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Air Implementation Pilot

Lessons learnt from the implementation of air quality legislation at urban level

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European Environment Agency

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Executive summary

Why have a pilot project for air policy implementation?

Almost three quarters of Europeans live in cities. The air quality in our cities is therefore of significant importance to the health of Europeans. Considerable progress has been made in the past twenty years in improving urban air quality, but issues remain. A number of different air pollutants such as nitrogen dioxide, particulate matter, and ozone remain above regulated levels, posing a threat to human health. This report describes a European pilot project to help identify and address the reasons underlying this 'gap' in implementation of air quality policy in 12 European cities, and thereby draw lessons of wider relevance.

The pilot took place within a broader policy context, three aspects of which are particularly important. The first is the European Commission's 2012 communication on implementation issues ([1]), which stressed the need to find effective ways of dealing with 'problems on the ground' that prevent implementation of environmental policy, and called for more effective implementation systems. The second is the ongoing review of air policy culminating in 2013, Europe's year of air. Later this year, the Commission will present the results of the review, which is expected to contain concrete legislative and policy proposals to revise and update Europe's air policy. The third is the continued focus on implementation proposed by the Commission in the context of the 7th Environment Action Programme ([2]).

The Air Implementation Pilot is a timely response to all three policy initiatives. Its aim is to show how a better understanding of policy implementation is needed to underpin both the current and any revised air policy. The pilot looked at implementation in two ways: firstly, by identifying the implementation challenge; and secondly, by improving knowledge on the policy tools that can address that challenge.

Implementation of EU policy is sometimes addressed primarily in terms of compliance: ensuring that countries adhere to EU law, and bringing legal challenges against them if they do not. While compliance is of course essential, this pilot focused on another important aspect: the collaborative work needed to build capacity and knowledge in order to deliver policy more effectively in pursuit of agreed objectives.

How the Air Implementation Pilot was organised

The Air Implementation Pilot brought together 12 cities across the European Union and was jointly run by the cities themselves, the European Commission, and the European Environment Agency (EEA). It aimed to better understand the challenges cities faced in implementing air quality policy, and also encouraged the cities to share their experiences, so they could learn from each other and see what has worked and what has not worked in other cities. The pilot also aimed to develop common proposals to help improve implementation of air policy.

The pilot lasted for 15 months, starting in March 2012. It consisted of several workshops held with representatives of the European Commission's Directorate General of Environment; the EEA; the EEA's Topic Centre on Air Pollution and Climate Change Mitigation; and representatives of the cities participating in the pilot. The EEA prepared the format and topics to be discussed at these meetings, sending out questionnaires and preparatory materials before each meeting in order to assist the discussions.

([1]) Communication on 'Improving the delivery of benefits from EU environment measures: building confidence through better knowledge and responsiveness' (EC, 2012a).
([2]) ec.europa.eu/environment/newprg/7eap.htm.

Eight cities originally took part in the pilot: Berlin, Dublin, Madrid, Malmö, Milan, Ploiesti, Prague, and Vienna. Four more cities subsequently joined at the end of 2012: Antwerp, Paris, Plovdiv, and Vilnius. The cities were selected so as to ensure a representative sample of the diversity of Europe's urban areas. The selection aimed at including cities from different parts of Europe, of different population sizes, with different administrative traditions, and with a variety of sources of pollutants.

The pilot focused on five 'workstreams', where lessons for implementation could most usefully be drawn. The first of these workstreams was local **emission inventories**. Emission inventories are sets of data that show what pollutants are emitted into the air, where, and from which sources. The second workstream was **modelling** and the use of air quality models. Models are the computer-based tools that help to understand air pollution processes. The third workstream was **monitoring networks**. These are the networks of sampling stations located across cities that take regular measurements of air quality. The fourth workstream was **management practices**. In this workstream, different administrative measures were considered to assess the effect they have on air quality. The fifth and final workstream was **public information**. This workstream focused on how the cities kept their citizens informed about air quality.

Lessons learnt from the Air Implementation Pilot

Although 11 of the 12 cities have **emission inventories**, the pilot uncovered a great variety of methodologies used to compile these inventories. This variety means that the cities' emission inventories are often not comparable with one another, or with the emission inventories of the regions within which they are located. Cities have problems taking into account all sources of pollution, due to the difficulty in finding available data, or because of the difficulty in appropriately quantifying different sources. The pilot project concluded that better input data and more guidance are needed on inventory methodology.

For **air quality modelling**, there was also a great diversity of models used by the cities. Because air quality models make use of emission inventories, often the shortcomings of these inventories carry over to the modelling activities. Additional issues encountered by the cities related to the other input data used in models, such as meteorological information, and background concentrations of pollutants. Another difficulty when applying models at urban level was how to accurately reflect the specificities of urban topography, such as pollution hot spots on kerbsides. Finally, many city representatives said that the results of their models were often highly complex, and therefore difficult to interpret, consuming a lot of resources and computational time. This complexity also makes the subsequent validation of the results more difficult.

The pilot project concluded that greater training in modelling was needed, along with improved input data (including meteorological data, background concentrations, and the specificities of each city's topography).

On **monitoring networks**, the pilot project found that most of the cities had the necessary number of monitoring stations required by the relevant directives. However, the criterion for the macro-scale siting of ozone stations (their distribution between urban and suburban locations) has not always been met in the cities participating in the Air Implementation Pilot.

The cities' experts therefore recommended addressing this issue of the location of monitoring stations. Some experts also suggested that the air quality directives provide more detailed requirements for measuring stations. These requirements would stipulate the macro-siting (where the stations are located with respect to major pollution sources) and micro-siting (where the stations are sited with respect to their immediate surroundings, such as their height, proximity to the kerb, etc.), as well as the representativeness of the stations (the spatial area over which the value measured at the station can be accepted as meaningful).

On **management practices**, the pilot project examined trends in concentrations of three air pollutants: nitrogen dioxide, particulate matter and ozone. This workstream also examined measures taken to improve air quality. No clear trend in concentrations of these pollutants could be seen in the monitoring stations considered. Nevertheless, some commonalities did emerge in the management measures taken by the cities. In most of the cities, and in agreement with the main pollutant sources identified, more than the 50 % of the implemented measures are traffic related. Other measures focused on the domestic, commercial and industrial sectors. Another common theme emerged among all the cities: how to define and assess the effects of measures. The cities' experts also expressed a common uncertainty regarding how best to assess the costs and benefits of measures to abate pollution.

Again, some of the deficiencies identified in previous workstreams have implications that carry over: improvement of inventories and modelling tools, for instance, would better enable cities to assess which of their measures were most effective in improving air quality. Further support was also requested in the form of proposals for new EU legislation. Examples included: standard methodologies to measure emissions from boilers, regulations for domestic stoves, and improved vehicle emissions data to help ascertain the effect of traffic measures on air quality.

Finally, with regard to **information to the public**, the pilot project showed that, by and large, air quality information that is required by legislation to be made public is promptly provided by the cities to the public, mostly through dedicated air quality internet sites. In general, the cities underuse mass media, social media websites, and new technologies like smartphone applications. Most of the participating cities lacked feedback on the interest of their citizens in air quality issues.

There is thus room for cities to increase the presence of air quality issues in the media and for them to develop their smartphone and social media presences. The adoption of a common Europe-wide index for air quality, using the same colour codes to facilitate comprehension, would also help make air quality information comparable across Europe.

Next steps

The Air Implementation Pilot has identified a number of challenges which cities face in implementing EU air quality policy. These will be taken up by the European Commission in its ongoing air quality review, which will consider how EU action can best support local, regional and national authorities in addressing them. Options could include:

- financing of improved management and capacity-building through the forthcoming revision of the LIFE regulation ([3]);
- the development of a broader network of cooperation on the urban air quality challenge across the EU, with regular information exchange, capacity building, and a common database of measures;
- promoting and enabling increased use of other EU funding opportunities, such as the structural funds, particularly to address local drivers of persistent non-compliance with EU air-related legislation.

One possibility that has been discussed is to package all the European measures related to urban air quality in a single programme, which would then be one of the accompanying documents to a revised Thematic Strategy on Air Pollution.

For its part, the EEA will continue to support its member countries and the European Commission in their aim to improve the implementation of environmental policy. The EEA's responsibilities and role in implementation varies across different environmental themes, but support to implementation as a strategic focus of Agency work is expected to be strengthened in the EEA multiannual programme for the period 2014–2018.

In the area of implementation of air policies and legislation, the EEA plans to:

- **focus on data**. The Air Implementation Pilot has shown the importance of comparable, timely information on air quality, and the role of this information in improving implementation. The EEA will work to improve further the quality of data collected and reported to meet the requirements of new implementing provisions for the air quality directives. The EEA will also support the future implementation of a revised National Emissions Ceilings (NEC) Directive. This focus on data will also serve Europe's commitments beyond its own borders. The EEA will assist its member countries in preparing data for the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP Convention). The EEA will also assist its member countries in improving the quality and timeliness of their air pollutant emissions and air quality data submissions.
- **streamline further its own information systems** to support the implementation of EU air policy. The EEA stores air pollution emissions and ambient air quality data, and

([3]) http://ec.europa.eu/environment/life/funding/background.

will ensure that its air pollutant and air quality indicators contribute to a better understanding of the state of Europe's air quality, both at country level and at city level.

- **deliver regular assessments of European air pollution, its impacts, and the effectiveness of air quality measures**. These assessments will, inter alia, examine the synergies and trade-offs between air pollutant emission reduction policies and greenhouse gas emission reduction policies, and the subsequent effects of these policies on air quality and climate change.

- Finally, the EEA will continue to **build capacity** by working with experts across scientific and policy networks, such as the European Environment Information and Observation Network (Eionet) and the EMEP Task Force on Emission Inventories and Projections.

1 Introduction

1.1 The context of air quality policy in Europe

The quality of Europe's air — and Europe's environment more generally — is protected by an extensive body of legislation, which has been informed by a continuously improving knowledge base. However, looking at the European Union's environmental targets and objectives, it is clear that progress has been mixed over the last decade. Europe's air is no exception to this trend (EEA, 2010). In the Communication 'Improving the delivery of benefits from EU environment measures: building confidence through better knowledge and responsiveness' (EC, 2012a), the European Commission pointed out the need to safeguard and improve 'the extent of our knowledge about the state of the environment', but also to find 'effective ways of dealing with problems on the ground' that prevent the effective implementation of environmental legislation.

Improving the knowledge on the implementation of environmental legislation is a prerequisite for addressing these problems. The Commission proposed with its communication to enhance understanding of implementation by 'more effective information systems on implementation'; 'improv[ing] EU-level information'; 'help[ing] to ensure confidence in the information generated at national, regional and local levels'; and 'clos[ing] important information gaps on compliance promotion and enforcement'. In his address to the European Environment Agency (EEA) Management Board on 23 June 2011, Commissioner Potočnik invited the European Commission's Directorate General for Environment (DG ENV) and the EEA to explore an enhanced EEA role in support of EU environment policy implementation, by way of two 'implementation pilots' on air and waste.

According to the EEA's founding Regulation (EC, 2009, Article 3) 'the Agency shall furnish information which can be used in the implementation of Community environmental policy'. This has been a main focus of the work of the EEA and the European Environment Information and Observation Network (Eionet ([4])) over the last two decades. The EEA was able to build on this experience when responding positively to the Commissioner's request ([5]).

The EEA's work in relation to the implementation of environmental policy also involves assessing data on compliance with this European legislation. For example, the EEA looks at exceedances of air quality standards as signals of the 'implementation gap' between policy goals and the reality on the ground. However, properly addressing the gap requires action on a wide range of information and management issues.

This report presents the main findings of the Air Implementation Pilot, carried out in cooperation with 12 European cities (Antwerp, Berlin, Dublin, Madrid, Malmö, Milan, Paris, Ploiesti, Plovdiv, Prague, Vienna and Vilnius), the DG ENV, and the EEA. Building on the context for the implementation of EU air quality legislation at urban level (Sections 1.1.1–1.1.4), and a description of the Air Implementation Pilot (Section 1.2), this report discusses the local knowledge base on air pollutant emission inventories (Section 2.1), modelling activities by cities (Section 2.2), air quality monitoring networks (Section 2.3), approaches to air quality management (Section 2.4), and public information at urban level (Section 2.5). Finally, the report outlines the European Environment Agency's role in relation to EU legislation on air and the potential for further action (Chapter 3).

([4]) Eionet is a partnership network of the European Environment Agency (EEA) and its member and cooperating countries. It consists of the EEA itself, six European Topic Centres (ETCs), and a network of around 1 000 experts from 39 countries in over 350 national environment agencies and other bodies dealing with environmental information. More information can be found in http://www.eionet.europa.eu.

([5]) For the main findings of the waste pilot, see EEA, 2013a.

1.1.1 A broader understanding of implementation of environmental legislation

In its Communication (EC, 2012a), the European Commission addresses judicial aspects of the implementation of environmental legislation, such as surveillance, inspections, complaint-handling, and compliance with environmental standards set by legislation. The European Commission also indicated that compliance-checking is only one element of a broader and more dynamic understanding of the implementation challenge. It indicated that elements such as capacity building, compliance promotion, knowledge, and responsiveness are also important for the implementation of environmental legislation.

According to the communication, there are a number of factors underpinning the successful implementation of environmental legislation:

- investment in capacity building and networking;
- investment in tools, guidebooks, guidelines, good practice reports, and manuals;
- review of monitoring systems, data, and models;
- investment in the knowledge base;
- investment in information, communication, and awareness raising.

1.1.2 Air policy and legislation in Europe

Air pollution is of concern since it seriously damages human health and the environment. It can, inter alia, cause respiratory and cardiovascular problems, aggravate existing diseases, and cause premature death in humans. It can also damage ecosystems by exposing them to ground-level ozone and the deposition of airborne nitrogen and acidic substances. These problems are not just felt in the immediate vicinity of the air pollution source. Air pollution can travel very long distances, making it a transboundary as well as a local problem.

Air quality has been a major focus of the European Union's legislation and policies. The European Commission's 6th Environment Action Programme (EC, 2002) established as one of its objectives the achievement of 'levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment'. To attain this objective, an air policy framework, the 'Thematic Strategy on air pollution' (EC, 2005) was endorsed by the European Union in 2006, setting 'interim' (6) health and environment objectives and associated pollutant emissions reduction targets for the period up to 2020.

In 2011, in the 'Roadmap to a Resource-Efficient Europe', the European Commission proposed the following policy milestone: 'By 2020, the EU's interim air quality standards will have been met, including in urban hot spots, and those standards will have been updated and additional measures defined to further close the gap to the ultimate goal of achieving levels of air quality that do not cause significant impacts on health and the environment' (EC, 2011a).

In relation to the control of pollutant emissions, the National Emissions Ceilings Directive (EC, 2001) and the Gothenburg Protocol (7) to the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP Convention (8)) set national emissions limits for sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds, and ammonia. The amended Gothenburg Protocol also includes new emission reduction commitments for primary $PM_{2.5}$ emissions, and includes black carbon as one of the components of particulate matter (PM); the first time black carbon has been included in the protocol. Other directives and international conventions regulate emissions of the main air pollutants from specific sources and sectors (9).

Together with the National Emission Ceilings Directive (EC, 2001) covering air pollutant emissions, the Air Quality Directives 2008/50/EC (EC, 2008a) and 2004/107/EC (EC, 2004a), both covering air pollutant concentrations, today constitute the overarching legal framework for air in the EU.

The latter two directives regulate different pollutants. Directive 2008/50/EC regulates sulphur dioxide (SO_2), nitrogen oxides (NO_X) including nitrogen dioxide (NO_2), particulate matter (PM_{10} and $PM_{2.5}$), ozone

(6) The targets were 'interim' because the analysis undertaken at that time, and which underpinned the Thematic Strategy on air pollution, established that no technical and economically viable scenario was available at the time to reach the EU's long-term objective by 2020.
(7) http://www.unece.org/env/lrtap/multi_h1.html.
(8) http://www.unece.org/env/lrtap.
(9) References to these directives can be found in http://ec.europa.eu/environment/air/pollutants/index.htm.

(O_3), lead (Pb), benzene (C_6H_6), and carbon monoxide (CO). Directive 2004/107/EC regulates the heavy metals arsenic (As), cadmium (Cd), mercury (Hg), nickel (Ni), and polycyclic aromatic hydrocarbons (PAH) (including benzo(a)pyrene (B(a)P)).

Under these two directives (see Box 1.1), European Union Member States are required to divide their territories into zones in order to assess air quality. This assessment is made via measurements taken at monitoring stations in fixed sampling points.

The measurements may be supplemented (and under some conditions replaced) by information obtained through the use of specific air quality models. The directives also indicate how to manage air quality (see Box 2.2 in Section 2.4). EU Member States are required to maintain the levels of air pollutants below certain air quality standards, and to take action to reduce these levels where the standards are exceeded. The directives state that this action should take the form of air quality plans for the particular air quality zone(s) in exceedance,

Box 1.1 Air quality directives — assessment of air quality

The air quality directives set up a series of air quality standards. These standards are concentrations of air pollutants in the ambient air that Member States should not exceed. There are five kinds of these standards for the protection of human health:

Limit values are maximum concentrations of a particular pollutant that cannot be exceeded by a fixed date. The limit values are averaged over a fixed period (yearly, daily or hourly), checked annually, and are set for all regulated pollutants in Directive 2008/50/EC except ozone. Some pollutants have different limit values. For instance, there are two limit values for PM_{10}, an annual limit and a daily limit. The daily limit is the stricter of the two. For NO_2, there are annual and hourly limit values, with the annual limit value being the stricter of the two. In some cases, a 'margin of tolerance' is also defined. This is a percentage of the limit value by which that value can be exceeded.

Target values are maximum concentrations of a particular pollutant that cannot be exceeded by a fixed date, where possible. The target values are averaged over a fixed period (yearly, May-July, daily 8-hours mean), checked annually, and are set for $PM_{2.5}$, O_3 and all regulated pollutants in Directive 2004/107/EC.

Long-term objective is a maximum concentration of ozone that has to be met in the long term via proportionate measures.

Information threshold is a level of pollutants posing a risk for particularly sensitive sections of the population. When this level has been reached, the Member State has to inform the population. It is defined only for ozone.

Alert threshold is a level of pollutants posing a risk for the population in general, and for which immediate steps have to be taken. It is defined only for ozone, SO_2 and NO_2.

To assess air quality in the European Union, the air quality directives ask EU Member States to establish zones and agglomerations throughout their territories. An air quality zone is a part of the territory delimited for air quality assessment and management. Agglomerations are urban zones with more than 250 000 inhabitants or urban areas with fewer than 250 000 inhabitants, but with a sufficient density to be determined by Member States.

The zones are classified with respect to assessment thresholds to determine which elements are used to assess air quality. The assessment thresholds set out are:

- Upper assessment threshold (UAT)
- Lower assessment threshold (LAT)

In general, if previous levels of pollutants are above the UAT, measurements are required for subsequent assessment. If levels are below the UAT but above the LAT, measures can be supplemented with modelling. Finally if levels are below the LAT, assessment using only modelling is permitted.

Annex 1 presents the main standards under the air quality directives.

outlining the methods, steps, and measures to be undertaken in order to bring the air pollutant concentration levels below the standards that were exceeded. Finally, the directives specify which kind of information must be provided to the public and reported to the European Commission (see Box 2.3 in Section 2.5).

1.1.3 *Exceedances of air quality standards*

Although it is more than a decade ago that the air quality standards were agreed (with the exception of $PM_{2.5}$, standards for which were introduced in 2008), there remain widespread exceedances for certain standards in the European Union. This is particularly true for the standards for protection of human health for PM_{10}, NO_2 and O_3. And recently, in some parts of Europe, it has also been true for B(a)P ([10]). However, there have also been some clear successes: the standards for CO, SO_2 and benzene have broadly been met ([11]).

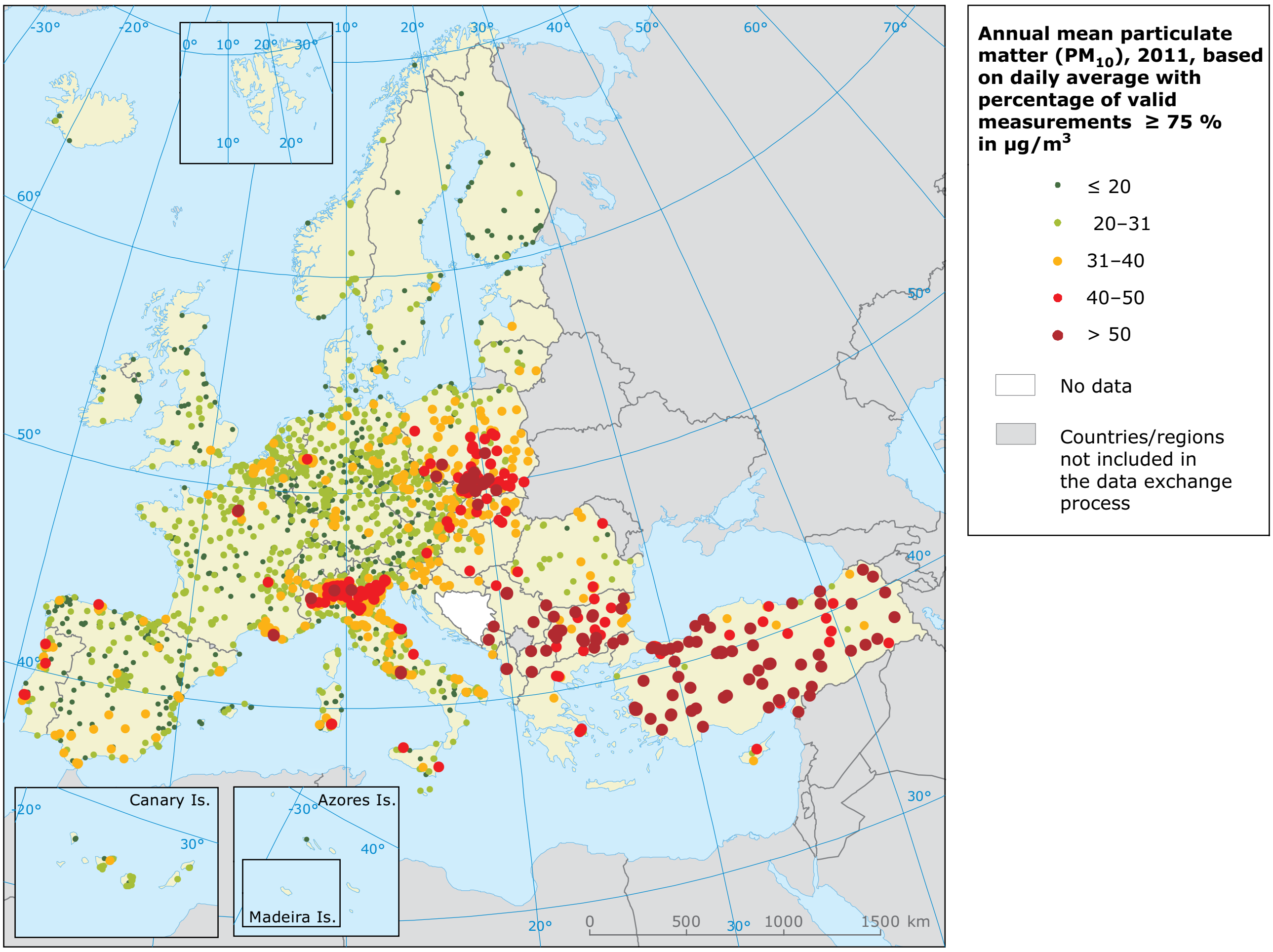
In the following maps (Maps 1.1–1.4), some of the limit value and target value status for PM_{10}, NO_2, O_3 and B(a)P in the EEA reporting countries ([12]) is shown ([13]). However, the analysis of the measurement stations where air pollutant concentrations are above the regulated thresholds cannot represent how many people are exposed to air pollution.

