11-24	2012-02-27
France	20082190	PM_{10}	2009-11-20 2013-02-21	2010-10-28 2015-04-29	2011-05-19	
Italy	20082194	PM_{10}	2009-01-29 2009-02-02	2010-05-05	2010-11-24	2013-06-20
Poland	20100549	AAQD	2010-07-16	2011-02-16	2011-11-24	Withdrawal 2012-11-21
Poland	20082199	PM_{10}	2009-01-29 2013-04-25 2014-03-28	2010-09-30 2015-02-26	2015-12-10	
Portugal	20082200	PM_{10}	2009-01-29	2010-03-18	2010-11-24	2013-06-20
Slovenia	20082202	PM_{10}	2009-01-29	2009-10-29	2010-03-18	2011-10-27
Spain	20082203	PM_{10}	2009-01-29 2013-02-21	2010-03-18 2014-10-16	2010-11-24	
Sweden	20082204	PM_{10}	2009-01-29	2009-10-29	2010-03-18	2011-10-27

Source: Commission decisions on infringements

Table 9: List of infringement cases of the NECD referred to the Court

Member State	Infringement Nr.	Formal notice	Reasoned opinion	Referral to Court	Closing
Germany	20030076	2003-01-23	2003-07-09	2003-12-16	Withdrawal 2004-10-13
Greece	20030190	2003-01-23	2003-07-09	2003-12-16	2005-10-12
Ireland	20030136	2003-01-23	2003-07-09	2003-12-16	2004-07-07
Italy	20030157	2003-01-23	2003-07-09	2003-12-16	2004-12-14
Luxemburg	20072197	2007-06-27	2007-10-17	2008-05-06	2009-06-25
Netherland	20030061	2003-01-23	2003-07-09	2003-12-16	2005-10-12

Source: Commission decisions on infringements

Table 10: Maximum PM_{10} levels in 2014 in Bulgarian air quality zones

Limit value	BG0001	BG0002	BG0003	BG0004	BG0005	BG0006
PM_{10} # of exc.	105	115	133	171	113	133
PM_{10} annual mean (µg/m³)	53.0	56.7	48.9	64.1	47.2	56.2

Source: EEA Dataset G.

Table 11: Maximum PM_{10} levels in 2014 in Spanish air quality zones

Limit value	ES.BDCA.AQD/ ZON_ES0302	ES.BDCA.AQD/ ZON_ES1201	ES.BDCA.AQD/ ZON_ES0915
PM_{10} # of exc.	114	57	66
PM_{10} annual mean (µg/m³)	48		

Source: EEA Dataset G.

Table 12: Maximum PM_{10} levels in 2014 in Poland's air quality zones

Zone	PM_{10} annual mean (µg/m³)	PM_{10} # of exceedances	Zone name
PL0201		73	Aglomeracja Wrocławska
PL0202		80	miasto Legnica
PL0203		60	miasto Wałbrzych
PL0204	71	129	strefa dolnośląska
PL0401	42	104	Aglomeracja Bydgoska
PL0402		78	miasto Toruń
PL0403		81	miasto Włocławek
PL0404	48	142	strefa kujawsko - pomorska
PL0601		59	Aglomeracja Lubelska
PL0602		57	strefa lubelska
PL0801		76	miasto Gorzów Wlkp.
PL0803		43	strefa lubuska
PL1001	45	115	Aglomeracja Łódzka
PL1002	55	138	strefa łódzka
PL1201	64	188	Aglomeracja Krakowska
PL1202		36	miasto Tarnów
PL1203	49	123	strefa małopolska
PL1401	42	84	Aglomeracja Warszawska
PL1402		44	miasto Płock
PL1403		74	miasto Radom
PL1404	42	98	strefa mazowiecka