Table 1.1 Description of the effects of main health-related pollutants

Pollutant	Health effects	Environmental effects	Climate effects
Particulate matter (PM)	Can cause or aggravate cardiovascular and lung diseases, heart attacks and arrhythmias, affect the central nervous system, the reproductive system and cause cancer. The outcome can be premature death.	Can affect animals in the same way as humans. Affects plant growth and ecosystem processes. Can cause damage to buildings. Reduced visibility.	Climate effects vary depending on particle size and composition: some particles lead to net cooling, while others lead to warming. Can lead to changed rainfall patterns. Deposition can lead to changes in surface albedo (the extent to which the Earth's surface reflects sunlight and thus the sun's heat).
Ozone (O_3)	Can decrease lung function; aggravate asthma and other lung diseases. Can lead to premature mortality.	Damages vegetation, impairing plant reproduction and growth, and decreasing crop yields. Can alter ecosystem structure, reduce biodiversity and decrease plant uptake of CO_2.	Ozone is a greenhouse gas contributing to warming of the atmosphere.
Nitrogen oxides (NO_X)	NO_2 can affect the liver, lung, spleen and blood. Can aggravate lung diseases leading to respiratory symptoms and increased susceptibility to respiratory infection.	Contributes to the acidification and eutrophication of soil and water, leading to changes in species diversity. Acts as a precursor of ozone and particulate matter, with associated environmental effects. Can lead to damage in buildings.	Contributes to the formation of ozone and particulate matter, with associated climate effects.
Benzo(a)pyrene (B(a)P)	Carcinogenic. Other effects may be irritation of the eyes, nose, throat, and bronchial tubes.	Is toxic to aquatic life and birds. Bioaccumulates, especially in invertebrates.	No specific effects.

([10]) Eutrophication and ozone damage to the environment, both outside the scope of this report, also remain problematic.
([11]) Acidification (which is outside the scope of this report) is also almost resolved.
([12]) In 2011, the EEA had 32 member countries: the EU-27 Member States plus Iceland, Liechtenstein, Norway, Switzerland and Turkey. The seven West Balkan countries were cooperating countries: Albania, Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Montenegro, Serbia, as well as Kosovo under the UN Security Council Resolution 1244/99. In the maps, all countries that reported assessment of air quality in 2011 are depicted.
([13]) Maps show information for stations with at least 75 % valid data, except for B(a)P, for which a more comprehensive measurement regime is required. Unlike with other pollutants, which require 75 % of registered data to be valid, B(a)P only requires 14 % of registered data to be valid. The maps do not give any indication of the spatial area affected by the exceedance in a given station.

Map 1.1 Annual mean particulate matter (PM_{10}) concentrations in monitoring stations with valid measurements ≥ 75 % in the EEA reporting countries in 2011 *



Note: If the value is > 40 μg/m³, the station is in exceedance of the annual limit value for PM_{10}.

* Not accounting for subtractions of natural contributions and/or of contributions of winter-sanding and salting (see Box 2.2).

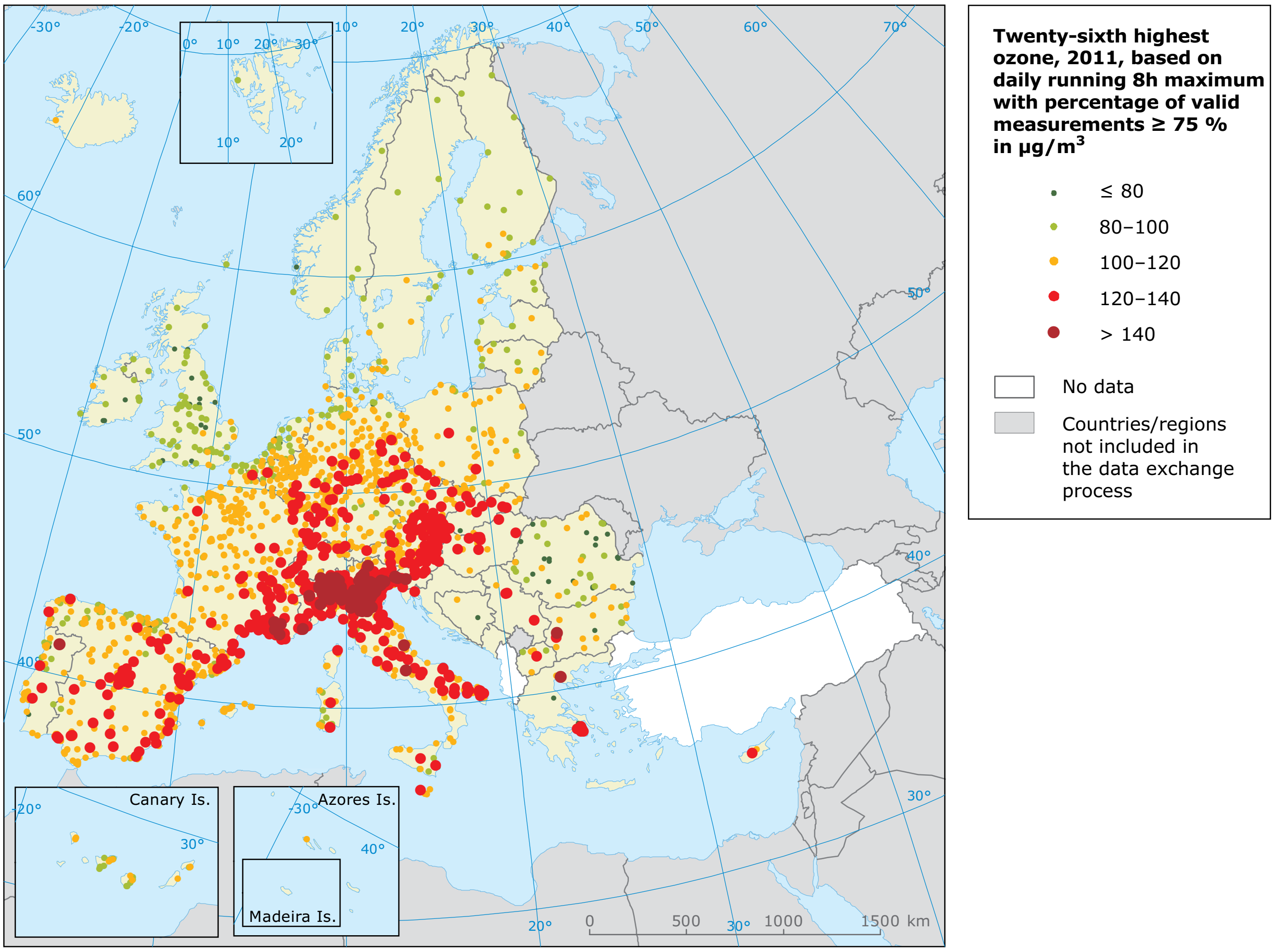
Although urban and suburban areas cover around 20 % of the surface area of the European Union, they are home to around 75 % of the European population (Eurostat, 2012 ([14])). Figure 1.1 shows that the urban population in the EU potentially exposed to air pollutant levels exceeding the EU standards in the period 2001–2011 has been: between 18 % (2008) and 40.6 % (2003) for the PM_{10} daily limit value; between 13.6 % (2011) and 61.3 % (2003) for the O_3 annual target value; and between 4.9 % (2011) and 27 % (2003) for the NO_2 annual limit value ([15]).

Understanding the apparent gap between EU air quality standards and the exceedances occurring in the European Union is one of the issues addressed by the European Commission in its review of EU air policies.

([14]) http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Statistics_on_European_cities#Further_Eurostat_information.

([15]) Benzo(a)pyrene is not considered in the Core Set Indicator 004, as measurements started later than for the rest of pollutants and the time series is still too short. The EEA estimated that between 20 % and 29 % of the urban population was potentially exposed in 2008–2010 to B(a)P concentrations above the EU target value (EEA, 2012).

Map 1.2 Twenty-sixth highest maximum daily 8-hour mean ozone value in monitoring stations with valid measurements ≥ 75 % in the EEA reporting countries in 2011



Note: If the value is > 120 μg/m³, this means that there were more than 25 days in that year in which that station registered maximum daily 8-hour mean ozone values above 120 μg/m³. In this case, the station is counted as exceeding the health-related target value for ozone.

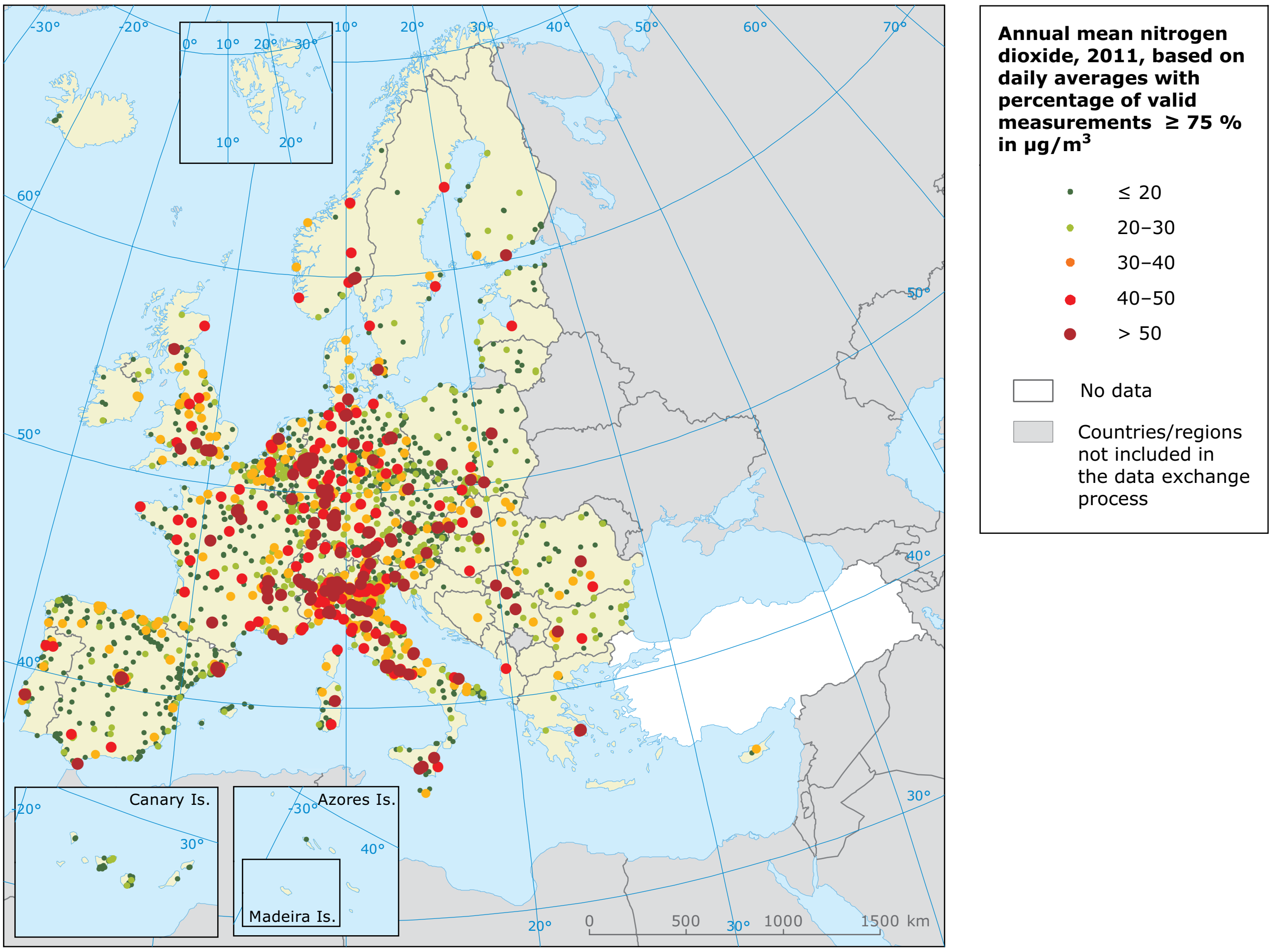
1.1.4 Review of air quality legislation and policies by the European Commission

The review of EU air policy, started by the European Commission in 2011, assesses the effectiveness of existing air policy, and will ultimately lead to a revised air policy for the EU. Initially, the review process paid particular attention to air quality measures that could be implemented quickly, while it also prepared the ground for more wide-ranging formal review initiatives to be completed by 2013.

The European Commission has not yet completed its assessment of all air quality measures that could be quickly adopted. However, some of the measures are now already in place. These adopted measures include the amended UNECE CLRTAP Gothenburg Protocol ([16]), and, in the European Union, the revised directive on the sulphur content of bunker fuels (EC, 2012b). Measures that are still being assessed include legislation on non-road mobile machinery (the review of which is scheduled for 2013), legislation on combustion installations between 1 and 50 megawatts (proposal expected by the end of 2013) and the implementation of the Euro 6 vehicle standards (for which the Commission has set out a timetable in its recent Cars 2020 Communication (EC, 2012c)). Although the review process has not been completed, the Commission

([16]) An international agreement on air pollution, which has been signed by Canada, USA, Europe, and other countries in the northern hemisphere, http://www.unece.org/env/lrtap/multi_h1.html.

Map 1.3 Annual mean nitrogen dioxide (NO_2) concentrations in monitoring stations with valid measurements ≥ 75 % in the EEA reporting countries in 2011



Note: If the value is > 40 µg/m³, the station is in exceedance of the annual limit value for NO_2.

has already indicated some options for the review of the National Emission Ceilings Directive (EC, 2001).

The wide-ranging, formal review of air policy is on-going. Stakeholder Expert Groups were created in 2011 as part of a consultation process for this review, and include participants from non-governmental organisations (NGOs), industry, Member States, and other experts.

Moreover, the Air Implementation Pilot, carried out in parallel to the air policy review, provides additional elements contributing to a better understanding of why there is a gap between the requirements of EU air legislation and the exceedances of air quality standards occurring in the European Union.

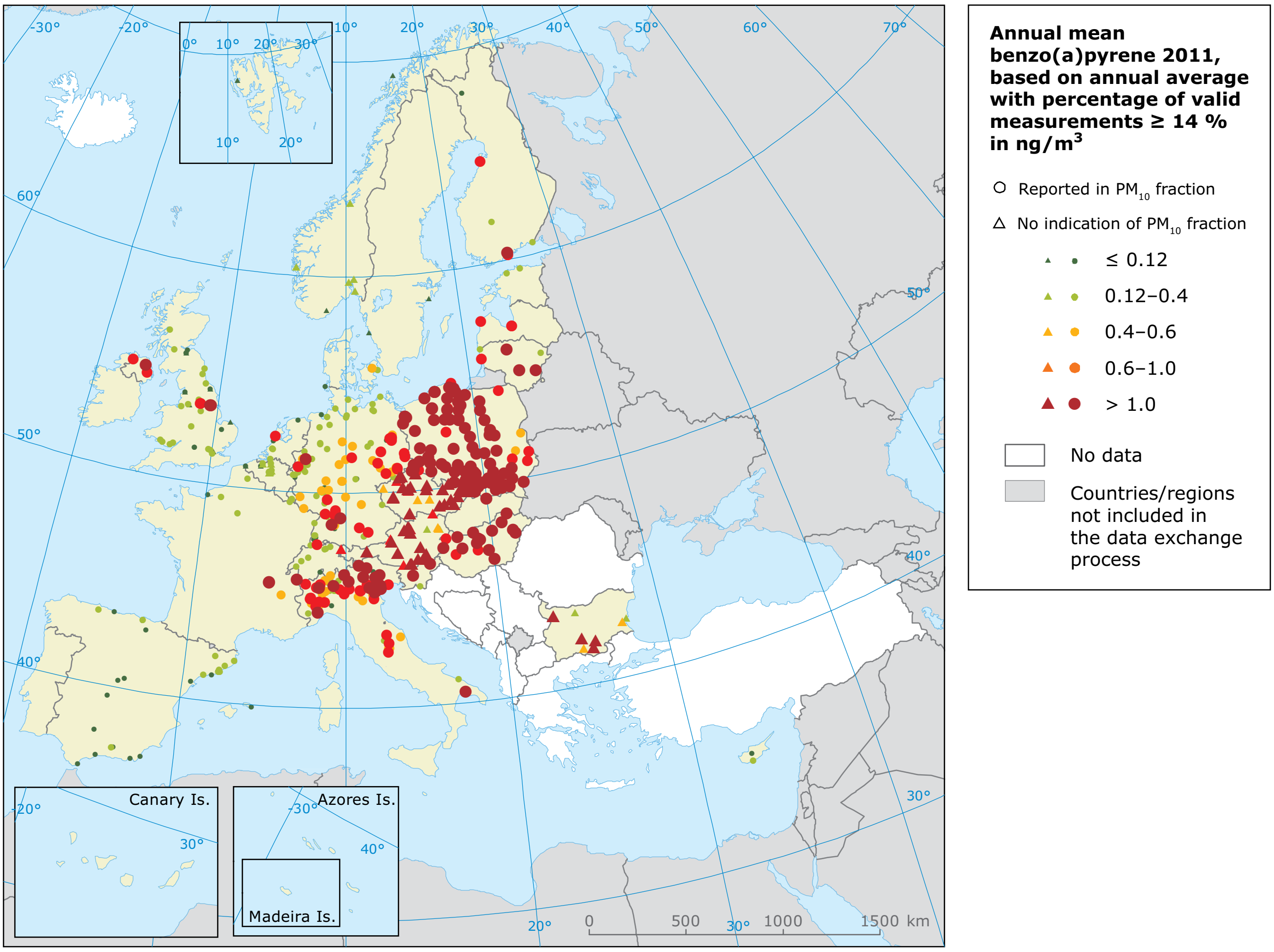
1.2 The Air Implementation Pilot

1.2.1 Description of the project

When the Air Implementation Pilot project was agreed between the European Commission and the EEA, it was decided that the project would focus on gaining a better understanding of what cities needed in order to better implement EU air quality legislation. It would identify good practices, promote the exchange of knowledge and experiences, and identify areas where further guidance would be helpful.

A first set of eight cities were selected and invited to join the project: Berlin (Germany), Bucharest (Romania), Dublin (Ireland), Madrid (Spain), Malmö

Map 1.4 Annual mean benzo(a)pyrene (B(a)P) concentrations in monitoring stations with valid measurements ≥ 14 % in the EEA reporting countries in 2011



Note: If the value is > 1 ng/m³, the station is in exceedance of the annual target value for B(a)P (to be in force in 2013).

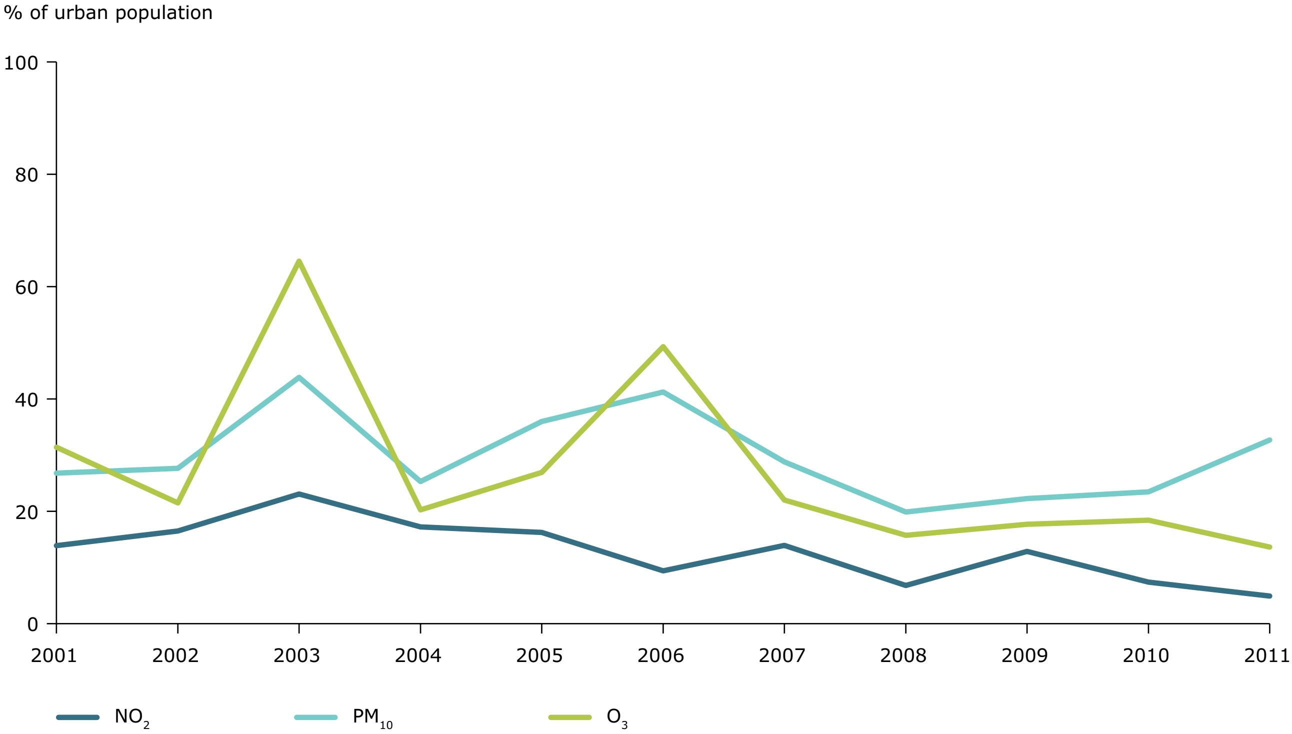
(Sweden), Milan (Italy), Prague (Czech Republic) and Vienna (Austria). The criteria for this selection were:

- cities should be part of an existing urban network (such as Eurocities ([17])), in order to facilitate future networking and further dissemination of results;
- cities should be part of Urban Audit ([18]), a project coordinated by Eurostat for the collection of comparable statistics and indicators for European cities ([19]);
- the selection of cities should be as diverse as possible, both in terms of geographical coverage (to take into account a wide European perspective), and in terms of population (to represent different sizes of cities);
- cities from countries with different types of administrative organisation should be represented.

All the invitations were accepted, with the exception of Bucharest. The Romanian authorities proposed instead that Ploiesti take part in the

([17]) Eurocities is a network of major European cities, which brings together the local governments of over 130 of Europe's largest cities and 40 partner cities, governing 130 million citizens across 35 countries. http://www.eurocities.eu/eurocities/home.
([18]) http://www.urbanaudit.org.
([19]) These statistics are used by the EEA for calculating indicators.

Figure 1.1 Percentage of EU urban population resident in areas where pollutant concentrations are higher than selected air quality standards, 2001–2011 (EU-27) *



Note: * Annual limit value for NO_2, daily limit value for PM_{10}, and annual target value for O_3.

Source: EEA, 2013c (CSI 004).

project as the Bucharest air quality monitoring network was being reorganised.

Experts from the cities were invited to a kick-off meeting, held on 7 June 2012 in the EEA's headquarters. Experts from the EEA, its European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM), and DG ENV also attended. City delegates provided a general overview of their cities' typical characteristics (location, climate, main economic activities, etc.); actions already undertaken to manage local air quality; challenges encountered in doing so; as well as a general statement about what their city required to better implement air quality legislation (see Annex 2). Based on this input and the ensuing discussions, a work programme centred around five workstreams was defined and agreed at the time, with a view to covering as many factors related to implementation as possible. Cities were asked to nominate contact persons in the five workstreams. These workstreams were:

- local emission 'inventories' and their level of detail and comparability: inventories are sets of data on what pollutants are emitted into the air, where, and from what sources;
- modelling activities: the computer-based tools that help to understand air pollution processes;
- air quality monitoring networks: the networks of sampling stations that take regular measurements of air quality. The pilot sought to assess whether these networks give an accurate representation of air quality in the cities;
- management practices: trying to detect trends in air quality and linking these to the most effective measures taken in cities to improve air quality;
- public information: how air quality information is communicated to citizens and how this information raises awareness of air quality among the population.

The EEA subsequently established and circulated questionnaires to be completed by experts in the eight participating cities with assistance and advice from the EEA and its ETC/ACM. These questionnaires covered the areas of emission inventories, modelling and public information, and basic city information. In order to conduct an analysis of the monitoring networks, the EEA made use of the previous submissions of information by the corresponding countries. These submissions of information included an annual questionnaire officially reporting the air quality assessment (EC, 2004b), which were already stored in the Central Data Repository (CDR) ([20]). The submissions also included data from the monitoring stations that were already stored in the air quality database AirBase ([21]). Finally, for the management activities, the EEA made use of two other pre-existing questionnaires. One questionnaire is used to report plans and programmes to the European Commission (EC, 2004c and CDR) for the improvement of air quality. The other one is used to notify the Commission that a Member State is postponing the attainment deadline for the limit values for nitrogen dioxide and benzene, or is applying for an exemption from the limit values for PM_{10} ([22]).

A progress meeting was hosted in Madrid by the Municipality of Madrid on 29 October 2012, where participants assessed progress across all five workstreams. As the Air Implementation Pilot had proved useful for the participants, and because a report by the ETC/ACM had highlighted the possible shortcomings of the selection of cities in the pilot at that time (ETC/ACM, 2012a), it was decided to expand the urban sample by inviting up to four additional cities to take part in the pilot. Contacts were subsequently established with the following four cities: Antwerp (Belgium), Paris (France), Plovdiv (Bulgaria) and Vilnius (Lithuania). These four cities were chosen after taking into account the geographical coverage, city size, and main pollution sources of the existing eight-pilot city sample, as well as the interest expressed by other cities in joining the pilot.

Following the same procedure as for the initial eight cities, the four new cities were integrated in the on-going workflows of the Air Implementation Pilot.

1.2.2 Geographical features of the cities participating in the Air Implementation Pilot

Geographical boundaries

As explained in Box 1.2, there are several different ways to define what constitutes a city. It can be a commercial centre, an administrative unit, an Urban Audit city, or a unit for air quality management. When collecting and comparing data for the Air Implementation Pilot, administrative units and units for air quality management (known in the EU as air quality zones or 'AQ' zones, see Box 1.1) were taken into account. Cities as defined in the Urban Audit project ([23]) were also considered.

In five of the twelve participating cities (Berlin, Madrid, Prague, Vienna and Vilnius), the administrative boundaries of the city are the same as the boundaries of the Urban Audit city unit, and the corresponding air quality zone.

For the other cities, the situation is more complex, with administrative boundaries not always coinciding with air quality zones or Urban Audit boundaries. For this reason, the decision as to what geographical city boundaries to use in the pilot was taken on a case-by-case basis and in agreement with the respective city-nominated experts for the pilot. In what follows, there is a description of each of these boundaries.

From the perspective of city administration, Antwerp is not only the Antwerp agglomeration (AQ zone BEF02A, without the special protection zones of Borsbeek, Edegem, Mortel, Schoten, Wijnegem and Wommelgem), but also its port (AQ zone BEF01S) and the district of Hoboken (AQ zone BEF07S), so the sum of these three AQ zones were considered in the project.

Dublin City, together with South Dublin County Council, Fingal County Council, and Dun Laoghaire Rathdown Council, forms the AQ zone IE001 or Irish Zone A. For the purpose of the pilot, only Dublin City was considered, and not the AQZ. This city corresponds to the Urban Audit city.

([20]) http://cdr.eionet.europa.eu.
([21]) http://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-7.
([22]) Article 22 of the AQD 2008/50/EC allows the Member States to postpone the attainment deadline for the limit values (LV) for nitrogen dioxide and benzene and to be exempt from the obligation to apply the LV for PM_{10} if certain conditions are met. http://ec.europa.eu/environment/air/quality/legislation/time_extensions.htm and Box 2.2.
([23]) http://www.urbanaudit.org.

Map 1.5 The 12 European cities taking part in the Air Implementation Pilot project

The 12 European cities taking part in the Air Implementation Pilot project

Box 1.2 Cities, where do they begin and end?

There are different ways of determining the geographical extent of a city, and this diversity has had to be considered when drawing up the boundaries of the participant cities in the Air Implementation Pilot. In day-to-day terms, many people consider the city to be the compact downtown area, where commercial, leisure, and working activities usually take place. However, the political boundaries of the city — the area controlled by the mayor and city council — may not coincide with this more compact understanding of the city.

In addition to the commercial and administrative understanding of the city's boundaries, there are the boundaries determined by the air quality (AQ) zone. The AQ zone is a territorial unit established by the Member States according to Directives 2004/107/EC and 2008/50/EC. The AQ zone is defined as 'a part of the territory of a Member State, as delimited by that Member State for the purposes of air quality assessment and management'. The 'agglomeration' is a special zone category. It is defined as 'a zone that is a conurbation with a population in excess of 250 000 inhabitants or, where the population is 250 000 inhabitants or less, with a given population density per km^2 to be established by the Member States'.

A further complexity in terms of delineating boundaries comes from the Urban Audit project (http://www.urbanaudit.org). This project aims at collecting comparable statistics and indicators for European cities, and considers three different spatial levels: the city, the larger urban zone (LUZ) and the sub-city district (SCD). For the calculation of some EEA indicators, the Urban Audit city level is used. The city levels were defined using political boundaries. In many countries, these boundaries are clearly established and well-known. As a result, for most cities, the boundaries used in the Urban Audit correspond to the general understanding of that city.

For the Air Implementation Pilot project, different city boundaries were selected for different cities according to criteria chosen by air quality experts in each of the respective cities.

Malmö forms, together with Burlöv, Lomma, Lund, Staffanstorp and Vellinge, the AQ zone SW6 Malmö. However, for the purpose of the pilot, only the municipality of Malmö was considered, as in Sweden the local authorities are tasked with air quality issues.

Until 2010, Milan was part of the Italian AQ zone IT0301 (Agglomerati Urbani (A1)), which was formed by the agglomerations of Milan, Bergamo and Brescia. In 2011, Milan City became its own AQ zone: IT0306 Milan Agglomeration. For the purpose of the pilot, this AQ zone IT0306 was considered, since the AQ zone is continuously urban (there is no rural area within its boundaries) and densely populated.

Paris is part of the AQ zone FR04A01, Île-de-France-Paris, which includes the wider region around the city. For the purposes of the pilot, only the Urban Audit small city level was considered. This corresponds to the 20 'arrondissements' of the urban area controlled by the mayor of Paris and is known as 'la ville de Paris'.

Until 2010, Ploiesti formed, together with the villages of Blejoi, Bucov, Păuleşti, Bărcăneşti, Brazi, Berceni, Ariceştii Rahtivani and Târgşoru Vechi the AQ zone RO0302 Ploiesti. In 2011, it became the AQ zone RO31601 Ploiesti, comprising only the municipality of Ploiesti. Nevertheless, for the purposes of the pilot, the entire AQ RO0302 zone was considered, as it was the zone for which the air quality plan has been implemented.

The municipality of Plovdiv is part of the larger AQ zone BG0002 'Plovdiv Agglomeration'. This AQ zone includes other municipalities over which the Mayor of Plovdiv does not have any authority or responsibility. Because of this, only the municipality of Plovdiv was considered in the pilot.

Table 1.2 Surface and population of cities participating in the Air Implementation Pilot and the AQ zones (AQZ) where they are included

City name	City surface (a) (km²)	City population	AQZ code	AQZ name	AQZ surface (km²)	AQZ population
Antwerp	204.5	565 000	BEF01S + BEF02A (b) + BEF07S	Port of Antwerp + Antwerp + Hoboken	**262.7**	**694 271** (c)
Berlin	**892**	**3 442 675**	DEZBXX001A	Ballungsraum Berlin	892	3 442 675
Dublin	**115**	**527 612**	IE001	Zone A	485.2	1 270 603
Madrid	**604**	**3 237 937**	ES1301	Madrid	604	3 237 937
Malmö	**155**	**302 000**	SW6	Malmö	912	503 273
Milan	182	1 307 495	IT0306	Milan Agglomeration	**1 144**	**3 593 025**
Paris	**105**	**2 200 000**	FR04A01	Île-de-France-Paris	2 869 (d)	10 400 000 (d)
Ploiesti	58	229 258	RO0302	Ploiesti	**299** (e)	**271 972**
Plovdiv	**102**	**338 153**	BG0002	Plovdiv Agglomeration	1 390	446 274
Prague	**496**	**1 257 158**	CZ010	Praha	496	1 257 158
Vienna	**415**	**1 731 444**	AT_09	Wien	415	1 731 444
Vilnius	**401**	**534 000**	LT0100	Vilnius	401	534 000

Note: (a) Corresponding to the political or administrative boundaries of the city.

(b) Without the surrounding special protection zones of Borsbeek, Edegem, Mortel, Schoten, Wijnegem and Wommelgem.

(c) Including the special protection zones.

(d) Data come from the 2011 AQ Questionnaire. Airparif informed in May 2013 that the population of the AQ zone FR04A01 was about 11 700 000 inhabitants.

(e) Data come from the 2010 AQ Questionnaire.

Bold numbers correspond to the geographical unit chosen for the purposes of the Air Implementation Pilot.

Seven out of the twelve pilot cities are the capital cities of their countries (Berlin, Germany; Dublin, Ireland; Madrid, Spain; Paris, France; Prague, Czech Republic; Vienna, Austria; and Vilnius, Lithuania). The remaining cities are the main cities of their respective regions or provinces (Antwerp, province of Antwerp; Malmö, Scania County; Milan, Lombardy Region; Ploiesti, Prahova County; and Plovdiv, region of Plovdiv).

Surface area

Cities taking part in the Air Implementation Pilot have a surface area (the area covered by the political administration of the city) that ranges from 58 km^2 in Ploiesti to 892 km^2 in Berlin (see Table 1.2). However, for the purposes of the Air Implementation Pilot, the municipality of Plovdiv, at 102 km^2, and the AQ zone of Milan Agglomeration, at 1 144 km^2, were the smallest and the biggest units respectively, considered in the project.

Population

The population of each of the pilot cities ranges from 229 258 inhabitants in the city of Ploiesti to 3 442 675 in Berlin. However, in terms of the areas of analysis in the pilot, the AQZ RO0302 of Ploiesti (271 972 inhabitants) and the AQZ IT0306 of Milan Agglomeration (3 593 025) are the least and most populated units in the pilot, respectively (see Table 1.2).

Berlin, Madrid, Milan, Paris, Prague and Vienna have a population over 1 000 000 inhabitants. Antwerp, Dublin and Vilnius have populations of between 500 000 and 1 000 000 inhabitants; and Malmö, Ploiesti and Plovdiv have populations of between 250 000 and 500 000 inhabitants.

See Annex 2 for further and more detailed information on the cities participating in the Air Implementation Pilot.

2 The Air Implementation Pilot: lessons learnt

In this chapter, the tasks undertaken in each of the five workstreams are presented. Special emphasis has been placed on the findings from each of these workstreams and the suggestions made to further improve performance in each one of them.

2.1 Local emission inventories

One of the aims of the Air Implementation Pilot was to review the local emission inventories in order to assess their ability to inform the development of air quality management plans (including addressing specific exceedances and source apportionment of concentration levels). The part of the pilot addressing emission inventories also sought to evaluate the potential of the emission inventories for identifying mitigation measures.

Introduction

'Emission inventories' are collections of data that show the amounts of air pollutants and/or greenhouse gases (GHG) released by different activities occurring within a defined geographical area.

For cities, the availability of an emission inventory allows:

- identification of the local sources of pollution and the relative importance of each in terms of the released emissions;
- knowledge on the contribution each source makes to the ambient air quality by using air quality models, and knowledge on the extent to which local air quality problems are caused by sources within or outside the city;
- identification of the sectors or sources that are important to control in order to improve local air quality;
- follow-up assessment of the effectiveness of local measures undertaken to improve air quality. This assessment is conducted by monitoring the calculated change in emissions with time.

At national or international level, emission inventories are key tools for:

- monitoring progress towards emission reduction targets (e.g. the EU National Emission Ceilings Directive for air pollutants (EC, 2001), or the United Nations Framework Convention on Climate Change's ([24]) Kyoto Protocol for greenhouse gases ([25]));
- monitoring the implementation of legislation regarding specific activity sectors (energy, transport, etc.) and the effectiveness of this implementation in reducing or controlling emissions.

Emission inventories are also used as an input to air quality models.

A questionnaire was prepared to analyse in a comparable way the air pollutant emission inventories in the participating cities. The questionnaire and the complete analysis have been presented in two ETC/ACM Technical Papers (ETC/ACM, 2012b; ETC/ACM, 2013a). The main results are highlighted below ([26]).

([24]) http://unfccc.int.
([25]) http://unfccc.int/kyoto_protocol/items/2830.php.
([26]) All these findings are also in line with those from another project, which examined the international city networks and national initiatives that have developed emission inventories or sustainable instruments at local level. The methodology and results of this project are presented in an ETC/ACM Technical Report (ETC/ACM, 2012c).

Description of the emission inventories in the participating cities

Out of the 12 selected cities, 11 (i.e. all the cities except Dublin) dispose of local and/or regional emission inventories (also known as 'EIs'). Dublin's EI is currently being developed as a result of the city's participation in the Air Implementation Pilot. Emission inventories are therefore regarded as a key element in the process of assessment and management of air quality.

Table 2.1 shows the pollutants included in the EIs. It can be highlighted that:

- three pollutants are covered in all of the EIs considered: sulphur dioxide (SO_2), particulate matter (PM_{10}), and nitrogen oxides (NO_X) (all cities' inventories cover NO_X, although in the case of Plovdiv, the EI only covers nitrogen dioxide (NO_2));
- greenhouse gases (GHGs) are currently not included in four EIs;
- so far, Antwerp and Malmö, for specific sources, are the only cities to cover black carbon (BC), an agent that is both an indicator for traffic-related air pollution and a short-lived climate forcer.

All of the cities' EIs cover the city within its administrative boundaries, and some EIs cover areas beyond these boundaries. The spatial resolution for area sources ([27]) ranges from 50 x 50 m^2 to 1 000 x 1 000 m^2. In most cases, point and line sources ([28]) are allocated to specific positions and road sections. The EIs are generally based on annual emissions data. However, additional temporal

Table 2.1 Pollutants included in the emission inventories of the cities participating in the Air Implementation Pilot

Cities	Pollutants			
	Gaseous	**PM**	**GHG**	**Other**
Antwerp	NO_X, SO_2	PM_{10}, $PM_{2.5}$, BC	CO_2	
Berlin	NO_X, VOC, SO_2	PM_{10}, $PM_{2.5}$		
Madrid	NO_X, VOC, NH_3, SO_2, CO	TSP, PM_{10}, $PM_{2.5}$	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6	As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn, HCH, PCP, HCB, TCM, PCE, TCB, TCE, DIOX, PAHs
Malmö	NO_X, VOC, NH_3, SO_2, CO	PM_{10}	Currently not included	BC for specific sources
Milan	NO_X, VOC, NH_3, SO_2, CO	TSP, PM_{10}, $PM_{2.5}$	CO_2, CH_4, N_2O	
Paris	NO_X, VOC, NH_3, SO_2, CO	TSP, PM_{10}, $PM_{2.5}$, PM_1	CO_2, CH_4, N_2O, SF_6	As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Se, V, Zn, PCDD_F, PCB, HCB, HCl, HF, PAHs, B(a)P, BbF, BkF, Indpy, BghiPe, BaA, BahA, FluorA, BjF
Ploieşti	NO_X, VOC, SO_2, CO	TSP, PM_{10}, $PM_{2.5}$	CO_2, CH_4, N_2O	Heavy metals, POPs, PAHs,
Plovdiv ([a])	NO_2, SO_2	PM_{10}, $PM_{2.5}$		Cd, B(a)P
Prague	NO_X, VOC, NH_3, SO_2, CO, benzene	TSP ([b]), PM_{10}, $PM_{2.5}$		Selected heavy metals ([b]) and POPs ([b])
Vienna	NO_X, VOC, SO_2, CO, NO_2	PM_{10}	CO_2	
Vilnius	NO_X, SO_2, CO	PM_{10}		

Note: ([a]) On a local level, an EI has been developed for PM_{10}, $PM_{2.5}$, SO_2, NO_2, Cd and B(a)P. On a regional level, an EI is provided for NO_X, SO_X, CH_4, NMVOC, CO, CO_2, N_2O, and NH_3.

([b]) Stationary sources.

([27]) Area sources are sources where the pollution can be considered as coming from a continuous surface (such as emissions from residential heating, commercial sources or agriculture).

([28]) Point sources are sources where the pollution can be considered as coming from a single point (such as emissions from industrial stacks or power plants). Line sources are those whose pollution can be considered as coming from a continuous line (such as traffic from a road).

emission profiles (hourly, daily and/or monthly) are available for Madrid, Malmö, Milan, Paris, Plovdiv, Vienna, and Vilnius. These temporal profiles are important for air quality modelling.

The categories of pollution sources in the EIs reflect, on the one hand, the importance of certain economic sectors in different urban regions, and on the other hand, the availability of reliable activity data and/or emission factors ([29]). This is indicated by the fact that agriculture, re-suspension of road dust, and emissions from construction activity (with the exception of exhaust emissions from vehicles used in construction such as earth-moving equipment, steamrollers, etc.) are not included in the EIs of six, four, and four cities, respectively. Antwerp is the only city whose EI covers all the emission sources. Most cities in the pilot used a conventional, common classification scheme such as SNAP ([30]) or NFR ([31]) when identifying the pollution sources in their EIs. However, in three cases (Berlin, Malmö and Vilnius), a custom scheme was used to classify the emission sources used in the EI.

The emission inventories used in the 11 cities clearly support the implementation of air quality policies relevant for the local and regional scale. EIs are used for modelling; for identifying sources of elevated pollutant levels; for identifying suitable measures to combat pollution; and partly for quantifying and monitoring the impact of those measures. Moreover, across all the EIs, there are elements and methodologies that can be regarded as best practice, so other city administrations beyond the pilot could take advantage of this vast experience when establishing their own emission inventories.

Currently, the EIs are not directly and easily comparable with each other. The reasons for this include differences in: source classification schemes, the pollutants covered, spatial resolution, the extent to which recent data is available, emission factors, the inclusion of fugitive sources, and the underlying type of database. The quality assurance/quality control (QA/QC) procedures in place in each city are also different. For these reasons, only some EIs are comparable to the inventories of the region in which they are located, or to EIs from other cities within the same member state. Generally speaking, the cities' inventories are also not comparable to the national EIs of the country in which they are located. Furthermore, the effect of pollution reduction measures taken by some cities is only presented in some of the EIs.

Possible solutions to improve the consistency and comparability of the EIs of European cities were suggested by the cities. A harmonisation of cities' EIs is deemed possible when the source categories (and their definitions), the methodology, and the emission factors (which essentially covers the whole process of preparing an inventory) are harmonised. It would be beneficial to exchange experiences on QA procedures, and to support cities in setting up QA/QC systems.

Due to their lack of comparability, EIs in their current state could mainly only be used at the European level for a general qualitative assessment of relevant pollutant sources in different cities, as they differ in too many aspects for them to be used in a more comprehensive assessment. Using several city EIs in a common modelling exercise or in quantitative source apportionments would require a considerable effort. The actual effort required would depend on the flexibility of the systems currently used; the completeness of the EI with respect to pollutants and sources; how up-to-date the EI is; and the spatial resolution it uses.

The extent to which emissions data is made available to the public varies between the participating cities. Summary emissions data is publicly available in all participating cities. However, more technical emissions data is not always publicly available. Technical documentation on emissions is publicly available in only seven cities, and the results of the EIs are publicly available in all but two cities (Vienna and Vilnius). In most cases, these results are presented as tables or pie charts.

The main references used in developing the EIs are the IPCC guidance documents for GHGs ([32]) and the EMEP/EEA air pollutant emission inventory guidebook for air pollutants (EEA, 2009). For traffic emissions, either HBEFA 3.1 ([33]) or COPERT 4 ([34]) is used. In Prague, a software programme called MEFA is used.

([29]) It is impractical to measure emissions from all the sources that, together, comprise an emission inventory. Consequently, the most common estimation approach is to combine information on the extent to which a human activity takes place (called activity data or AD) with coefficients that quantify the emissions or removals per unit activity, called emission factors (EF). The basic equation is therefore: Emissions = AD x EF.

([30]) SNAP — Selected Nomenclature for Air Pollution.

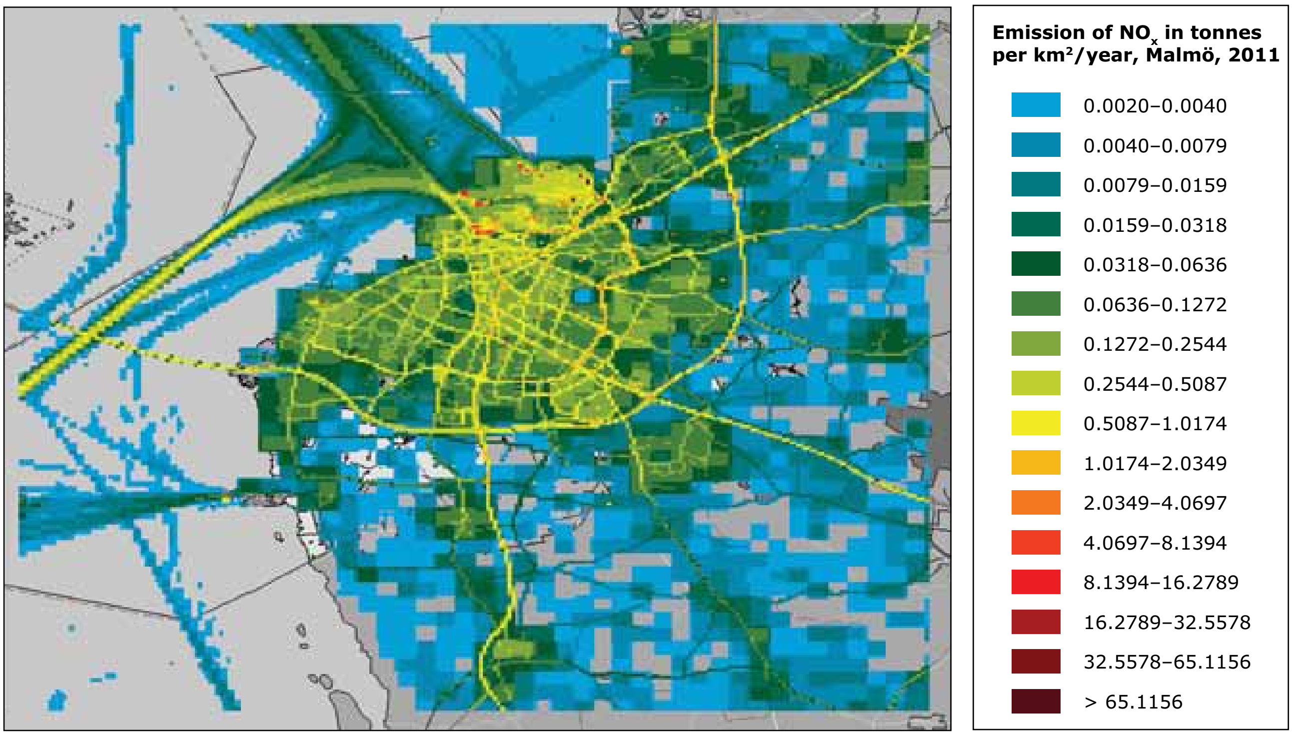
([31]) NFR — Nomenclature For Reporting.