Zone	PM_{10} annual mean ($\mu g/m^3$)	PM_{10} # of exceedances	Zone name
PL1601		71	miasto Opole
PL2401	51	144	Aglomeracja Górnośląska
PL2402	53	125	Aglomeracja Rybnicko-Jastrzębska
PL2403		74	miasto Bielsko-Biała
PL2404	48	131	miasto Częstochowa
PL2405	56	138	strefa śląska
PL2601		68	miasto Kielce
PL2602		54	strefa świętokrzyska
PL2801		36	miasto Olsztyn
PL2803		41	strefa warmińsko-mazurska
PL3001		72	Aglomeracja Poznańska
PL3002		80	miasto Kalisz
PL3003	42	104	strefa wielkopolska
PL3201		39	Aglomeracja Szczecińska
PL3203		57	strefa zachodniopomorska
PL1602	45	115	strefa opolska
PL1801		26	miasto Rzeszów
PL1802		79	strefa podkarpacka
PL2001		37	Aglomeracja Białostocka
PL2201		48	Aglomeracja Trójmiejska
PL2202	45	124	strefa pomorska

Source: EEA Dataset G.

Table 13: Maximum PM_{10} levels in 2014 in Italian air quality zones

Zone	PM_{10} annual mean ($\mu g/m^3$)	PM_{10} # of exceedances	Zone name
IT0118		115	Torino agglomerato
IT0119		86	Piemonte Pianura
IT0120		40	Piemonte Collina
IT0306		88	Agglomerato di Milano
IT0307		56	Agglomerato di Bergamo
IT0308		90	Agglomerato di Brescia
IT0309		71	Pianura ad elevata urbanizzazione (A)
IT0310		71	Pianura (B)
IT0312		48	Fondovalle (D)
IT0508		66	Agglomerato Venezia
IT0509		58	Agglomerato Treviso
IT0510		59	Agglomerato Padova
IT0511		77	Agglomerato Vicenza
IT0512		43	Agglomerato Verona
IT0513		49	Pianura e Capoluogo Bassa Pianura
IT0514		40	Bassa Pianura e Colli
IT0892		61	Pianura Ovest (Emilia-Romagna)
IT0893		52	Pianura Est (Emilia-Romagna)
IT0909		59	Zona Valdarno Pisano e Piana Lucchese

Zone	PM_{10} annual mean (µg/m³)	PM_{10} # of exceedances	Zone name
IT1007		35	Valle (Umbria)
IT1008		57	Conca ternana (Umbria)
IT1101		36	Zona A (Regione Marche)
IT1212	44	107	Zona Valle del Sacco
IT1215		35	Agglomerato di Roma
IT1305		40	Agglomerato Chieti Pescara
IT1403		44	Pianura (piana di Bojano - Piana di Venafro)
IT1501		45	Zona Di Risanamento - Area Napoli E Caserta (Campania)
IT1503		69	Zona Di Risanamento - Area Avellinese (Campania)
IT1504	43	77	Zona Di Risanamento - Area Beneventana (Campania)
IT1613		6	zona industriale (Puglia)
IT2007		40	agglomerato di Cagliari (Sardegna)

Source: EEA Dataset G.

Table 14: Maximum PM_{10} levels in 2013 in French air quality zones

Zone	PM_{10} # of exceedances	Zone name
FR03A02	60	Provence-Alpes-Cote-D-Azur-Marseille
FR04A01	140	Ile-De-France-Paris
FR15A01	55	Rhone-Alpes-Grenoble
FR16A02	56	Alsace-Strasbourg
FR18N10	38	Picardie-Zur
FR20A01	68	Rhone-Alpes-Lyon
FR20N10	57	Rhone-Alpes-Zur
FR39N10	48	Martinique-Zur

Note: Data from 2013 taken as there are wrong numbers in the 2014 data.

Source: EEA Dataset G.

CAT: QA-02-16-464-EN-C (paper)
CAT: QA-02-16-464-EN-N (pdf)

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ISBN 978-92-823-9229-4 (paper)
ISBN 978-92-823-9228-7 (pdf)

doi:10.2861/741 (paper)
doi:10.2861/261956 (pdf)

Publications Office

Implementation of the Ambient Air Quality Directive