([32]) http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.

([33]) http://www.hbefa.net/e/index.html.

([34]) http://www.emisia.com/copert/General.html.

Map 2.1 Emissions of NO_x in tonnes per km²/year, 2011, Malmö



Source: Miljöförvaltningen, City of Malmö.

There is a reasonable amount of interaction between policy areas such as air pollution, climate change, and noise. However, GHGs are not covered in all emission inventories; climate change policies are not considered in all air quality programmes; and air quality policies are not considered in all emission inventories. It is worth noting that the input data for air quality management and for climate change policies are the same in most cases, making it relatively easy to fully integrate these two policy sectors in all the participating cities. The first step for improving this interaction would be to combine the different inventories, or to include GHGs in emission inventories. Based on common underlying data, a common database, and thereby a common EI, an integrated programme to reduce both GHG emissions and air pollutants could be developed.

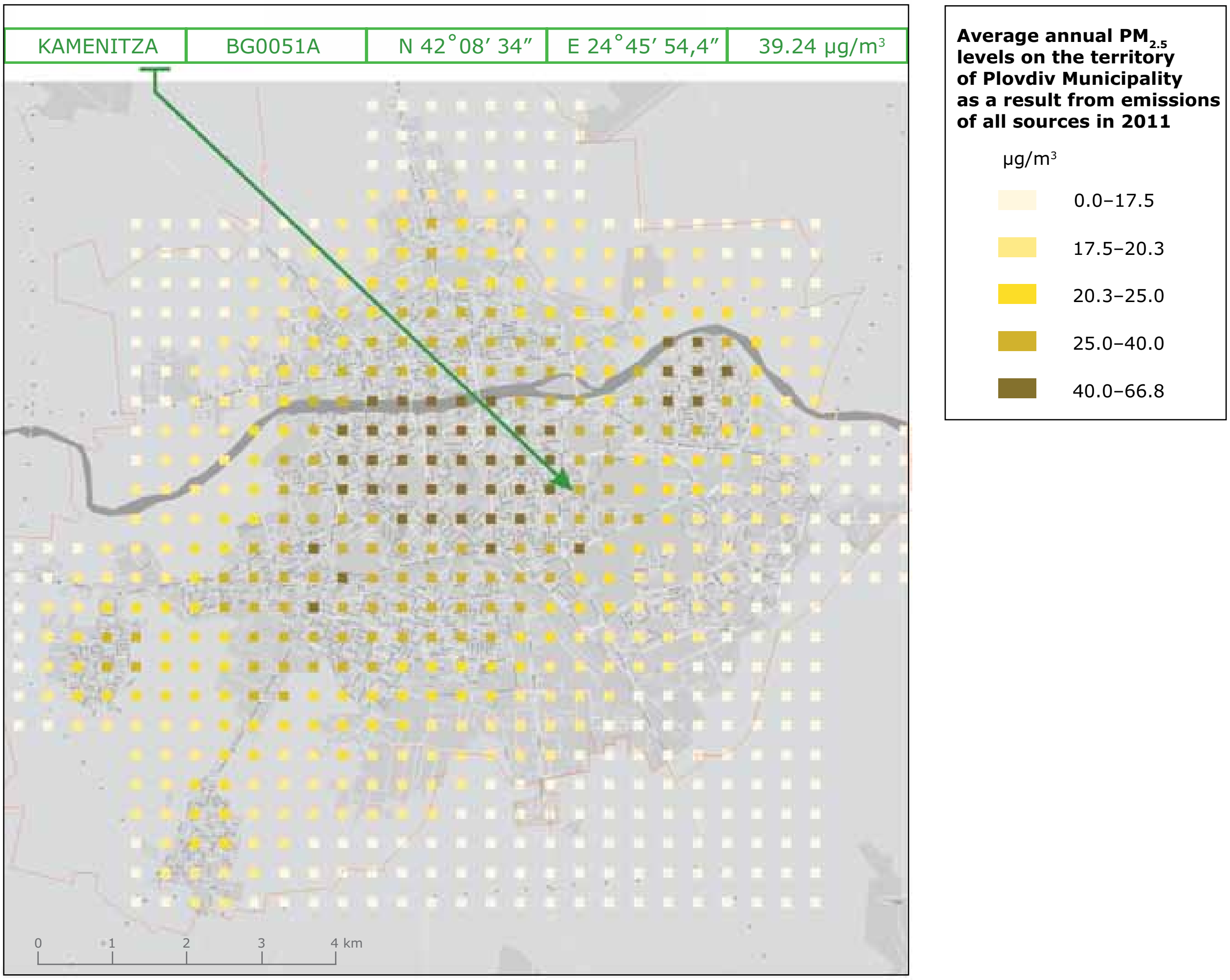
Challenges faced by cities when compiling EIs and possible improvements

There are three suggestions for improvements, covering training on EI methodologies, improvement of the emissions factors, and improvement of input data. In the bullet points below, each of these suggestions is expanded upon.

- There is hardly any information exchange between European cities concerning the methodology used to compile EIs. Nonetheless, some cities said that they had participated in European projects where experiences in compiling the EIs were discussed. Training and guidance on EI methodologies and guidance on setting up QA/QC systems would therefore be helpful. Specifically, a regular exchange of best practice and close cooperation with FAIRMODE (see Box 2.1) is seen as highly beneficial.

- Obtaining representative emission factors (coefficients that quantify the emissions or removals per unit activity and, together with the activity data, allow to estimate the emissions of an activity) is a common problem. In particular, obtaining reliable and accurate emission factors for fugitive sources is seen as a pressing challenge in most cities, and was also seen as a challenge in relation to other diffuse sources of emissions, such as wood burning, construction activity, or real-world driving conditions. City experts also highlighted the uncertainties associated with these emissions factors as a common shortcoming. The cities suggested improving the EIs by improving the quality of the emission factors, providing default emission factors, and

Map 2.2 Average annual $PM_{2.5}$ levels on the territory of Plovdiv Municipality as a result from emissions of all sources in 2011



Source: Municipality of Plovdiv.

simplifying the databases for emission factors, for instance with the creation of a common and up-to-date database. The improvement of emission factors could be achieved through common research programmes and could be made on a national and/or European scale.

Most of these aspects are already addressed by the EMEP/EEA Guidebook (EEA, 2009), which provides common (default) updated emission factors for many sources, including those identified by the cities. Future initiatives that help to publicise to city experts the existing information sources will clearly be beneficial. It must also be recognised that, even if more research and measurements will help to develop improved emission factors, the diffuse sources identified by cities will always be highly uncertain. This is due to the wide range of local practices, materials, and types of equipment used.

- Another problem commonly voiced by the cities concerns the quality and availability of input data (for instance, traffic data, especially for heavy-duty vehicles or local energy data). Precise input data are needed in order to know exactly where emissions are coming from. This is also necessary in order to quantify properly the fraction of emissions coming from outside the city or from sources not yet well-described, such as motorcycles. The quality of these input data needs to be improved on the local level, but also, depending on the dataset, at the regional or national level.

For current guidance on emission inventories, see EEA, 2013b.

Box 2.1 FAIRMODE: The Forum for Air quality Modelling (http://fairmode.ew.eea.europa.eu)

The Air Quality Directive 2008/50/EC places new emphasis on the use of models combined with monitoring data for a range of applications, for example the compilation of air quality plans. In view of this, the European Environment Agency (EEA) and the European Commission Joint Research Centre (JRC) jointly initiated a Forum for Air Quality Modelling in Europe (FAIRMODE) in 2008. The overall scope of FAIRMODE is to promote synergies and information exchange between the air quality model users — at a local and national level — and the model developers. FAIRMODE's main objectives are to:

- coordinate and gather information from modellers and users within Europe;
- develop guides and recommendations on air quality modelling for modellers, users, and the European Commission;
- provide harmonised tools and methodologies for model benchmarking and assessment;
- provide recommendations for scientific research in air quality modelling.

FAIRMODE has two working groups (WG): WG1 (led by the EEA) addressing guidance on modelling and user interaction, which includes hosting of the FAIRMODE website; and WG2 (led by JRC) on model quality assurance and benchmarking. WG2 is divided in several sub-groups focussing on the combination of using measurement and modelling information, on source apportionment of air pollutants, on local (bottom-up) air pollutant emissions, and on model quality assurance benchmarking.

2.2 Modelling activities

One of the aims of the Air Implementation Pilot was to examine modelling practices (where they exist) in the participating cities, to assess the strengths and weaknesses of model applications, and to identify further what cities need to improve their air quality models.

Introduction

Air quality models are computer-based applications used to represent and forecast the ways in which different concentrations of different pollutants interact and move around the atmosphere. Different real-world events, such as changes in weather, can also be fed into these models. Because models produce a quantifiable result, their predictions can be compared against data produced by pollution measurement stations, and further refined. Most of the air quality models are dispersion models: they represent the process of dispersion of pollutants in a given area, and they consist of the following major elements (ETC/ACM, 2011):

- the emissions themselves (the main sources of most pollutants);
- meteorological information (wind, rain, sunshine, etc., and the effects these can have on the pollutants);
- dispersion processes (transport and dispersion of the pollutants);
- chemical processes (chemical transformation of the pollutants once they have been emitted);
- removal processes (wet and dry 'deposition' — the ways in which pollution leaves the atmosphere by being deposited on water, the land, or other living things);
- boundary conditions (the condition of pollutant concentrations and of the weather outside the immediate geographical area being modelled) and initial conditions (the initial state of the model).

According to the current Air Quality Directives (EC, 2004a; EC, 2008a), the main applications of models in relation to air quality legislation are:

- Assessment of existing air quality: to supplement, complement, or replace monitoring (models can reduce the required number of monitoring stations); and to provide adequate information on the spatial distribution of the ambient air quality.

- Management of air quality and providing assistance in the drafting of the following plans (see also Box 2.2 in Section 2.4):
  - long-term air quality plans when limit values or target values are exceeded;
  - short-term action plans in regard to exceedances of alert thresholds;
  - joint international air quality plans with other Member States when transboundary air pollution is the cause of exceedances.

  Models are applied to analyse the impacts of measures (both in short-term and in long-term predictions) and for air quality forecasting.

- Source apportionment: modelling in combination with monitoring to assess the causes of exceedances and the contribution to pollution from different sources.

- To provide supplementary information for the geographical area (on a certain spatial scale) not covered by measurement data. This could serve as a basis for calculating the collective exposure to pollution of the population living in an area.

Apart from these four main uses for air quality models, there are three other reasons to use models in combination with monitoring for air quality assessments (EEA, 2011):

- modelling can potentially provide complete spatial coverage of air quality;

- modelling can also be applied prognostically, i.e. it can be used to predict air quality as a result of changes in emissions or changing meteorological conditions;

- modelling provides an improved understanding of the sources, causes, and processes that determine air quality.

To achieve the aim of this workstream a questionnaire was prepared to:

- ascertain whether models have been used, and if not, what the reasons were for not using them;

- obtain an overview of the applications for which models are used, and the institution responsible for running the models;

- gain an insight on how the model has been applied for each of the purposes (setting configurations, choosing input data, validation methods, etc.), and to get feedback from the cities about their experience in the use of models;

- learn about cooperative activities in the use of air quality models that have been undertaken by, or in cooperation with, other institutions (regional or national administrations, scientific institutions, etc.)

The questionnaire and the complete analysis have been presented in an ETC/ACM Technical Paper (ETC/ACM, 2013b) and the main results are highlighted below.

Description of the modelling activities in the participating cities

All the cities, with the exception of Dublin, have used models for air quality activities. There are several reasons why Dublin has not used air quality models. These reasons include: administrative issues (the difficulty of bringing together the various stakeholders); the current economic situation; and the perception that air quality modelling is an area where there is a lack of the required skills and experience to develop a robust model. As a result of the city's participation in the Air Implementation Pilot, the city of Dublin is now building an air quality model for the region as part of its air quality management plan. In this process, the city of Dublin will benefit from the experience of other cities, which will be able to give guidance on the technical and budgeting aspects of model development.

All of the other 11 cities replied to the questionnaire on modelling activities, with the exception of Ploiesti, which instead submitted a document informing that it used models only to assess air quality in general and for no other purpose. Therefore, for the sake of comparability, information from Ploiesti has not always been taken into account.

Air quality models can be used for many different purposes. In the questionnaire, the participating cities were asked about eight specific applications:

1. Assessment of air quality in general (including evaluating the impact on air quality of new infrastructure, such as highways, airports, etc.)

2. Reporting of air quality compliance assessments (both under the air quality assessment questionnaire or for Time Extension Notifications)

3. Assessment of source contributions

4. Long-term planning and scenario calculations

5. Short-term action plans

6. Air quality forecasting

7. Assessment of the exposure of populations to air pollution

8. Supplementing measurements from monitoring stations.

None of the cities have used models for applications other than the eight mentioned above. There was considerable diversity between the cities, and there was no single application used by all the cities. Figure 2.1 shows the summary of the applications for which the cities have used models.

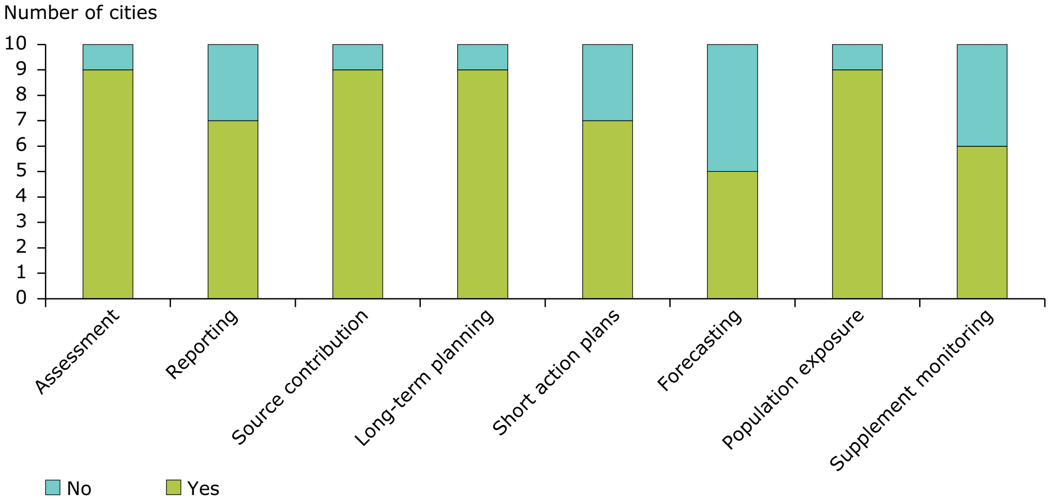
Models generally differ from city to city (only three models are used in more than one city). In Table 2.2, all of the models are summarised (with information on model name, type, purposes and documentation). For a more detailed description of the models, see ETC/ACM, 2013b. Information about all these models is available and can be consulted by the public, mainly in the Model Documentation System ([35]), which has been developed and is maintained by the EEA and its ETC/ACM.

The air quality models are usually run by a service contract consultant. Only Malmö and Milan run the models directly as a unit of the municipal government. In Antwerp, Malmö, Paris, Prague, and Vilnius, some other modelling activities have been undertaken in cooperation with other institutions, usually research institutions.

Most of the models used by the cities are dispersion models, which make extensive use of both emission inventories and meteorological data. Each of these is dealt with in the paragraphs below.

- **Emission inventories**: all the cities have adapted their local emission inventories or developed specific inventories to use with their models. The spatial and temporal resolution of the emission inventories vary according to the model used. The sources included in the inventories also vary from city to city and from model to model. For instance, so-called 'street canyon' models (used to describe streets) typically only use road traffic sources, while in other models, all the known sources of pollution are included (this usually means that all sectors are taken into account in the emission inventory). However, as was highlighted in Section 2.1, some traffic emissions such as non-exhaust sources of particulate matter (e.g. cars driving over PM

Figure 2.1 Number of cities, out of the 10 that submitted the questionnaire, that have used models for each particular air quality purpose



Note: Note that while Ploiesti does use AQ models, it only uses them for general assessment of air quality and this use has not been taken into account in the 'Assessment' bar on the far left of this figure.

([35]) http://acm.eionet.europa.eu/databases/MDS/index_html.

Table 2.2 Summary of the type of model, applications, and model documentation of the models used in the cities participating in the Air Implementation Pilot

Name of the model	Type	Applications	City	Documentation
AERMOD	Gaussian	1; 3; 4; 5; 7	Malmö	http://pandora.meng.auth.gr/mds/showlong.php?id=128
OSPM	Street canyon	2; 5 1; 4; 7; 8	Malmö Madrid Antwerp	http://pandora.meng.auth.gr/mds/showlong.php?id=74
FARM	Eulerian	1; 2; 4; 5; 7; 8	Milan	http://pandora.meng.auth.gr/mds/showshort.php?id=130
SPRAY	Lagrangian	3	Milan	http://pandora.meng.auth.gr/mds/showshort.php?id=87
CALPUFF	Gaussian	3 1	Milan Paris	http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#calpuff
CBM	Chemical mass balance	3	Milan	http://www.epa.gov/scram001/receptor_cmb.htm
GRAL modified	Lagrangian	1; 2; 3; 4; 7; 8	Vienna	http://pandora.meng.auth.gr/mds/showlong.php?id=133
CAMx	Eulerian	5; 6;7	Vienna	http://pandora.meng.auth.gr/mds/showshort.php?id=177
SERENA	Statistical Neural Network	6	Madrid	http://www.mambiente.munimadrid.es/opencms/opencms/calaire/SistIntegral/SistPrediccion.html
CMAQ	Eulerian	2; 3; 4; 5	Madrid	http://www.cmaq-model.org
WRF-Chem	Eulerian	2; 3; 4; 5	Madrid	http://www.acd.ucar.edu/wrf-chem
ATEM	Gaussian	1; 2; 3; 4; 5; 7	Prague	http://www.atem.cz/en/atem.html
SYMOS	Gaussian	5	Prague	http://pandora.meng.auth.gr/mds/showshort.php?id=119
REM_CALGRID_RCG	Eulerian	1,3	Berlin	http://pandora.meng.auth.gr/mds/showshort.php?id=173
IMMISluft (IMMIScpb)	Gaussian	1; 3; 4; 7; 8	Berlin	http://pandora.meng.auth.gr/mds/showshort.php?id=178
CHIMERE	Eulerian	1;2;3;4;6;7	Paris	http://pandora.meng.auth.gr/mds/showshort.php?id=144
ADMS urban	Gaussian, Lagrangian	1 1, 2, 3, 5, 6, 7, 8	Paris Vilnius	http://pandora.meng.auth.gr/mds/showshort.php?id=18
PMSS	Eulerian		Paris	http://www.harmo.org/Conferences/Proceedings/_Kos/publishedSections/H14-176.pdf
STREET	Street canyon	2; 4; 7	Paris	N.A.
AUSTAL 2000	Lagrangian	1; 3; 4; 5; 7;8	Plovdiv	http://pandora.meng.auth.gr/mds/showlong.php?id=132
PROKAS_B	Gaussian	1; 3; 4; 5; 7	Plovdiv	http://pandora.meng.auth.gr/mds/showlong.php?id=115
VinMISKAM	Eulerian	1; 3; 4; 5; 7	Plovdiv	http://pandora.meng.auth.gr/mds/showlong.php?id=123
POLTRAN	Eulerian	1; 3; 7; 8	Plovdiv	NA
RIO	Interpolation model	1; 4; 7; 8	Antwerp	http://rma.vito.be/demo/faces/documents/rio/RIO.pdf
AURORA	Eulerian	1; 4; 7; 8	Antwerp	http://pandora.meng.auth.gr/mds/showlong.php?id=167
IFDM	Gaussian	1; 4; 7; 8	Antwerp	http://pandora.meng.auth.gr/mds/showlong.php?id=50

deposited on roads and 're-suspending' them, or PM emitted by car brakes or tyres) are a known source of pollution but they are not usually fully included in the emission inventory because of the difficulty in quantifying them.

Looking at the specific sources, not all the models are capable of reflecting traffic congestion as a problem. This is because traffic emissions are based on traffic counting, which cannot completely reflect congestion effects. Emission inventories have several shortcomings (see conclusions in Section 2.1). One shortcoming is so-called PM 'speciation'. This means that emission inventories still do not account for the precise amount and type of particulate matter (PM_{10} and $PM_{2.5}$ and their chemical composition) being emitted by the commercial, domestic, and industrial sectors. Moreover, the precise location within the city of commercial and domestic sources is not always known. A further difficulty is the lack of data on the height of these sources. Pollution emitted at street level behaves differently to pollution emitted higher up in the atmosphere.

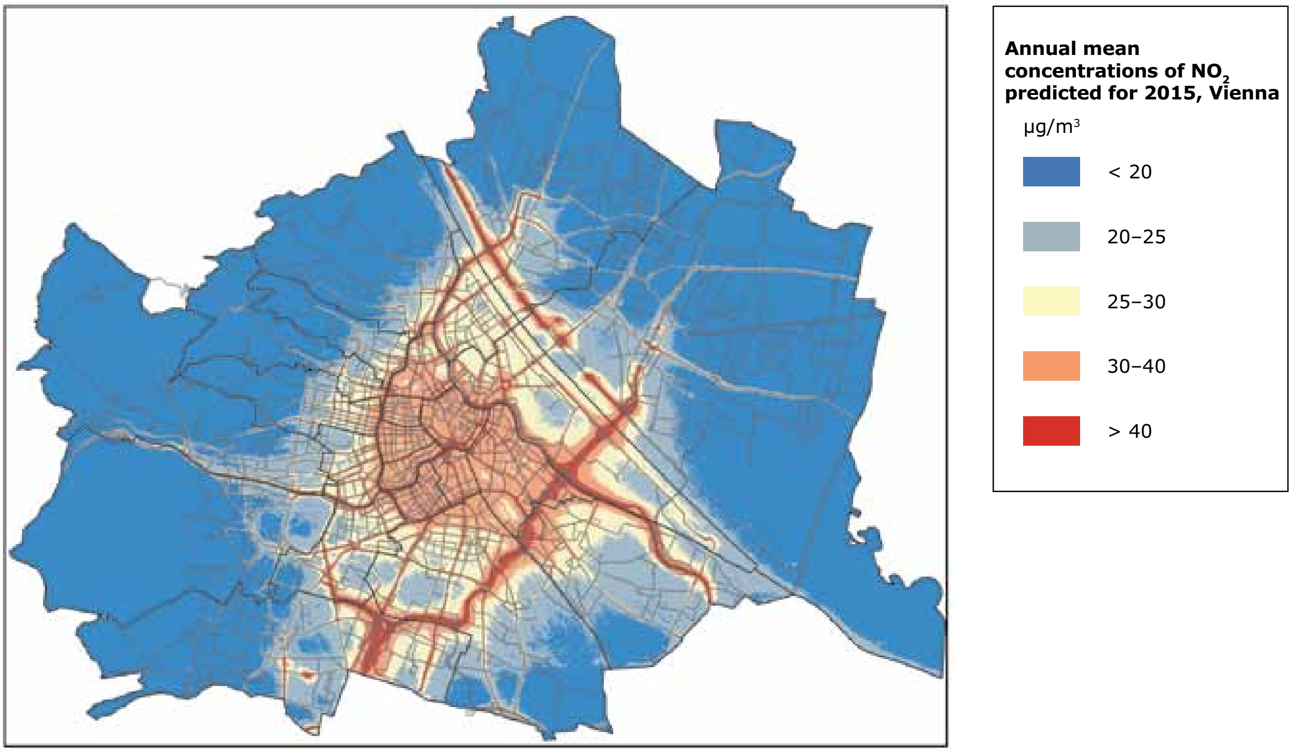
- **Meteorology**: meteorological data for air quality modelling are obtained from different sources such as measurement towers, high resolution meteorological models, or model results combined with a local monitoring network (as in the case of Milan). In some cases, these meteorological data are validated against local measurements.

All the cities have validated their models against local measurements. Although the models used by cities differ greatly, most of the cities use the same air quality indicators to assess the quality of their model outputs. Most of the cities have also estimated the 'uncertainty' ([36]) of their air quality model as required by EU legislation.

Challenges faced by cities when applying air quality models and possible improvements

All cities have found their models to be helpful for the purpose for which they were implemented. In general, the results from the models have been taken into account by the cities in their air quality management decisions.

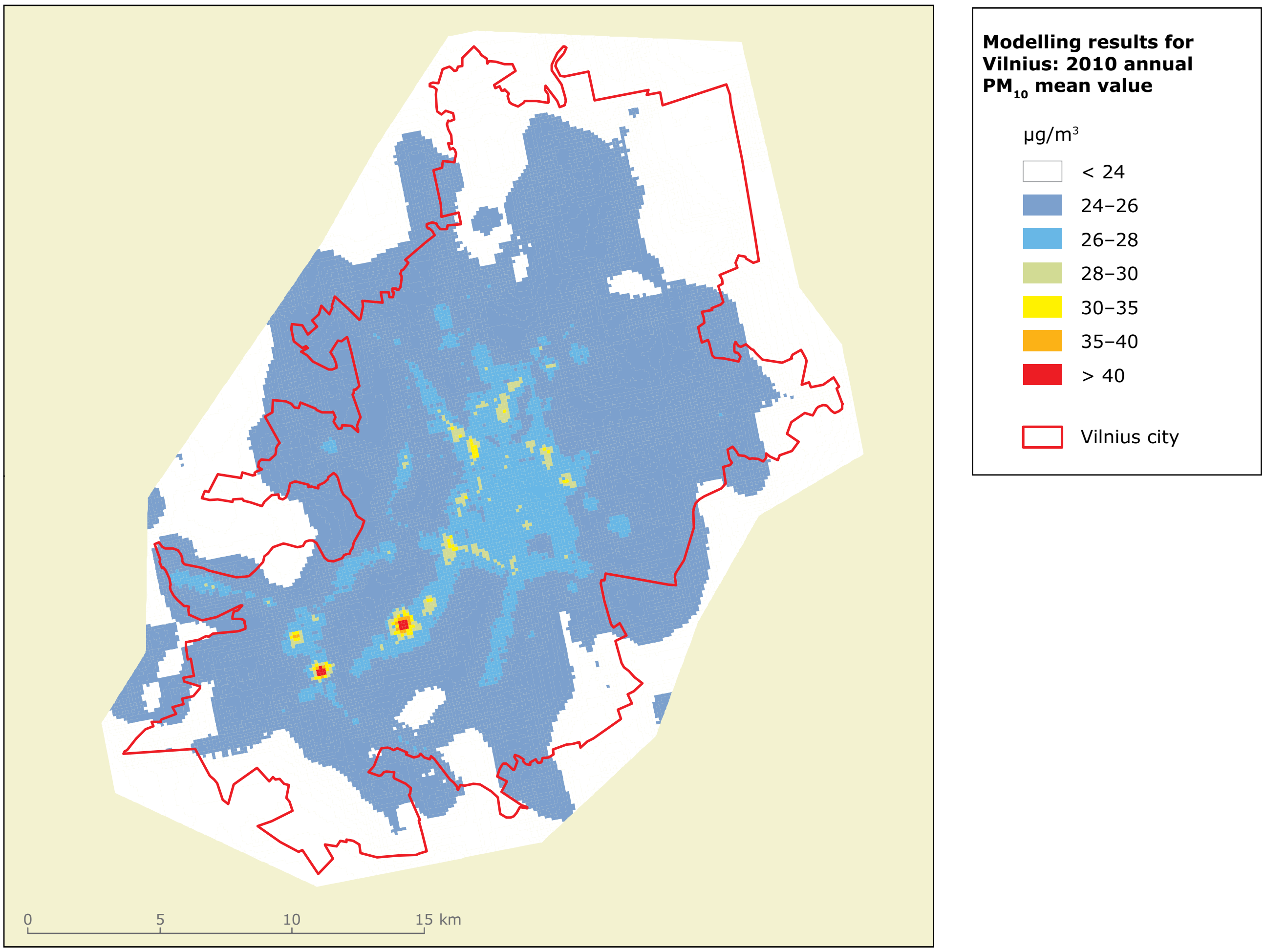
Map 2.3 Annual mean concentrations of NO_2 predicted for 2015, Vienna



Source: City of Vienna — Environmental Department MA22.

([36]) The term 'uncertainty' is used in the air quality directives to describe the accuracy of a model.

Map 2.4 Modelling results for Vilnius: 2010 annual PM_{10} mean value



Source: Municipality of Vilnius.

Nevertheless, the cities' modelling experts did find some difficulties when running their models. These difficulties were:

- Those associated with the input data, of which there were two components:
  - on emission inventories, cities had trouble: estimating background and international concentrations; estimating the uncertainties in every source sector; dealing with the lack of data on fugitive emissions; and managing the quality of input data (for instance, traffic);
  - on meteorological inputs: there is a lack of good quality urban meteorological data.
- Technical difficulties, such as how to account for the specificities of urban topography (hot spots, biases at kerbside), and specific model processes (coupling ([37]), sub-grid scale processes ([38])).
- Either overestimations or underestimations in the results. For instance, Vienna highlighted general overestimations in the forecasts, whereas Berlin and Paris highlighted underestimations of PM_{10} concentrations.

([37]) When the output from one model serves as input for an other model. For instance a regional air quality model can be coupled to a meteorological model to get the meteorological variables (temperature, wind, etc.) and also to a climatic model to get the boundary conditions.

([38]) Those physical or chemical processes that take place at a scale lower than the resolution of the model grid. For instance, if the model grid is 5 km^2 it cannot take into account the full details of the streets.

- The computational time is long and consumes lots of resources.
- The complexity of the results, and the work required to validate them makes them difficult to interpret.

As a result, the experts concluded that improvement in modelling activities in the cities could come from the following areas:

- Training/guidance on how to use a model, how to apply it, and how to validate it. Training is also needed on how to know which model to use.
- Improvement of input data, for instance to take into account the different topography in the different cities.
- Production of emission inventories with the right level of detail in relation to the source contribution to concentrations and to the optimal updating frequency. Ensuring that the emission inventories do not require excessive amounts of resources to produce. Improvement of emission inventories as described in Section 2.1, and increasing synergies between emission inventories and modelling.
- Creation of a service that provides cities with background concentrations as an input for their models. These background concentrations would be calculated for several years under several different scenarios. They would be updated according to new policy developments.
- Creation of a general framework for modelling, criteria harmonisation, and exchange of experiences. The involvement of cities in FAIRMODE activities (see Box 2.1) was seen as a way of promoting this exchange of experiences.

For current guidance on models, see Annex 4.

A guide on the use of models for air quality assessment and management in urban areas is under preparation, and will become available by the end of 2013. This guide builds on the analysis of the modelling approaches of the cities participating in the Air Implementation Pilot. It addresses some of the needs expressed by the participating cities in order to improve their air quality models.

2.3 Monitoring networks

One of the aims of the Air Implementation Pilot was to understand whether the current monitoring stations give an accurate representation of air quality in the selected cities, and whether further support or guidance is needed in this area.

Introduction

The most obvious way to assess the amount of pollution in the atmosphere is by direct measurements made at monitoring stations. Measurements carried out at these stations can be complemented with models, as explained in Section 2.2. These models provide a more complete spatial assessment of air quality, and help better understand the causes and processes that determine it.

The Air Quality Directives (EC, 2004a; EC, 2008a) established the minimum number of monitoring stations needed in every zone for assessing air quality. The directives also set out criteria for the type of stations to be used and their location within each zone. Station types are defined and classified according to the kind of area they represent (urban, suburban, rural), and the dominant emission sources in that area (traffic, industrial, background) (EC, 1997; EC, 2011b). Results from the monitoring sites are reported officially by Member States, and stored at the EEA in the public air quality database AirBase ([39]).

Description of monitoring networks in the participating cities

Data from and information on the stations stored in AirBase for the 12 cities were retrieved, checked for completeness, and analysed. The results presented below are based partially on those found in ETC/ACM, 2012a.

The adequacy of monitoring networks can be checked against different objectives, two of which are particularly important:

([39]) http://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-7.

- A legislative objective: is the assessment of urban air quality in compliance with the requirements set out in the air quality directives?

- An effect-oriented objective: will the network of monitoring stations provide estimates that accurately represent the exposure to pollutants of the urban population?

In what follows below, it is examined whether the legislative objective has been met. The AQ zone was used as the spatial unit of measurement here, even though for the purposes of the pilot, AQ zones were not always used (as explained in Section 1.2.2). The reason to use the air quality zone in this monitoring exercise is because the air quality directives explicitly set up monitoring requirements on the basis of AQ zones.

Table 2.3 lists the number of stations per regulated pollutant operational (that is, with at least one valid measurement) during 2011 in the AQ zones.

According to the air quality directives, the minimum number of stations depends on population size and the classification of zones with respect to assessment thresholds (see Box 1.1 and Annex V and IX in the Directive

Table 2.3 Number of operational monitoring stations in 2011 in the AQ zones where the cities participating in the Air Implementation Pilot are located

City (a)	Zone code (b)	Pollutant											
		SO_2	NO_2	O_3	PM_{10}	$PM_{2.5}$	CO	Lead	C_6H_6	As	Cd	Ni	B(a)P
Antwerp	BEF01S	7	7	1	5	1							
	BEF02A	2	4	2	4	4	1		2				1
	BEF07S							4		4	4	4	
Berlin	DEZBXX0001A	2	16	7	14	5	2	3	4	3	3	3	5
Dublin	IE0001	5	8	3	8	3	3		2	2	2	2	2
Madrid	ES1301	10	24	14	12	9	10	2	6	2	2	2	1
Malmö	SW6	2	4	3	4	3	1		1				
Milan	IT0306	5	14	5	11	4	8	3	2	3	3	3	3
Paris (c)	FR04A01	3	40	19	19	6	4	1		1	1	1	1
Ploiesti	RO0302 (d)	5	5	4	3	1	4	3	4	3	3	3	
Plovdiv	BG0002	2	2	1	3	1	2	1	2		2		1
Prague	CZ010	10	15	9	15	7	4	7	4	7	7	7	2
Vienna	AT_09C	7	17	5	13	6	4	1	2	1	1	1	2
Vilnius	LT0100	2	3	2	4	2	2	1	2	1	1	1	1

Note: (a) The name of the city is not always the same as the AQ zone name (see Table 1.2).

(b) For this analysis, it is the AQ zone that has been considered in all cases.

(c) Airparif informed in the context of the Air Implementation Pilot that the number of stations actually operated by the local air quality network in April 2013 was 4 for SO_2; 37 for NO_2; 15 for O_3; 21 for PM_{10}; 8 for $PM_{2.5}$; 5 for CO; 1 for lead; 12 for benzene, 1 for As; 1 for Cd; 1 for Ni; and 5 for B(a)P.

(d) Data for 2010, as new zones were defined in 2011.

The city of Paris and the new AQ zone RO031601 Ploiesti were also taken into account:

Geographical unit	Pollutant											
	SO_2	NO_2	O_3	PM_{10}	$PM_{2.5}$	CO	Lead	C_6H_6	As	Cd	Ni	B(a)P
City of Paris (a)		13	5	6	1	2	1		1	1	1	
RO31601 (Ploiesti)	1	2	1	1	1	1	2	2	2	2	2	

Note: (a) Airparif informed in the context of the Air Implementation Pilot that the number of stations actually operated by the local air quality network in April 2013 was 1 for SO_2; 13 for NO_2; 3 for O_3; 6 for PM_{10}; 3 for $PM_{2.5}$; 3 for CO; 1 for lead; 7 for benzene, 1 for As; 1 for Cd; 1 for Ni; and 2 for B(a)P.

2008/50/EC, and Annex III in Directive 2004/107/EC for further details). The directives allow for a reduction in the number of stations when the information from the fixed measurement stations is supplemented by information from modelling and/or indicative measurements, when some other specific conditions are met. For simplicity issues, the minimum number of stations as listed in the annexes of the air quality directives was used, without considering the possible use of models as supplementary information.

In the Air Quality Questionnaire on annual reporting on ambient air quality assessment (EC, 2004b), there are two types of information: mandatory information that must be supplied and voluntary information that the reporting authorities may supply if they wish. Information on the classification of the corresponding air quality zones with respect to assessment thresholds is provided voluntarily in the annual Air Quality Questionnaire. When the classification of zones with respect to assessment thresholds was not available from the questionnaire, it has been estimated from AirBase data. Results are summarised in Table A5.1 in Annex 5. By combining this information on classification of zones with respect to assessment thresholds with the population numbers, the required minimum number of stations per AQ zone has been calculated, and it is given in Table A5.2 in Annex 5. Note that for particulate matter, the sum of PM_{10} and $PM_{2.5}$ sampling points is given.

With regard to NO_2, ozone and PM, the following conclusions can be drawn:

- For NO_2, the number of operational stations is higher than the required minimum. The additional criterion for national networks that 'the total number of urban background stations and traffic-oriented stations in a Member State shall not differ by more than a factor of 2' is generally met also at AQ zone level.

- For ozone, the number of operational stations equals or exceeds the required number. However, the criterion that at least 50 % of the stations be located in suburban areas (Annex IX of Directive 2008/50/EC) is generally not met.

Monitoring station PH-2 in Ploiesti

Photo: © APM Prahova

- For particulate matter, all zones have the required number of operational stations or more. The Air Quality Directive 2008/50/EC requires that on a national level — although not on a city level — the number of PM_{10} and $PM_{2.5}$ stations should not differ by more than a factor of two. This criterion is not fulfilled in all the cities.

Overall therefore, the monitoring networks in the corresponding zones fulfill the requirements on density of stations. However, the criteria for the type of ozone stations and the criterion set for national networks regarding the ratio of PM_{10} and $PM_{2.5}$ stations are not always fulfilled. In order to have as complete a picture as possible of different air quality situations in cities, it is therefore desirable that these other criteria on the different types of stations should also be fulfilled.

Challenges faced by cities when setting monitoring networks and possible improvements

Air quality experts from the cities expressed the difficulties they encountered in trying to classify appropriately the monitoring stations according to the criteria in the directives, as these criteria seem to be quite generic. In order to increase the comparability of measurements across the different cities, some of the cities suggested that the directives be revised to contain stricter and clearer criteria regarding:

- micro-scale siting of stations (how stations are located in relation to the immediate surroundings), in particular those related to the distance of traffic stations to the kerbside;

- macro-scale siting of stations (how stations are located in relation to dominant sources of pollutants);

- representativeness of stations (the spatial area over which the value measured at the station can be taken as meaningful).

Further considerations about classification of monitoring stations can be found in Annex 6.

2.4 Management practices

One of the aims of the Air Implementation Pilot was to identify and create an inventory of effective policies and measures ([40]).

Introduction

The Air Implementation Pilot analysed the measures implemented in the participating cities, mainly via the air quality plans. To do this, the EEA made use of the official reporting 'plans and programmes' (P&Ps) questionnaires submitted by Member States to the Commission (EC, 2004c and CDR) when there is an exceedance of a limit value or a target value. The EEA also made use of the Time Extension Notifications, submitted by countries when they wish to ask for more time to achieve a certain pollutant limit value (see Box 2.2). Finally, the EEA used direct contact with the nominated experts from participating cities in order to analyse the city's air quality measures.

The analysis of the implemented measures in the first eight cities has been presented in an ETC/ACM Technical Paper (ETC/ACM, 2012a), updated subsequently to include the additional four cities that joined the pilot later (ETC/ACM, 2013c).

Member States have sent to the European Commission air quality plans (or P&Ps) regarding eight out of the twelve cities taking part in the Air Implementation Pilot (i.e. Antwerp, Berlin, Dublin, Milan, Paris, Ploiesti, Prague and Vilnius; Table 2.4). Madrid and Vienna did register exceedances, and although they implemented a plan, they did not submit the questionnaire to the EC.

Time extension requests have been made by Member States for Antwerp, Berlin, Madrid, Milan, Paris, Ploiesti, Prague, Plovdiv and Vienna (Table 2.4). The applications for time extensions include similar information to that contained in the P&Ps, such as a summary of the measures implemented or to-be-implemented for compliance purposes. In addition, the applications for time extension include the predicted pollutant concentrations at the final deadline for compliance (for example, a zone does not meet the 2010 limit value and applies for an extension until 2015. In the application for the time extension it therefore has to forecast what its pollutant concentrations will be in 2015).

([40]) A previous aim was to detect if there were statistically significant changes in the monitoring time series at stations in the selected cities and to try to associate these changes with implemented measures. See Annex 7 for the results from the analysis of trends.

Box 2.2 Air quality directives — management of air quality

The air quality directives require Member States to prepare, implement, and report plans to improve air quality in case of exceedances of the air quality standards (see Box 1.1 and Annex 1).

- Air quality plans: when a limit or target value is exceeded in a zone, the directives require Member States to establish air quality plans to attain those standards. Member States also have to submit their air quality plans (which in the previous directives were referred to as plans and programmes, (P&Ps)) to the European Commission. Air quality plans are reported to the Commission as an Excel file (the questionnaire on P&Ps, EC, 2004c) that includes:
  (1) General information;
  (2) Description of the exceedance situation addressed by the air quality plans;
  (3) Analysis of the causes of exceedance;
  (4) Summary descriptions of individual measures.
- Short-term action plans: measures to be implemented in a zone when there is a risk of exceeding an alert threshold.
- Joint international plans: when exceedances of limit or target values are due to transboundary pollution, Member States have to cooperate and draw up joint activities.

Other aspects relevant for air quality management are:

- Exemptions: Article 22 of the Air Quality Directive 2008/50/EC allowed the Member States to postpone the attainment deadline for the limit values (LV) for PM_{10} (until 11 June 2011) and for nitrogen dioxide and benzene (until 1 January 2015) if certain conditions are met. Member States have to notify to the Commission where these postponements will apply using the Time Extension Notification (TEN) format, as defined by the European Commission in two Commission Staff Working Papers (EC, 2008b; EC, 2011c). Furthermore, notifications must be accompanied by an air quality plan for the zone or agglomeration concerned.
- Natural sources: when exceedances of limit values are attributable to natural sources, Member States can subtract the natural contributions in order to demonstrate compliance with limit values.
- Winter salting and sanding: when exceedances of limit values are attributable to winter salting or sanding or roads, Member States can subtract these contributions in order to demonstrate compliance with limit values.

The information concerning compliance with limit values, reasons for exceedances, and proposed measures is directly comparable between the cities if they have submitted the P&Ps or have applied for a time extension. Therefore, the pilot evaluated the eleven cities together. The one city not included in this evaluation is Malmö. Malmö has not registered exceedances of air pollution limits in the last five years, which explains its lack of reporting of both P&Ps and TENs.

Description of the measures taken in the participating cities to improve air quality

In their P&Ps and the TENs, the cities identify traffic as the primary source for both NO_2 and PM_{10} levels. The cities with NO_2 exceedances that have identified contribution sources place these sources in the same order of declining importance: first traffic sources, then commercial and residential sources, and then industrial sources. All of the cities identify NO_2 as an urban problem.

Regarding PM_{10}, there were differences in the ranking of sources by the cities that reported on the contribution of sources to PM_{10} exceedances. All of the cities identify traffic as the main source of PM_{10}. Commercial and residential sources are placed either in second (Berlin, Milan, Vilnius) or third (Paris, Prague) place, with the exception of Ploiesti, where it is not considered a main source. Regarding industry, Paris and Ploiesti identify it as a main contributor to PM_{10} levels, while for Prague it is the least important contributor. Milan is the only city to consider agriculture as a main source of PM_{10}. And finally, Milan also considers natural sources to be a contributor to PM_{10}, albeit the smallest contributor.

Table 2.4 Overview of the Plans and Programmes (P&Ps) and Time Extension Notifications (TENs) in the cities participating in the Air Implementation Pilot

City	AQZ name (code)	P&P (year)		TEN	
		NO_2	PM_{10}	NO_2	PM_{10}
Antwerp	Antwerp (BEF02A)	Yes (2008)	No	No	Yes (2010)
Berlin	Ballungsraum Berlin (DEZBXX001A)	Yes (2002)	Yes (2002)	Yes (2009)	No
Dublin	Zone A (IE001)	Yes (2009)	(-)	No	No
Madrid	Madrid (ES1301)	Yes ([b])	Yes ([b])	Yes (2010)	No
Malmö	Malmö (SW6)	No	No	No	No
Milan	Agglomerati urbani (A1) (IT0301) ([a])	Yes (2009)	Yes (2009)	Yes (2008–2009)	Yes (2005)
Paris	Île-de-France-Paris (FR04A01)	Yes (2010)	Yes (2010)	Yes (NA)	Yes (2005, 2006, 2007)
Ploiesti	Ploiesti (RO0302)	(-)	Yes (2009)	No	Yes (2007)
Prague	Praha (CZ010)	Yes (2004)	Yes (2004)	Yes (2010)	Yes (2006)
Plovdiv	Plovdiv Agglomeration (BG0002)	No	No	Yes (2010)	Yes (2007)
Vienna	Wien (AT_09)	Yes ([c])	Yes ([c])	Yes (2010)	Yes (2005)
Vilnius	Vilnius (LT0100)	No	Yes ([d]) (2010)	No	No

Note: (year) refers to the year for which the exceedance has been assessed.

(-): the city has submitted a P&P questionnaire but has not reported exceedances for that pollutant.

([a]) Changed to IT0306 in 2011.

([b]) In the year 2006, the document 'Estrategia Local de Calidad del Aire de la Ciudad de Madrid 2006–2010' was submitted. It contained measures to reduce levels of NO_2 and PM_{10}. However, the Excel file was not submitted so the P&P has not been analysed for Madrid.

([c]) Vienna implemented air quality plans for PM_{10} (2005) and NO_2 (2005 and 2008). However, the Excel file was not submitted so the P&P has not been analysed for Vienna.

([d]) Vilnius submitted the first P&P for PM_{10} in the year 2006. The measures contained in the second and third P&Ps submitted after the first one are general and will help to reduce the ambient levels not only of PM_{10} but also NO_2 among other pollutants.

Source: TEN and P&Ps.

These findings are in line with what the cities reported as the main contributing sources of PM_{10} and NO_2 in meetings held during the project (see Annex 2).

The number and characteristics of the measures applied vary from city to city, but some common features can be identified. For instance, in agreement with the main sources identified, in most of the cities more than the 50 % of the implemented measures are traffic related.

Some of the measures related to road traffic that have been applied by the cities (usually a combination of different measures is applied) to reduce the concentrations of NO_2 and PM_{10} are:

- creation of a Low Emission Zone (LEZ);
- improvement of public transport;
- promotion of cycling;
- management of traffic flow;
- change in speed limits;
- investment in technology to reduce emissions from public transport.

The commercial and residential sectors were also targeted by measures. These sectors were identified as the second most important contributor to NO_2 and PM_{10} exceedances in almost every city. Milan and Prague have implemented — or are going to implement — an important number of measures dealing with the energy efficiency of buildings and environmentally friendly fuels for heating. 24 % of Milan's measures and 21% of Prague's measures will deal with these issues. These measures aim to ensure that the two cities comply with the limit value for NO_2.

Some of the measures affecting this sector that were considered successful by the cities are:

- ensuring compliance with new low-sulphur standards for shipping fuels in the port area;
- a ban on the marketing, sale, and distribution of bituminous coal;
- fuel conversion in domestic heating;
- the creation of district heating.

Industry is another source of pollutant emissions. Milan has implemented the most measures to deal with industrial sources of air pollutants. Other cities that also took a large number of measures to deal with industrial sources of air pollution include Antwerp, Madrid, Paris, and Vienna.

Some of the measures implemented that affected the industrial sector are:

- retrofitting of installations with enhanced abatement technology;
- measures to reduce diffusive dust emissions in ports;
- relocation of factories and industrial sites out of the urban area.

Measures to tackle emissions from agriculture have not been as numerous as the other implemented measures. Besides the fact that only Milan identified agriculture as an important contributing sector, another probable reason for the lack of agriculture-focused measures at the city level is that measures affecting agriculture are usually undertaken at regional or national level. This is because of the fact that although emissions from agriculture can have an impact on air quality in cities, agriculture-related air pollutants are generally emitted outside the legal boundaries of the cities, and thus outside the city authority's jurisdiction. Apart from Milan, the cities of Antwerp, Madrid and Vienna also reported measures dedicated to reducing emissions from agriculture, even though these measures did not represent a large share of their total measures.

Finally, all cities have implemented or plan to implement campaigns to raise awareness, in order to encourage the population to help reduce emissions. Those measures are important to make sure that air quality problems are well understood among the population of the city.

Access panel to the LEZ in Milan

Photo: © ARPA Lombardia

A list of the implemented measures for the initial eight participating cities can be found in Annex II to *Progressing to cleaner air — evaluating non-attainment areas* (ETC/ACM, 2012a). Additional information on the implemented measures can be consulted in the P&P ([41]) and TEN ([42]) questionnaires.

The number of measures also varies from city to city, although it must be noted that the number of measures is not always related to the effectiveness of the overall programme of measures.

Further analysis of management practices: the workshop on measures

From the analysis of the Plans and Programmes (P&P) and of the Time Extension Notifications (TEN), it was unfortunately not possible to identify which were the most efficient measures in each city. This is because not all the cities reported the expected local impact of the measures on ambient

([41]) http://cdr.eionet.europa.eu.
([42]) http://ec.europa.eu/environment/air/quality/legislation/time_extensions.htm.

concentrations of pollutants. A workshop was therefore held to get input from the cities themselves on how they evaluated the effectiveness of the measures.

The objectives of the workshop were to understand:

- the process leading to the choice of measures;
- how expected effects are estimated (before implementation), and how aimed effects are calculated (after implementation);
- estimation of costs/benefits;
- challenges in implementation;
- the need for further guidance.

In order to prepare the workshop, a questionnaire was sent out to the cities' experts, asking them to provide information about what they considered to be the three most effective measures they have implemented. The results of the workshop were presented in an ETC/ACM Technical Paper (ETC/ACM, 2013d). Below, a summary of the results is presented.

Initial analysis of the workshop questionnaires and the process leading to the choice of measures

Consistent with the main pollutant sources, most of the top three measures chosen by the cities target traffic. Most of these measures affect public transport (conversion of the fleet to alternative fuels, modal shift from private vehicles to public transport, promotion of cycling, etc.). Some of the other measures involve the implementation of low-emission zones (LEZ), and a few others imply speed limits, congestion charges, or changes to spatial planning. Four cities chose measures targeting the residential use of fuels (e.g. biomass/bituminous fuel burning) as among their most effective measures. Only Vienna named a measure targeting industrial emissions as being among the three most effective measures it implemented. Antwerp also highlighted three measures aimed specifically at port emissions. One of these measures was to increase awareness of emissions by promoting eco-sailing practices, and two were technological: the installation of a hybrid-powered crane and a programme of subsidies for low-emission cargo-handling equipment. Most measures are still on-going, meaning that they have been implemented and continue to be implemented.

The areas in which the measures were implemented depend on the types of measures chosen. Those measures related to residential and commercial sources affect buildings, and those measures addressing road traffic emissions extend from specific areas of the city (e.g. the inner city in the case of congestion charges) to the whole city (e.g. the renewal of public transport fleet). In the case of Antwerp, specific measures were put in place for the harbour. And in a few cases, the implementation area extends further than the city to cover regional areas (for instance, the ban on some fuels in Dublin was also implemented in some other Irish cities, and the LEZ in Milan was designed to include some other locations in the Po Valley).

Different pollutants are targeted by each measure, but NO_2 and PM are targeted by all measures. Only one of the chosen measures targets B(a)P, the main source of which is wood burning, although it can also be emitted by road traffic. None of the selected measures was specifically undertaken to reduce emissions of VOCs, which are precursors of ozone.

Figure 2.2 A poster advertising stage 2 of the LEZ in Berlin

Source: Berlin Senate.

Finally, some of the measures implemented did not always target air pollution as their primary aim, but instead aimed at noise reduction, re-design of the city centre, reducing emissions of greenhouse gases, etc. Nevertheless, the participating cities reported that these measures often had spill-over benefits in terms of air quality.

The cities participating in the Air Implementation Pilot reported that the public's reaction to the measures ranged from indifference (for example in the case of technological measures implemented in public transport) to acceptance (for example in the case of bike-sharing programmes) to rejection (for example LEZs, traffic restrictions). There is some evidence that acceptance is higher when public perception and knowledge of air pollution issues are high, when the city provides alternatives (such as making public transport or alternative fuels easily available), and when there are economic incentives for the public to comply with the measure.

From all these examples of selected measures, it was found that the criteria most used to select possible air quality improvement measures were: their effect on reducing emissions; their co-benefits in other environmental areas; their legal feasibility (sometimes related to the competences of the city in implementing them); their economic and social 'proportionality' (the extent to which they do not pose excessively heavy burdens on low-income citizens or vulnerable groups); and their technical feasibility.

Challenges in estimating the effects of measures

Before the implementation of the measures, the most commonly used tools to forecast their effects were emissions analysis, air quality modelling, and impact studies. The workshop participants were all of the view that estimating effects is a complex issue, which depends strongly on the specific measures to be implemented. In any case, all measures reported to the Commission have to be accompanied by an estimate of their effects.

After implementation, the most frequently used tools were measurements from the monitoring networks; estimations of the changes in emissions; the use of indicators; and estimations of the changes in fleet composition. The problem of estimating effects seems less difficult in the post-implementation phase than the pre-implementation phase, as several robust assessment methods are available. In general, this post-implementation impact assessment seems slightly more feasible when applied to technological measures than when applied to other types of measures. A critical factor for assessment of the effects of a measure is data availability, in particular technical data (e.g. emission factors, or the proportion of vehicles using an improved technology, etc.).

Electric bus in Prague

Photo: © Department of Environment of the City Hall of Prague

Finally, it was highlighted by some of the workshop participants that there is still no single definition of what constitutes an effective measure.

Challenges of estimation of costs/benefits

Cost and benefit estimation seems to be the most complex issue, according to feedback from the city experts. The difficulty here is that investment in measures should not be seen only from the perspective of pollutant mass reductions, but instead more overall approaches should be taken (considering the economic, social, urban, and other effects of the measure). For instance, if only emissions criteria are considered, measures such as bicycle lanes would seem ineffective when compared to technical measures (e.g. particle filter traps). However, bicycle lanes may be favoured for additional reasons such as reducing congestion.

Several city experts agreed that calculating the social benefits of a measure is not simple, but that these benefits are especially relevant for policymakers and politicians. Other factors, such as the proportion of the population affected by the measures, should also be included in investment calculations.

In general terms, it seems much easier to assess the costs for technological measures than for other types of measures (e.g. so-called 'structural' measures, which seek to change citizens' habits and where air quality is only one of many potential benefits. These types of measures often seem not to be cost-effective when looked at in isolation, i.e. from the air quality perspective alone).

It also appears that the current economic situation is a clear limiting factor for the implementation of further air quality measures.

Challenges of implementation

Finally, the city experts reported several major challenges encountered when implementing air quality measures. These challenges were technological, cultural, legal, political, and economic, and they are consistent with the challenges identified by the city experts at the beginning of the project (see Annex 2). Public opposition was also considered to be a significant challenge, and was visible in the difficulty of modifying the public's perception of a given environmental problem (e.g. climate change versus air quality) or solution (e.g. biomass burning to reduce CO_2 emissions).

Legal considerations also pose a challenge, chief among which is the way that competences may be split between different levels (state/region/municipality). From an EU perspective, the cities requested support from the EU in the form of additional legislation, which preferably would include sanctions for non-compliance with air quality standards.

Political realities also constitute a challenge in the sense that air quality does not always rank very high on political agendas.

Other challenges raised by the cities included a lack of human resources and funding in the context of the current economic situation, and the difficulty they had in trying to change this situation by promoting air quality improvement as an opportunity for economic growth.

Possible improvements in the implementation of measures

Further support was requested by city experts, mainly in the form of EU-wide regulations and legislation. Examples include: requests for new EU-standard methodologies to measure emissions from boilers; new EU regulation for small domestic stoves & fireplaces (< 35 kW); regulation for the retrofitting of non-road heavy machinery; and regulation for environmentally-friendly eco-design and energy labelling requirements. Regarding vehicle emissions, the participating city experts said that a greater number of tests of Euro 6 vehicles would improve the data found in emissions inventories and therefore the modelling exercises used to assess the effectiveness of measures.

2.5 Information to the public

The final aim of the Air Implementation Pilot was to examine how cities inform the public about the status of air quality, how they identify and compile innovative ideas in communication, and how EEA dissemination platforms can provide access to local information on air quality.

Introduction

Box 2.3 summarises the information Member States have to provide to the public, according to EU legislation.

A questionnaire was distributed by the EEA to participating cities in order to gain some insight about different communications practices regarding this information summarised in Box 2.3, as well as any other information considered relevant for citizens. All cities replied to the questionnaire with the exception of Malmö. The questionnaire, its complete analysis, and further findings on the communication of air quality to the citizens, have been presented in an ETC/ACM technical paper (ETC/ACM, 2013e). The main results are highlighted in what follows.

Description of the activities to communicate air quality issues to the public in the participating cities

The competent authorities for informing the public on issues related to air quality in every city reflect (as highlighted in Annex 2) the different structures of administration in both cities and Member States. In most of the cities, the competence is under the remit of the local authorities. This is the case for Berlin (the *Land* or city-state), Dublin (in cooperation with the national agency), Madrid (except for postponements/exemptions, which are the competence of the national ministry), Ploiesti, Prague (which shares this competence together with

Box 2.3 Air quality directives — information to the public

Article 26 in Directive 2008/50/EC (EC, 2008a) and Article 7 in Directive 2004/107/EC (EC, 2004a) establish the information that must be made available to the public. This information covers four areas:

a. Ambient air quality
b. Postponements/exemptions
c. Air quality plans
d. Competent authorities.

Furthermore, Directive 2008/50/EC also requires Member States to provide information to the public regarding exceedances of 'alert thresholds' (Art. 19); the content and implementation of short-term action plans (Art. 24.3); and exceedances of thresholds in relation to transboundary air pollution (Art. 25).

the national ministry and meteorological institute), Vienna (where the competence is exercised by the province of Vienna, except for postponements/exemptions, which is the competence of the federal institutions) and Vilnius. In some other cities, this competence lies with the regional authorities. This is the case for Antwerp, Milan and Plovdiv (where the local region shares responsibility with the national government). Finally, in Paris this competence is undertaken by Airparif, an autonomous association under French law, whose administration board consists of representatives from the municipality of Paris (one of the key partners); other local authorities; the national government; industry; environment and consumer NGOs; and health and air pollution experts. Local authorities also play a role in communication activities.

In general terms, all information required to be made public by the legislation is promptly provided to the public. The most common way of providing information on air quality issues is through the internet. Most cities have their own dedicated webpages (see Box 2.4), and in some cases the pages are administered by the national or regional governments. However, air quality information is not always easily accessible in these pages, as sometimes the underpinning data are not accessible through the homepages or through direct links (sometimes this issue is due to the design of the pages). Most of the pages also provide their information in English, so it can be read by a wider international audience.

Information on concentrations of air pollutants and air quality status is provided by different means, with a widespread use of reports. These reports are issued with different frequencies: most of them are issued annually, in accordance with the legal obligation to assess air quality on a yearly basis. But there are also daily and monthly reports, and some bulletins are issued on a near-real-time basis. Billboard-style electronic displays of real-time data placed at city centre locations are used in

Image of the smartphone application 'El Aire de Madrid', Madrid

Photo: © Municipality of Madrid

approximately half of the cities (in some of the other cities, they are not considered to be an efficient form of communication). Several cities have also implemented systems to receive and respond to specific air quality information requests.

Traditional mass media (newspapers, television, radio, etc.) are less widely used to inform the public. In general, they are only used by the cities to issue alerts of high pollutant levels due to specific episodes. More day-to-day information does not appear in these traditional media. One of the city representatives commented that it was difficult to get traditional media interested in covering air quality issues. There therefore appears to be space to enhance the presence of air quality issues in the media, although it may be very difficult to do so effectively.

Figure 2.3 Airparif page in Facebook, Paris

Source: © Airparif.

More innovative means of reaching the public are also underused. SMS alert systems for exceedances are in place in only two cities (Madrid and Vienna). Social media websites are only used by the city of Paris (which uses both Twitter and Facebook); even though some of the other cities have also shown an interest in using these websites. And only four of the cities (Madrid, Paris, Prague and Vienna) make use of smartphone applications. The smartphone air quality applications for these cities are all well established.

All cities participate in the exchange of up-to-date (UTD) data on the platforms operated by the EEA ([43]). City experts have expressed satisfaction on how comprehensive UTD maps were.

Data on air pollutant concentrations are frequently updated, in most cases on an hourly basis. Access to historical air quality data is also made available to the public. Data are presented as raw data, statistics, and in the form of indicators or indices. Indices are a simplified way of providing information on the state of air quality, as they provide a qualitative classification, together with a colour code, based on the concentrations of pollutants. Many of the indices used locally by cities to assess air quality are not comparable across countries. A common system would make information more comparable and more understandable at the European level. However, the adoption of a unique air quality index across EEA member countries has proven to be difficult, even though the EEA has well-developed indices for both UTD and historical data. Similar initiatives to encourage the adoption of a pan-European air quality index have been made elsewhere in Europe ([44]).

The use of models for information purposes could be further promoted. Forecasts of air pollutant concentrations are used in only six cities, and the EEA suggested that these forecasts could be a way of addressing health-related issues (for example,

([43]) The EEA's UTD exchange includes information for more than 1 500 stations, which cover more than 450 cities across Europe. This information is updated hourly. EEA platforms include both maps and reports of up-to-date air quality information as well as information on historical data (http://www.eea.europa.eu/themes/air/air-quality/map/airbase), which covers more than 5 000 stations. UTD air quality maps (http://www.eea.europa.eu/themes/air/air-quality/map/real-time-map) make use of well-established indices to illustrate homogeneous air quality information across Europe.

([44]) In the context of the Interreg project CITEAIR (Common Information To European Air) an EU air quality index was developed. CITEAIR continues to be operational, and the index is made available on a website (airqualitynow.eu) and updated every hour based on the participating cities' measurements (about 115 cities among which 4 of those participating in the Air Implementation Pilot).

forecasting episodes of high ozone levels) and of increasing public awareness of air pollution. Nevertheless, to engage citizens it is necessary to produce a mature, reliable, and credible forecasting system. The city experts also agreed that it is easier to raise awareness on air quality if suggestions are made to the public on how citizens can best respond to high levels of air pollutants.

Most of the cities also provide links to information on other environmental issues (such as climate change, noise, water, or waste), and information on other air quality issues apart from air pollutant concentrations (emissions, pollutant sources, effects of pollution, legislation, drafting and implementation of air quality plans, and short-term action plans). In addition, most of the cities' webpages provide links to the air quality activities of other institutions, such as national and regional governments, and European institutions.

In general, there is good interaction between city air quality authorities and other stakeholders, such as environmental NGOs, which in most cases form part of ad-hoc working groups or councils.

The public's opinion of the air quality information that is made available to it is often unknown, as most cities do not yet have any statistics on the effect this information has on the public. Nevertheless, according to the few studies available (Eurostat, 2011; EC, 2013), it appears that people increasingly consider air pollution and air quality to be important issues. The cities agreed that it was necessary to further increase public awareness of air quality, and to obtain more public feedback on air quality issues.

Challenges for improving information to the public

- The presence of air quality issues in the media could be enhanced by presenting in the media the results of the reports already produced by cities, and the results of reliable and credible forecasting systems to inform the public about current and expected pollutant concentration levels.

- The use of smartphone applications and social media websites appear to be one of the most cost-effective ways of reaching a large share of the population.

- The adoption of a common system of indicators, with comparable indices and colour codes would make information more comparable and more understandable at the European level.

- According to the latest Eurostat Eurobarometer survey on the 'Attitudes of Europeans towards air quality' (EC, 2013), people across Europe increasingly consider air pollution and air quality to be important issues, and are keen to be kept well-informed about them. It is therefore important to get the public's feedback on the information provided by cities so as to better serve their needs.

Box 2.4 Air quality webpages of the cities participating in the Air Implementation Pilot

Antwerp: http://www.antwerpen.be/eCache/ABE/82/10/708.Y29udGV4dD04MDMzOTAz.html.

See also the Flemish Environmental Agency webpage: http://www.vmm.be; and the Belgian Interregional Environment Agency (IRCEL) webpage: http://www.irceline.be.

Berlin: http://www.stadtentwicklung.berlin.de/umwelt/luftqualitaet/index.shtml.

See also the German Federal Environmental Agency webpage: http://www.env-it.de/umweltbundesamt/luftdaten/index.html.

Dublin: http://www.dublincity.ie/WaterWasteEnvironment/AirQualityMonitoringandNoiseControl/Pages/AirQualityandNoiseControl.aspx.

See also the Irish Environmental Protection Agency webpage: http://www.epa.ie/irelandsenvironment/air.

Madrid: http://www.mambiente.munimadrid.es/opencms/opencms/calaire/index.html.

Malmö: http://www.malmo.se/Medborgare/Miljo--hallbarhet/Miljolaget-i-Malmo/Luft.html.

Milan: the Lombardy Environmental Protection Agency webpage: http://ita.arpalombardia.it/ITA/qaria/Home.asp.

Paris: http://www.paris.fr/pratique/environnement/bruit-et-qualite-de-l-air/p136.

See also the Air Quality Monitoring Network (AirParif) webpage: http://www.airparif.asso.fr.

Ploiesti: the Ministry of Environment and Climate Change's Environment Protection Agency webpage: http://www.calitateaer.ro.

Plovdiv: http://www.plovdiv.bg/item/ecology/%d0%b2%d1%8a%d0%b7%d0%b4%d1%83%d1%85.

See also the Regional Inspectorate for Environment and Waters — Plovdiv (RIEW) webpage http://plovdiv.riosv.com/main.php?module=content&cnt_id=1; the Ministry of Environment and Waters (MEW) webpage: http://www3.moew.government.bg/; and the Environment Executive Agency (EEA) webpage http://www.eea.government.bg.

Prague: the Czech Hydrometeorological Institute webpage: http://portal.chmi.cz/portal/dt?action=content&provider=JSPTabContainer&menu=JSPTabContainer/P1_0_Home&nc=1&portal_lang=cs#PP_TabbedWeather.

Vienna: https://www.wien.gv.at/umwelt-klimaschutz/luft.

See also the Austrian Federal Environmental Agency webpage: http://www.umweltbundesamt.at/umweltsituation/luft.

Vilnius: http://www.aplinka.vilnius.lt/lt.

See also the Vilnius Public Health Office webpage: http://www.vvsb.lt; and the Environmental Protection Agency of Lithuania webpage: http://gamta.lt/cms/index.

3 Further steps in the implementation of European air-related legislation

3.1 The EEA's role

The EEA's support to the implementation of environmental legislation differs across environmental themes, such as air quality or waste management. The type of support it provides to European bodies and member countries reflects to a certain extent the stage of decision-making reached by policymakers on each issue. The EEA is proposing to its stakeholders that it will respond to the need for a better understanding of the implementation of environmental policy by further supporting this field of work throughout the period of its next multiannual work programme (2014–2018). In the specific area of EU air policies and legislation, the EEA plans to invest in the following actions:

a. **Data collection, processing, quality checking, review, and related capacity building with member countries**

   The Air Implementation Pilot has shown the importance of a strengthened knowledge base for the implementation of EU air policies. The EEA will therefore work further on improving data that can be used for a better understanding of the implementation of air policies, notably the Ambient Air Quality Directives (EC, 2004a; EC, 2008a), the National Emissions Ceiling (NEC) Directive (EC, 2001), the European Pollutant Release and Transfer Register (E-PRTR ([45])), and other source-based legislation. Part of these improvements will take place when new reporting provisions of the air quality directives (EC, 2011b) (1 January 2014) and the NEC Directive will be in force. The EEA will also implement further changes after 2014 to the new air quality e-reporting system.

   At international level, the EEA will work with its member countries on data reported under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP Convention ([46])) and cooperate with the European Monitoring and Evaluation Programme's (EMEP ([47])) Centre on Emission Inventories and Projections ([48]).

   The EEA will also provide support to its member countries to improve the quality and timeliness of their data submissions on air pollutant emissions and air quality. This support will include direct immediate feedback on quality aspects of their data, as well as capacity building in the form of workshops, dedicated training sessions, and in some instances, country visits.

b. **Information systems**

   The EEA will further streamline its information systems in order to support the implementation of EU air policies and legislation. Air pollutant emissions and ambient air quality information reported under international and EU legislation are made available and can be queried and downloaded at the European Air Pollution Data Centre ([49]). This information can also be viewed in the form of maps of air pollutant emissions and of air quality. The EEA will also work on improving web-based tools for accessing and analysing this data.

   Air pollutant and air quality indicators will further contribute to a better understanding of where the European Union stands in terms of implementing EU air policies and legislation. The EEA is in the process of developing country- and city-related air pollution

([45]) http://prtr.ec.europa.eu.
([46]) http://www.unece.org/env/lrtap.
([47]) http://www.emep.int.
([48]) http://www.ceip.at/unece-clrtap-emep-tfeip.
([49]) http://www.eea.europa.eu//themes/air/dc.

indicators. This activity will be continued and consolidated in order to support national and local discussions on better implementation of air legislation, and in order to contribute to the knowledge base in the field of air pollution.

c. Assessments

The EEA will annually assess Europe's air quality situation, evaluating whether EU air quality standards have been achieved at European and national levels. It will assess summer ozone levels (exceedances in summer) and examine whether EU air quality standards in the air quality zones and agglomerations of the EEA member countries have also been attained. The EEA also will inform on the official air pollutant emission data reported under the NEC Directive (EC, 2001) and the Gothenburg Protocol ([50]). As part of this work, the EEA will evaluate progress made in meeting the respective policy targets.

Integrated and targeted assessments of air pollution that address its impacts on human health and the environment, the effectiveness of air quality measures, and related co-benefits, are an essential element underpinning a better understanding of EU air policy and legislation. The EEA will deliver such assessments, taking into account the effects of European mitigation measures for air pollutants and greenhouse gas emissions, synergies and trade-offs between air pollutant emission and greenhouse gas emission reduction policies, and the subsequent effects of these policies on air quality and climate change.

d. Capacity building with expert communities

As the Air Implementation Pilot has shown, enabling experts to exchange their knowledge, for example on air quality models or emission inventories, will ultimately promote a better understanding of issues related to the implementation of air policies. Therefore, the EEA will continue work with expert communities in technical fora and expert networks, such as in Eionet ([51]), FAIRMODE (see Box 2.1) and the EMEP Task Force on Emission Inventories and Projections ([52]).

3.2 Potential for further action

The Air Implementation Pilot has demonstrated that there remains substantial potential for improving implementation at local and national level by among other things strengthening local air quality assessment capacity and management capacity, notably in relation to the workstreams identified during the pilot.

Some additional needs have arisen from the common work with the cities:

- A need to take stock of the momentum created by the pilot and create a stable communication forum among the cities and also among cities and other administrative levels (national, regional, European): some of the existing networks could be used, and participation of cities in these networks could be promoted.

- A need to make use of new, cost-effective technologies (for instance, webinars) to promote the exchange of experiences.

These challenges will be taken up by the European Commission in its ongoing air quality policy review, which will consider how EU action can best support local, regional and national authorities in addressing them. Options could include:

- financing of improved management and capacity-building through the forthcoming revision of the LIFE regulation;

- the development of a broader network of cooperation on the urban air quality challenge across the EU, with regular information exchange, capacity building and a common database of measures;

- promoting and enabling increased use of other EU funding opportunities, such as the structural funds, particularly to address local drivers of persistent non-compliance with EU air-related legislation.

One possibility that has been discussed is to package all the European measures related to urban air quality in a single programme, which would then be one of the accompanying documents to a revised Thematic Strategy on Air Pollution.

([50]) http://www.unece.org/env/lrtap/multi_h1.html.
([51]) http://www.eionet.europa.eu.
([52]) http://tfeip-secretariat.org.

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Annex 1 Air quality standards according to EU legislation (for health protection)

Pollutant	Concentration	Averaging period	Comments
Particulate matter (PM_{10})	50 µg/m³	One day	Limit value. In force since 1.1.2005 ([a]). Not to be exceeded on more than 35 days per year
	40 µg/m³	Calendar year	Limit value. In force since 1.1.2005 ([a])
Fine particles ($PM_{2.5}$)	25 µg/m³	Calendar year	Target value. In force since 1.1.2010 Limit value enters into force 1.1.2015
	20 µg/m³	Calendar year	Indicative limit value enters into force 1.1.2020 (to be confirmed)
	20 µg/m³	Averaged over 3 years	Exposure concentration obligation (the Average Exposure Indicator (AEI), a three-year average of concentration measurements in urban background locations) Must be achieved in 2015 (average of 2013, 2014 and 2015)
	A percentage reduction requirement (0, 10, 15, or 20 %) of the AEI in 2010	Averaged over 3 years	Exposure reduction target Must be achieved in 2020 (average of 2018, 2019 and 2020)
Ozone	120 µg/m³	Maximum daily 8-hour mean	Target value. In force since 1.1.2010. Not to be exceeded on more than 25 days averaged over 3 years (2010 to 2012)
Nitrogen dioxide (NO_2)	200 µg/m³	1 hour	Limit value. In force since 1.1.2010 ([a]). Not to be exceeded on more than 18 hours per year
	40 µg/m³	Calendar year	Limit value. In force since 1.1.2010 ([a])
Benzo(a) pyrene	1 ng/m³	Calendar year	Target value. In force since 31.12.2012
Sulphur dioxide (SO_2)	350 µg/m³	1 hour	Limit value. In force since 1.1.2005. Not to be exceeded on more than 24 hours per year
	125 µg/m³	One day	Limit value. In force since 1.1.2005. Not to be exceeded on more than 3 days per year
Lead (Pb)	0.5 µg/m³	Calendar year	Limit value. In force since 1.1.2005 ([b])
Carbon monoxide (CO)	10 mg/m³	Maximum daily 8 hour mean	Limit value. In force since 1.1.2005
Benzene	5 µg/m³	Calendar year	Limit value. In force since 1.1.2010 ([a])
Arsenic (As)	6 ng/m³	Calendar year	Target value. In force since 31.12.2012
Cadmium (Cd)	5 ng/m³	Calendar year	Target value. In force since 31.12.2012
Nickel (Ni)	20 ng/m³	Calendar year	Target value. In force since 31.12.2012

Note: (a) Under Directive 2008/50/EC Member States can apply to postpone the attainment deadline.

([b]) January 2010 in the immediate vicinity of the specific industrial sources situated on sites contaminated by decades of industrial activities.

Annex 2 Additional information on the cities participating in the Air Implementation Pilot

Climatic features

The cities participating in the Air Implementation Pilot range from those whose air quality (AQ) situation is negatively affected by their topography and geographical location, to those with no topographic feature affecting air quality, to those where topography and geographical location positively affects air quality. Madrid, Milan, Ploiesti, Plovdiv, Prague, and Vienna fall into the first category. All of these cities are affected by thermal inversion, a temporary phenomenon where temperature increases with altitude. This prevents a good mixture of air and the dispersion of pollutants. Berlin and Malmö are in the middle category, while Antwerp, Dublin, and Paris are in the last category:

- Thermal inversions are a feature of six of the cities participating in the pilot. They occur in autumn and winter in Madrid, Milan and Prague. In Ploiesti and Vienna, thermal inversions occur in winter. Plovdiv experiences thermal inversion even more frequently — on 81 % of the days of the year. The city is located 160 m above sea level on the banks of the Maritsa Rivera, and seven hills in the city favour the formation of a microclimate.

- Milan's air quality is particularly affected by its location in the middle of the Po Valley, where it is surrounded by the Pre-Alps, the Alps, and the Apennines. This position means that air does not circulate as much, reducing air flow and the dispersion of air pollutants. Ploiesti is located at the base of an amphitheatre and is surrounded by hills. It also suffers from a lack of air flow with average wind speeds below 1.5 m/s, which leads to an increase in measured concentrations of pollutants. Prague also suffers poor ventilation conditions due to the complicated morphology along the river Vltava and its tributaries. Finally, the old town of Vilnius is also affected by poor air-flow (and thus higher concentrations of pollutants) as it is surrounded by hills.

- Antwerp and Dublin are more positively affected by their geography. Their coastal locations ensure good ventilation by the western Atlantic air currents and the sea breeze, respectively. It should be noted that thermal inversions do occur in Dublin but severe cold spells are infrequent. Paris also benefits from its geographical position. It is located in the basin of the Seine River, with good dispersion conditions due to the flat terrain (mostly < 150 m high). Finally, in Malmö, air quality is favoured by its coastal position and flat surroundings.

Cities in Central Europe (Berlin, Prague, Vienna, and Vilnius) are characterised by cold winters and mild summers, cloudy skies (which cover these cities on average two thirds of the time), and rain on average every second day. Paris has an average annual temperature of between 12 and 13 °C and one day in three is rainy. Ploiesti county's climate is classed as temperate continental, with a cloudy winter. Plovdiv also has a moderate continental climate, with roughly equal amounts of rainfall in each season (a particular climatic feature of the area is the lengthy periods with no rainfall), and a relatively large number of days with fog. By way of contrast, Madrid has a continental Mediterranean climate, with dry and hot summers, and mild and rainier winters. Milan has mild winters, hot summers and rain throughout the year, and is noted for its low-speed wind. Coastal cities (Antwerp, Dublin, and Malmö) have a mild coastal climate with mild winters and summers. In Dublin, it rains on average every third day.

The prevailing winds in Berlin are westerly and south-westerly, while in Malmö they are westerly and southerly, and in Paris they are south-westerly. Ploiesti is predominantly affected by north-easterly winds (40 % of the time) and south-easterly winds (23 % of the time), with an average speed of 2.8 m/s. In Plovdiv, westerly and easterly winds prevail, although at insignificant speeds. In Vilnius south-easterly winds prevail.

Map A2.1 City limits considered in the Air Implementation Pilot of Antwerp, Berlin, Dublin and Madrid and air quality zones (for PM_{10}, 2010) in which they are included

Antwerp city and Belgian air quality zones (PM_{10})

- Antwerp city
- Antwerp Urban Audit city
- Belgian air quality zones
- Protection zones

Berlin city and German air quality zones (PM_{10})

- Berlin city and air quality zone
- German air quality zones

Dublin city and Irish air quality zones (PM_{10})

- Dublin city
- Irish air quality zones

Madrid city and Spanish air quality zones (PM_{10})

- Madrid city and air quality zone
- Spanish air quality zones

Map A2.2 City limits considered in the Air Implementation Pilot of Malmö, Milan, Paris and Ploiesti and air quality zones (for PM_{10}, 2010) in which they are included. The city of Milan corresponds to the new 2011 AQ zone IT0306

Malmö city and Swedish air quality zones (PM_{10})

Malmö city

Swedish air quality zones

Milan city and Italian air quality zones (PM_{10})

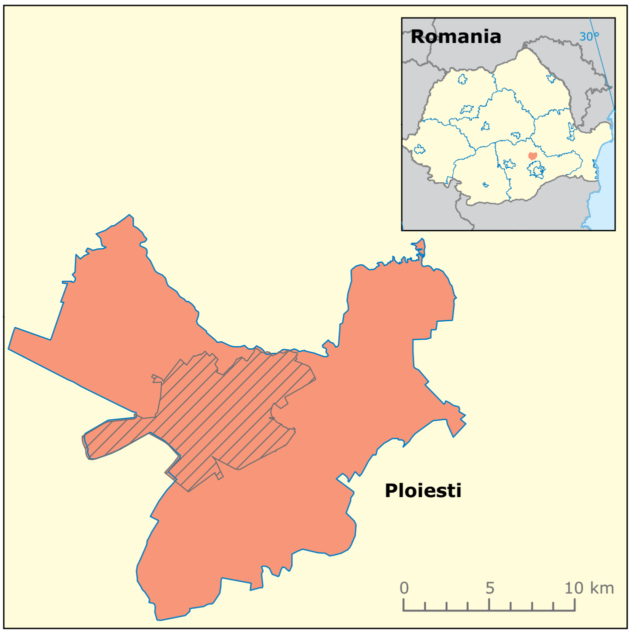
Milan city

Italian air quality zones

Paris city and French air quality zones (PM_{10})

Paris city

French air quality zones



Ploiesti city and Romanian air quality zones (PM_{10})

Ploiesti city

Ploiesti Urban Audit city

Romanian air quality zones

Map A2.3 City limits considered in the Air Implementation Pilot of Plovdiv, Prague, Vienna and Vilnius and air quality zones (for PM_{10}, 2010) in which they are included

Plovdiv city and Bulgarian air quality zones (PM_{10})

Plovdiv city

Bulgarian air quality zones

Prague city and Czech Republic air quality zones (PM_{10})

Prague city and air quality zone

Czech Republic air quality zones

Vilnius city and Lithuanian air quality zones (PM_{10})

Vilnius city and air quality zone

Lithuanian air quality zones

Vienna city and Austrian air quality zones (PM_{10})

Vienna city and air quality zone

Austrian air quality zones

View of Antwerp

Photo: © Municipality of Antwerp

Demographic and urban features

The age distribution in the cities is similar, with a great share of young inhabitants (25 to 40 years old). When grouped according to the difference in percentage between the youngest (< 15 years) and the oldest groups (> 64 years), there are three classes of cities:

1. those where the youngest group is larger than the oldest: Antwerp (although here, the cut-offs for the age groups were < 20 years and > 69 years), Dublin, and Paris (here, the cut off for the youngest group was < 20 years);

2. those where both groups are roughly same equal in size: Berlin, Malmö and Vilnius;

3. those where the oldest group is larger than the youngest: Plovdiv and Vienna (where the difference is small); and Madrid, Ploiesti (where the oldest group is > 60, Prahova County data) and Prague. This group also includes Milan, which has the biggest difference between the size of the youngest group and the size of the oldest group (there are almost twice as many people in the oldest group than the youngest group in Milan).

The urban characteristics of the participant cities are as follows:

- Antwerp consists of the urban agglomeration (without the surrounding protected communities of Borsbeek, Edegem, Mortsel, Schoten, Wijnegem and Wommelgem), the port area, and the district of Hoboken. Approximately half of the area is occupied by the port. The most compact neighbourhoods are located in the city centre (where there is an average of 41.5 households per hectare), with the suburban areas (residential neighbourhoods) being less densely populated.

- Berlin is a non-compact city, with lots of green areas, a highly populated centre, and lower-density residential neighbourhoods further removed from the centre.

- Dublin City is a low-rise, widely-spread city, with relatively low population density. The northern, southern and western suburbs are dominated by low-rise (typically two-floor) houses. The population is relatively young, with approximately half of them below 34 years.

- Madrid is a compact city surrounded by residential neighbourhoods, although it contains a large green area of Mediterranean forest in the northwest of the city known as El Pardo. The average age of the population is 42.5 years. It has the second-largest number of persons per household in the participating cities group (2.73, see Table A2.1).

- Malmö has a compact downtown, where 82 % of all households are apartments and the remaining 18 % are single-family houses. About 75 % of all households are occupied by one or two occupants. People over 65 make up 17 % of the city's population. The city is growing fast, and in the last 25 years its population has increased by around 40 %.

- Milan has a compact downtown and residential neighbourhoods. Its inhabitants are relatively old, with almost one quarter of its population more than 65 years old. Milan has the lowest average number of persons per household, at 1.09, though this increases to 2.35 per household in the larger urban zone.

- The city of Paris is a compact and very densely populated city. 61 % of the population is under 44 years old, including many students.

- Ploiesti has a compact downtown with 19 residential neighbourhoods and a small share of green areas. Though its population density is one of the lowest of the participating cities (3 952 inhabitants/km^2), it has the largest number of persons per household: three. No population data were provided for the city of Ploiesti, but in Prahova County people older than 60 years make up 20 % of the population.

- The city of Plovdiv is the only settlement within the limits of the broader municipality of Plovdiv. The city has a compact centre, which is the most densely populated in relation to the other areas in the municipality, and has the lowest average number of people per household of any area in the municipality.

- Prague is a particularly green city, with more than half of the city's surface occupied by green areas. It is the city with the second-lowest population density of the participating cities (2 534). The average age of the population of Prague is 41.6 years. The downtown inner city accounts for approximately 5 % of city's total surface area.

- Vienna has a compact downtown and residential neighbourhoods with a low population density.

- Vilnius has the smallest population density of any city in the pilot (1 335 inhabitants/km^2). It consists of a compact downtown surrounded by residential neighbourhoods.

The administrative organisation of air quality issues in the cities participating in the Air Implementation Pilot

Five cities (Berlin, Madrid, Malmö, Prague and Vienna) undertake at local level the actions related to air quality assessment and management (compilation of local emission inventories, modelling activities, monitoring of air quality, air quality plans, and information to the public). Other aspects of air quality organisation in these cities include the following:

- In Berlin, the national authority also compiles emissions inventories and there are also modelling activities at regional level. Local reports are also submitted to the national authority.

- Reporting and information to the public are also undertaken by regional and national authorities in Madrid, and at national level in Vienna.

- In Malmö, monitoring and reporting obligations regarding ozone are performed on a national level. And short-term action plans for air quality are issued at regional level.

- All the actions, except the establishment of air quality plans and monitoring of their implementation, are also undertaken at national level in Czech Republic (Prague). A part of the air quality monitoring network is financed by the local administration of the City of Prague.

For the other seven cities, the following comments can be made regarding the division of responsibilities between local level, regional level, and national level:

- In Antwerp, all air quality activities are undertaken at the regional level by the Flemish Environment Agency (VMM), or, in the case of action plans and reporting, by the Flemish

Table A2.1 Land use and population facts on the cities participating in the Air Implementation Pilot

City name	Green areas	Residential area	Industrial area	Roads	Population density (inhab./km²)	Persons/ household
Antwerp (a)						2.08
Berlin	41 %	24 %	5 %	15 %/ 5 413 km	12 500 (in inner circle)	1.7
Dublin	-	-	-	-/1200 km	4 525	2.59
Madrid (b)	48.69 %	20.68 %	2.5 %	12.6 %/ 2 944 km	5 361 (9 058 excluding the large green area of El Pardo)	2.73
Malmö	Not available					2.05
Milan (c)	11 %	47 %	22 %	5 %/903 km roads + 242 km highways	7 272	1.09
Paris	28.6 %	71.4 %	0 %	- / 1 600 km (36 of which are highways)	22 000–37 000	1.9
Ploiesti	-	-	-	-	3 952	3
Plovdiv (d)	49 %	12.7 %	10.7 %	10 %	3 350	2.4
Prague	55 %	28 %	7 %	- / 3 966 km	2 534	2.27
Vienna	50.2 % (including 4.6 % of water)	24.8 %	3.8 %	14.4 %/ 2 851 km	4 173	2.02
Vilnius (e)	43.8 % (including 1.8 % of water)	27.2 %	7 % (including commercial)	7.8 % (infrastructure)	1 335	2–3

Note: (a) Living area: 132.12 km² (green space: 51.38 km²; recreational space: 16.65 km²; streams, ditches, moats: 1.01 km²; houses and roads: 63.08 km²). Port area: 130.57 km² (harbour infrastructure such as docks, locks, canals: 20.11 km²; Scheldt river: 23.30 km²; streams, ditches, moats: 2.62 km²; industrial infrastructure such as buildings, roads, industrial constructions etc.: 38.51 km²).

(b) Other accounts for 16 %, including the airport (5 %).

(c) Surface data for the AQZ; other (sports facilities; railways and related areas; cemeteries; airports, heliports and ports; hospitals; campsites; archaeological areas; construction sites; and areas in transition) accounts for 15 % of the surface. Population density data for the city (density of the AQZ = 3 141).

(d) Green areas include 41 km² of agricultural land, 1 km² of forest, 4 km² of water and 4 km² of green landscape; Other (special purpose and technical infrastructure) accounts for 17.6 % of surface.

(e) Other accounts for 11.8 % of surface, and Societal accounts for 2 % of surface.

Environment Administration. Apart from that, the Antwerp Port Authority (APA) supplies information for some specific emission sources. It also delivers air quality maps as a result of its modelling activity, exploits some supplementary measuring points for PM, and provides information to the public on an ad hoc basis. The municipal environment unit also delivers air quality maps from its modelling activities, cooperates in the implementation of action plans, and informs the public on local air quality. Finally, the Belgian Interregional Environment Agency (IRCEL) produces national air quality maps from its modelling, informs the public in cases of high-pollution episodes, and reports assessment results to the European Commission.

- Dublin does not compile local emissions inventories or carry out modelling activities. Its monitoring and public information activities are undertaken at national and local levels; the establishment of plans are undertaken at regional level; and its reporting obligations are undertaken at national level.

- In Milan, all air quality activities are undertaken at the regional level. Local authorities also contribute to the implementation of air quality plans — with the adoption of specific measures — and to informing the public.

- In Paris, all air quality activities are undertaken at the regional level (emission inventories, modelling activities, assessment of air quality plans, and information to the public) by an independent NGO (Airparif) entrusted with the task by the French ministry of environment. Local authorities are in charge of setting up air quality plans, mitigation actions, and public information. Most of them are part of Airparif's administrative board, which also contains NGOs, industries and the national government.

- In Ploiesti, all activities are undertaken at local level, except the compilation of local emission inventories and modelling activities, responsibility for which is at national level.

- In Plovdiv, assessment (including modelling) and management activities are performed at local level, whereas AQ monitoring, calculation of emissions, reporting, and informing the public are performed at national level.

- Vilnius undertakes at local level all the activities except for monitoring, which is performed at national level.

Economic activities and their influence in air quality

The principal economic activities in the cities participating in the Air Implementation Pilot

The services sector is the most important economic sector in all of the participating cities, except Antwerp and Ploiesti. Regarding the services sector in the cities, the following features can be highlighted:

- Berlin has lots of small- and medium-sized businesses.

- Dublin attracts investments in financial services; ICT and electronics; professional services; and the creative industries. It also has a very strong track record in attracting investment in research & development (R&D) projects across different sectors.

- In Malmö, 15 % of workplaces are in wholesaling, retail, or food service; 15 % are in business services; 14 % are in health care and social services; and 9 % are in education.

- Paris has an important finance sector.

- Plovdiv has several important service industries: retail, transport, communications, tourism, education, healthcare, administration, culture, and sport, etc.

- In Prague, the services sector represents 82 % of GDP. The main subsectors are wholesaling and retail (13 %), finance (12 %), IT (10 %), science and technology (9 %), and public administration (8 %). Prague also has an important transport sector (it is also at the intersection of important transportation routes).

Winetavern Street monitoring station in Dublin

Photo: © Air Quality Monitoring Unit, Dublin City Council

- In Vienna, the main economic sectors are wholesaling, retail and financial services (especially insurance services).

Antwerp's most important economic sector is its port. It is focused mainly on the handling of containers, as well as liquid and dry bulk. The Antwerp Port area is the largest petrochemical cluster in Europe, and the second-largest such cluster in the world, after Houston in the USA.

For Ploiesti, the industrial sector is the most important, and the following industries are most significant: oil (with important activities in refining; production equipment; drilling; chemicals and petrochemicals; pump and pipeline construction; research and design in the oil sector; and technological equipment), wood processing, chemicals, textiles, ceramics, and food. While Ploiesti is the most reliant on industry of the participating cities, some of the other cities still retain an important industrial sector. They include:

- Berlin, where construction is important;
- Dublin, which still has brewing and bottling installations;
- Malmö, where 8 % of workplaces are in the manufacturing industry, though there is no single industrial sector that predominates;
- Milan, with a significant manufacturing and construction sector;
- Plovdiv, which has a small industrial sector that is estimated to account for less than 3 % of pollutant emissions. The following sectors are important for Plovdiv's industry: production of electric power and heat; glass containers; food products (meat, dairy, cereal, fruit and vegetable); beverages (including beer); confectionery and tobacco; textiles, knitwear and clothing; machinery, electrical equipment and electronic products; leather products and footwear; perfumery and cosmetics; paper and printing products; tiles and concrete products; and construction and construction materials;
- Prague has an important energy sector (representing 5 % of GDP);
- Vienna, which has an industrial sector focused mainly in manufacturing, energy supply, transportation, and storage;
- Vilnius, where furniture and paper production are important industries.

In some cities, such as Dublin, Madrid, Paris, Plovdiv, Prague and Vienna, tourism is also a relevant sector. For instance, Dublin is the 6th most popular city region in Europe for city breaks, and it received more than 4.3 million overseas visitors in 2008.

Also, in the case of capital cities, it must be remembered that they host the headquarters of national administrations with the associated economic activity this generates.

Main sources of pollution in the cities participating in the Air Implementation Pilot

In spite of these diverse activities, all cities consider traffic to be the main pollutant source for NO_2, PM_{10} and O_3 precursors.

Residential sources are also highlighted as being important for NO_2, PM_{10}, and VOC emissions in cities like Antwerp, Dublin, Madrid, Milan, Ploiesti, Plovdiv, Vienna and Vilnius.

Industrial activities are important sources of air pollution for Antwerp (where the main pollutants emitted are NO_2, fine particles from incineration processes, PM from port activities such as dry bulk handling, and VOCs from chemical production processes); Milan (with emissions of O_3 precursors from solvent use); Ploiesti (where the main sources of pollution are electricity production and heat production, as well as VOCs from oil-processing activities, which also cause an odour problem); and Vienna.

Malmö is close to the Öresund, with considerable sea traffic. Here also, public transport is one of the major sources in places where exceedances in air pollutant concentrations occur.

In Milan, agriculture is an important source of NH_3 emissions.

In Vienna, construction sites are also important sources of air pollutant emissions.

Initial perception of the state of air quality in the cities participating in the Air Implementation Pilot

Cities were asked in the questionnaire to identify their air quality state; the main challenges they face in terms of the air quality state; the possible solutions to air quality problems; and which measures/policies they have been found to be most and least successful when addressing air quality issues. Also, in their presentations at the kick-off meeting, the first eight cities reported what they considered to be the policies or measures that were most needed at the different levels, from local to international. This initial exchange revealed a broad range of experience in air quality management in different geographical conditions, but there was considerable agreement between the representatives about what the main challenges were.

What pollutants are present in the air?

Air quality has improved in all cities, but it also remains a concern for all cities. The main concerns are NO_2, and PM_{10} (and sometimes $PM_{2.5}$, as in the case of Plovdiv).

NO_2 is a problem even in cities with few or no exceedances of the legal limits. These include Dublin, with only one exceedance of nitrogen dioxide levels in 2009; and Malmö, where air quality is acceptable, apart from a few problematic streets. Other cities have more serious NO_2 problems. In Madrid for instance, the number of stations with exceedances of the hourly limit value for NO_2 has increased from 6 in 2010 to 9 in 2011, due to the greater number of days of unfavourable weather in 2011 compared to 2010. Paris reports between 3 and 4 million citizens exposed to pollutant levels above the EU limit values for PM_{10} and NO_2 in the region Île-de-France. In Prague, exceedances of NO_2 limits are registered in the city centre, along road transport corridors. And in Berlin, where local contribution to PM_{10} levels shrunk, PM_{10} is still a problem in years with adverse weather.

Ozone (O_3) poses a problem in some cities, where there have been exceedances of the target value. These cities include Madrid, Milan, Paris, Prague and Vienna. For instance, in Madrid the annual target value (2010–2011) has been exceeded in three suburban stations and one (out of eight) background stations. Prague reported that O_3 exceedances are typically due to emissions of ozone precursors (such as NO_X, CO (traffic), anthropogenic VOCs ('fugitive' emissions), and biogenic VOCs (e.g isoprene)) from different sources. These sources include biogenic sources (VOCs, 10 %), traffic (40 %), industry (30 %), and trans-boundary transport (20 %). However, Prague cautioned that there is still insufficient knowledge on O_3 formation.

Finally, in Plovdiv and in Prague there are some exceedances of the benzo(a)pyrene (B(a)P) annual target value; while Paris experiences exceedances of the benzene limit value on some very busy roads and crossroads.

What is causing the air pollution?

According to the cities participating in the Air Implementation Pilot, the main reasons for the current air quality situation are:

- **Traffic**, which contributes to PM and NO_2 levels. Several cities highlight diesel vehicles as the main cause of their elevated NO_2 levels. Antwerp is located in north-western Europe, where the air quality on average is poorer than in most other parts of the continent. This region is densely populated, and there are intensive industrial and port activities, which attract a lot of traffic. The city of Antwerp also reported high concentrations of elementary carbon (EC), especially in street 'canyons'. Berlin blamed its NO_2 problem on EU vehicle emission control policy, because Euro 3–5/III–V has not generated much progress in reducing NO_2 under urban driving conditions, and the share of NO_2 originating in diesel exhaust emissions has gone up (because there are more diesel cars on the roads than before, diesel cars emit greater amounts of NO_2 than conventional petrol cars, new diesel vehicles emit more NO_2 in real driving conditions than old diesel cars and sources other than motor traffic are almost negligible). Better vehicle technology (such as the Euro 6 standards) can help, but according to the cities' experts, it is being introduced too late to meet NO_2 targets by 2015. Madrid reported a similar problem, having experienced a larger reduction of NO_X emissions than of NO_2 emissions, due to the diesel effect (63 % of cars are diesel cars. These diesel cars emit 98% of NO_2). Paris highlighted how a carbon tax at purchase and a fuel tax (diesel cars use less fuel than conventional petrol cars) favoured a growth in the diesel fleet, and thus unwittingly encouraged higher NO_2 emissions. Vienna also pointed out the high share of diesel vehicles, while Prague reported PM 're-suspension' from road traffic as an additional source of air pollution.

- **Long-range transboundary transport of pollutants originally emitted outside the urban area**, which contributed to PM in some areas. Antwerp reported that up to 80 % of PM levels were due to background concentrations in the port area. Berlin reported that this PM long-range transport will become more and more important. It will be difficult to reduce further the city's contribution to the total PM amount of pollution for three main reasons: firstly, non-exhaust emission by traffic can hardly be controlled by technical measures; secondly, stationary sources have already been abated; and thirdly, biomass burning mostly occurs outside the agglomeration (including other countries such as Poland), which is out of their control. Malmö highlighted the need to keep track of $PM_{2.5}$ levels due to transboundary transport. And finally, Vienna also reported exceedances at background sites due to long-range transport of pollutants.

In Plovdiv, long-range transport also poses a challenge in the levels of NO_2 and $PM_{2.5}$ as — according to source apportionment studies in the city — background concentrations account for up to 66 % of NO_2 levels in the background station, 56 % in the traffic station, and nearly 40 % of $PM_{2.5}$ in the urban background station.

- **Residential heating**, which contributed to PM, NO_X and some other pollutants, such as soot or B(a)P. In Berlin, the use of biomass as a fuel for home heating results in higher soot emissions. In Milan, wood and biomass combustion is a widespread habit and poses a potential problem, which was dealt with by means of improvements to the city's emission inventory and source apportionment studies. In Milan's case, a Regional Decree was also important in preventing the use of old technologies for wood combustion. Paris and Ploiesti also mentioned the problem of pollution from residential heating, although in a generic way. In Plovdiv, domestic heating affects mainly PM_{10}, $PM_{2.5}$ and B(a)P levels, due to the use of solid fuels. Finally, Prague mentioned the local combustion of natural gas and solid fuels as the source of between 5 % and 50 % of the NO_X concentrations in the city.

- **Growing cities**: Malmö pointed out an increase in emissions within the city due to growing population numbers and growing population density. And Vienna, also a growing city, also mentioned urban sprawl as the cause of an increase in emissions.

- **Agriculture**, which is a source of NH_3 in Milan.

- **Industry**, which is a source of air pollution (mainly in the form of NO_2) in the cases of Antwerp and Ploiesti. The port of Antwerp is an area with a high density of industry and related traffic, which is adjacent to a city that has a high population and also has high traffic density. Both areas emit high quantities of NO_X, which results in elevated concentrations that sometimes exceed the EU air quality standards for NO_2. In Ploiesti, industry also causes an odour problem, even though the city is in compliance with all air quality objectives. Ploiesti also pointed out the difficulties it had in elaborating its emission inventory because of 'fugitive' emissions (those emissions that do not come from exhausts and are thus hard to measure; examples include paint vapour, chemical leaks, and dust from quarries). Vienna also reported exceedances of NO_2 at industrial sites.

- **Weather**: especially adverse thermal inversion situations (see beginning of this annex).

Challenges for air quality improvement

The main challenges for improving air quality that were highlighted by the cities are listed below. This is a non-exhaustive list of the challenges cities reported in dealing with their current air quality situation:

- Transboundary pollution and the high amount of traffic on the ring road running around the edge of the city (Antwerp city).

- The large share of background concentrations, the large influence of meteorological conditions on changes in PM_{10} levels, and the high density of NO_X emitters, all of which obliges the area to take more stringent measures than those needed in less industrialised areas (Port of Antwerp).

- The need to act against transboundary pollution (Berlin).

- The economic downturn, which has resulted in a number of major strategic transport projects being postponed. This forces the city to manage even more with even less and means the city has to struggle to retain political commitment when there are other pressing needs (Dublin).

- To strengthen cooperation between local and regional authorities (Dublin).

- To ensure that energy, transport, and air quality policies are truly integrated with each other and with climate policies (Dublin, Milan).
- To learn from past mistakes (Dublin).
- To reduce private transport, and promote both public transport and electric-powered transport (Madrid).
- To reduce the levels of NO_2 and to control the levels of tropospheric ozone and particles (Madrid).
- To minimise individual motorised travel and implement measures to restrict car use in the inner city (Malmö).
- To encourage the use of more sustainable modes of transport. To provide more space to sustainable modes of transport at the expense of existing space for car traffic (Malmö).
- To improve the environmental performance of vehicles by means of stricter emission standards on light and heavy vehicles (Malmö).
- To secure high-level scientific support (Milan).
- To foster cooperation and harmonisation between the EU and other political levels in order to develop better strategies and technologies (Milan).
- The lack of authority to adopt measures at a larger scale than just the city (Paris).
- The need for a regulatory framework and specific actions to address odour pollution (Ploiesti).
- The scarcity of financial (Milan, Ploiesti, Vienna) and human (Ploiesti) resources to implement certain measures.
- The limited influence of local actions on reducing emissions from household residential heating (Plovdiv).
- How to take into account the adverse weather conditions that prevent dispersion of pollutants (Plovdiv).
- Local area sources, which contribute to between 5 % and 50 % of local NO_X concentrations (Prague).
- The need to raise citizen awareness of air quality issues (Vienna).
- The promotion of public transport; heat generation plants; and encouraging the shift to cleaner fuels for residential heating (Vilnius).

What new policies are needed?

At **local level**, the cities participating in the Air Implementation Pilot focused on their most immediate problems, and there was a great diversity in the types of policies that the cities said they needed. Ploiesti highlighted the need for methods to identify and quantify odour and to create a legislative framework for limiting emissions of substances that create odour. Ploiesti also called for the rehabilitation and modernisation of urban infrastructure and an extension of green areas. Malmö said it would be necessary to minimise motorised individual travel, alter the distribution of traffic in the inner city, and improve the environmental performance of vehicles (see point above). And Prague would like to see a shift in parking policy and a policy to restrict access by private vehicles to the city centre.

At **regional level**, Milan thought there was a need for a Programme at the level of the whole Po Valley basin for improving air quality. It said that local actions on their own were not very efficient. Plovdiv also pointed out the need for regional programmes, to create synergies with neighbouring municipalities. Vienna also pointed to the need for regional-level policies to reduce commuter traffic by car.

In terms of what the cities participating in the Air Implementation Pilot suggested for **national level** policies, the reflections of local problems can again be seen. Some of the required measures are: restrictions on (or stricter emission standards for) solid fuels used in domestic heating and the promotion and use of renewable energy sources; additional financial support; and the enhancement of the coherence between climate and air quality policies (e.g. residential biomass and renewables) and coherence in both development and transport policies.

At **European Union level**, several cities identified a similar need for emissions standards, especially regarding vehicle emissions. Thus, Malmö asked for a more effective regulation of vehicle emissions; and Prague called for more stringent Euro standards. Milan suggested that sectoral vehicle emission standards (e.g. the Euro VI standards) should be introduced as soon as possible, and that the timescales should be linked to dates when limit values have to be met. Milan also said that action was needed to introduce standards to control all relevant emissions (e.g. residential biomass combustion in fireplaces and stoves; emissions from off-road vehicles; emissions of PM from tyres and brakes). In addition, Malmö and Milan asked for European-level financial support for local and regional action on air quality; Plovdiv called for European-level funding for the replacement of fuels; Prague called for European legislation on low-emission zones; and Vienna appealed for a greater use of transnational communication and European policies based on 'quality of life'.

At **international level**, Milan also thought it was necessary to improve coordination between air quality policies and climate policies (by providing incentives and subsidies to biomass and renewables). Prague asked for improved cooperation between regions in different countries; and Vienna pointed out the need to reduce emissions in neighbouring countries, and emissions from international aviation and shipping.

Annex 3 Glossary

Air pollutants

As	Arsenic
B(a)P	Benzo(a)pyrene
BaA	Benz(a)anthracene
BahA	benzo(a,h)anthracene
BbF	Benzo(b)fluoranthene
BC	Black carbon
benzene	Benzene
BghiPe	Benzo(g,h,i)perylene
BjF	Benzo(j)fluoranthene
BkF	Benzo(k)fluoranthene
Cd	Cadmium
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
DIOX	Dioxine
FluorA	Fluoranthene
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HCl	Hydrochloric acid
HF	Hydrogen fluoride
HFCs	Hydrofluorocarbons
Hg	Mercury
Indpy	Indeno(1,2,3-cd)pyrene
Mn	Manganese
N_2O	Nitrous oxide
NH_3	Ammonia
Ni	Nickel
NMVOC	Non-methane VOC
NO_2	Nitrogen dioxide
NO_X	Nitrogen oxides
PAHs	Polycyclic aromatic hydrocarbons
Pb	Lead
PCB	Polychlorinated biphenyl
PCDD_F	Polychlorinated dibenzo-p-dioxins and Polychlorinated dibenzofurans
PCE	Perchloroethylene
PCP	Pentachlorophenol
PFCs	Perfluorinated compounds
PM_1	Particulate matter < 1 µm
$PM_{2.5}$	Particulate matter < 2.5 µm
PM_{10}	Particulate matter < 10 µm
POPs	Persistent organic pollutants
Se	Selenium
SF_6	Sulphur hexafluoride
SO_2	Sulphur dioxide
TCB	Trichlorobenzene
TCE	Trichloroethylene
TCM	Trichloromethane
TSP	Total suspended particles
V	Vanadium
VOC	Volatile organic compounds
Zn	Zinc

Annex 4 Information on modelling activities

At EU level, the following guidance on modelling is available.

- Guidance documents were developed in the framework of the EU project Air4EU (http://www.air4eu.nl/reports_products.html).

- Documents under FAIRMODE (http://fairmode.ew.eea.europa.eu/)
  - The application of models under the European Union's Air Quality Directive: A technical reference guide, (EEA, 2011) (http://www.eea.europa.eu/publications/fairmode).
  - Guide on modelling Nitrogen Dioxide (NO_2) for air quality assessment and planning relevant to the European Air Quality Directive (ETC/ACM, 2011) (http://acm.eionet.europa.eu/reports/docs/ETCACM_TP_2011_15_FAIRMODE_guide_modelling_NO2.pdf).

- The Model Documentation System (MDS) http://acm.eionet.europa.eu/databases/MDS/index_html, with descriptions about air quality models and the purposes for which they can be used.

At national level, there is also guidance available. Some examples:

- The Norwegian Air Quality modelling website MODluft (http://www.luftkvalitet.info/ModLUFT/ModLUFT.aspx) contains information about how to apply models to management activities. This information is only available in Norwegian.

- The Iberian Website for the Modelling of Air Pollution (*Web Ibérica sobre modelización de la contaminación atmosférica*, http://mca-retemca.ciemat.es/MCAportal/), provides descriptions of models and examples of their applications. This information is only available in Spanish.

Annex 5 Density of monitoring networks

In the tables below can be found the classification with respect to assessment threshold of the air quality zones where the cities participating in the Air Implementation Pilot are located. The tables show the relevant assessment thresholds (Table A5.1) and the required minimum number of stations when assessment is based only on fixed measurements (Table A5.2). More information is available in Section 2.3.

Table A5.1 Classification of the selected AQ zones with respect to assessment thresholds; information extracted from the AQ Questionnaire (2011 data, except RO0302, 2010 data)

City	AQ zone	Pollutant ([a])										
		SO_2	NO_2	PM_{10}	$PM_{2.5}$	CO	Lead	C_6H_6	As	Cd	Ni	B(a)P
	BEF01S	< LAT	> UAT	> UAT	> UAT	-	-	-	-	-	-	-
Antwerp	BEF02A	< LAT	> UAT	> UAT	> UAT	< LAT	-	< LAT	-	-	-	L-UAT
	BEF07S	-	-	-	-	-	L-UAT	-	> UAT	> UAT	< LAT	-
Berlin	DEZBXX 0001A	*< LAT*	*> UAT*	*> UAT*	*> UAT*	*< LAT*	*< LAT*	*L-UAT*	*< LAT*	*< LAT*	*< LAT*	*> UAT*
Dublin	IE0001	< LAT	> UAT	> UAT	< LAT	< LAT	< LAT	< LAT	L-UAT	< LAT	< LAT	< LAT
Madrid	ES1301	< LAT	> UAT	> UAT	L-UAT	< LAT	< LAT	< LAT	< LAT	< LAT	< LAT	< LAT
Malmö	SW6	< LAT	> UAT	> UAT	> UAT	< LAT	< LAT	L-UAT	< LAT	< LAT	< LAT	< LAT
Milan	IT0306	< LAT	> UAT	> UAT	> UAT	< LAT	< LAT	L-UAT	< LAT	< LAT	< LAT	> UAT
Paris	FR04A01	< LAT	> UAT	> UAT	> UAT	< LAT	< LAT	> UAT	< LAT	< LAT	< LAT	< LAT
Ploiesti	RO0302	< LAT	> UAT	> UAT	*?*	< LAT	< LAT	> UAT	< LAT	< LAT	< LAT	*?*
Plovdiv	BG0002	> UAT	> UAT	> UAT	> UAT	L-UAT	< LAT	< LAT	-	> UAT	-	> UAT
Prague	CZ010	< LAT	> UAT	> UAT	> UAT	< LAT	< LAT	< LAT	> UAT	< LAT	< LAT	> UAT
Vienna	AT_09	< LAT	> UAT	> UAT	> UAT	< LAT	< LAT	< LAT	< LAT	< LAT	< LAT	> UAT
Vilnius	LT0100	< LAT	L-UAT	> UAT	L-UAT	< LAT	< LAT	< LAT	< LAT	< LAT	< LAT	> UAT

Note: ([a]) Information given in italics has been estimated from AirBase data.
'?' indicates that insufficient information is available to estimate the classification of zones with respect to assessment thresholds.
< LAT: below the lower assessment threshold;
L-UAT: between the upper and lower assessment thresholds;
> UAT: above the upper assessment threshold.

Ozone is not considered in the table because the assessment criteria for this pollutant are calculated differently.

'-' means the zone is not defined to assess that pollutant.

Table A5.2 Required minimum number of stations when assessment is based on fixed measurements only (i.e. not using modelling)

City	Population ([a])	Pollutant										
		SO_2	NO_2	O_3	PM	CO	Lead	C_6H_6	As	Cd	Ni	B(a)P
Antwerp (BEF01S)	69 982	-	1		2							
Antwerp (BEF02A)	599 159	-	2	2	3	-		-				1
Antwerp (BEF07S)	25 130						1		1	1	-	
Berlin	3 442 675	-	7	5	10	-	-	3	-	-	-	3
Dublin	1 270 603	-	4	3	6	-	-	-	1	-	-	-
Madrid	3 237 937	-	7	5	10	-	-	-	-	-	-	-
Malmö	503 273	-	2	2	3	-	-	1	-	-	-	-
Milan	3 593 025	-	7	5	10	-	-	3	-	-	-	3
Paris	10 400 000	-	10	8	15	-	-	10	-	-	-	-
Ploiesti	271 972	-	2	1	3	-	-	2	-	-	-	?
Plovdiv	446 274	2	2	1	3	1	-	-		1		1
Prague	1 257 158	-	4	3	6	-	-	-	2	-	-	2
Vienna	1 731 444	-	5	3	7	-	-	-	-	-	-	2
Vilnius	534 000	-	1	2	3	-	-	-	-	-	-	1

And, for the cases of the city of Paris and the new AQ zone RO031601 Ploiesti:

Geographical unit	Pollutant										
	SO_2	NO_2	O_3	PM	CO	Lead	C_6H_6	As	Cd	Ni	B(a)P
City of Paris	–	6	4	8	–	–	6	–	–	–	–
RO31601 (Ploiesti)	–	1	–	2	1	–	1	–	–	–	?

Note: ([a]) Note that the population numbers refer to the population in the corresponding air quality zone and not to the city according to administrative or other boundaries.

Empty cells mean the zone is not defined to assess that pollutant.
'–' means only modelling can be used;
'?' indicates that insufficient information is available to estimate the classification of zones with respect to assessment thresholds.

Annex 6 Complementary classification of monitoring stations

The recommendations in Section 2.3 are in line with the known limitation in the current classification of monitoring stations that some categories (especially the urban background and suburban background) cover a broad range of possible air quality situations, are hard to differentiate, and can easily be classified as one or the other. A recent document produced by the Joint Research Centre (JRC ([53])) (JRC, 2013) recommends that additional classification schemes be refined or developed to complement the classification scheme of the Air Quality Directives (and which is found in AirBase) and thus enlarge the amount of available information. In order to gain a better insight into what an additional classification scheme might look like, ETC/ACM, in cooperation with the EEA, has applied the Joly and Peuch (2012) methodology to the initial eight cities participating in the Air Implementation Pilot, and to other monitoring networks across Europe. According to the Joly and Peuch methodology, stations are classified for each pollutant independently. This is not the case with the AirBase classification, which only classifies the stations according to pollutants in two categories: ozone and all other pollutants. The classification is based on eight quantitative indicators describing the variability of pollutant concentrations over time, and is supposed to reflect the influence of anthropogenic activities and emissions on air quality. The stations' historical dataset and their AirBase classification are used as further inputs. The output is a pollutant-specific discrete classification going from class 1 to class 10, which is considered as 'objective' since it rests on numerical criteria that are uniformly applied across Europe. In ETC/ACM, 2012d, the first results of applying this methodology to the initial eight cities can be found.

The analysis of the new classification in relation to AirBase metadata leads to a first categorisation of the cities as follows:

- cities for which the new classification matches the AirBase classification quite well, with a clear distinction between suburban background, urban background, and urban traffic sites (e.g. Berlin);
- cities with high urban density and an overall strong influence of traffic (e.g. Madrid);
- cities for which the 'traffic behaviour' of monitored data (in so far as a station produces data that suggest it is influenced by traffic regardless of whether or not the station is located close to traffic) is less pronounced, and which show no marked difference between urban background and urban traffic sites (e.g. Dublin, Milan);
- cities characterised by low population density and negligible influence from traffic, even if differences are observed between urban background and urban traffic sites (e.g. Malmö).

In addition to the usual AirBase classification scheme, the methodology developed by Joly and Peuch (2012) offers the potential to characterise monitoring stations in more depth (which is often necessary for modelling purposes) and highlight the influence of emissions on measured data. The classes obtained for NO_2 and PM_{10} are usually consistent with each other, but display some differences that could be due to emission sources. Land cover (the amount of an area covered by urban space) and population density are useful data that help to interpret the results but they are not sufficient. For a better understanding of the classification at city level, other variables and parameters should be considered, such as high-resolution emission inventories, topography (city or street configuration), aerial views etc. Further analysis and additional feedback from the data providers are therefore needed.

([53]) http://ec.europa.eu/dgs/jrc/index.cfm.

Annex 7 Analysis of trends in the monitoring series concentrations

As discussed in Section 1.1.2, if certain pollutant limits are exceeded, EU Member States are required under EU legislation to implement air quality plans to improve air quality (see Box 2.2 for more information on management of air quality). One of the ways to check if there has been an improvement in air quality is to statistically analyse the measurement series at monitoring stations to see if pollutant levels are following a decreasing trend, and if this trend is significant. Further investigations would then be needed to ascertain whether the detected changes are due to the air quality measures implemented (by the city, or by regional and national governments) or to some other factors, such as meteorological conditions.

As part of the Air Implementation Pilot's workstream on monitoring networks, data from the monitoring stations located in the eight cities taking part in the project early in 2012 were retrieved from AirBase ([54]). To analyse them, a consistent set of stations was selected according to the following criteria:

- for each year in the period 2001–2010, the data coverage (percentage of valid data out of the total) should be 75 % or more;
- the station should be operational for at least eight years in the ten-year period 2001–2010. (Ploiesti could not be analysed because its monitoring network is relatively new and therefore the available series were not long enough).

Once these criteria had been met, a statistical test (the Mann-Kendal test, de Leeuw (2012)) was applied for PM_{10}, NO_2 and ozone over the time series. The results are presented in ETC/ACM, 2012a.

The results showed a decreasing trend for PM_{10} in all the initial participating cities analysed. However, this trend could only be classed as 'significant' in a limited number of stations. For NO_2, the assessment showed a different result. Half of the stations showed a tendency of increased concentrations of NO_2, although this trend was not significant. Finally, at three out of 40 stations, the ozone concentrations showed a significant and steep decreasing trend. At the other stations however, no clear trend for ozone could be detected. There was thus no discernible trend in any of the cities. Therefore, from this analysis by the ETC/ACM, no conclusions can be drawn from the considered monitoring stations about the effects of the air quality measures taken by the participating cities. A further avenue for research would be to analyse the series together with data on the polluting activity (energy production, industrial output, traffic volumes) or any other data that could help in the interpretation.

([54]) http://www.eea.europa.eu/data-and-maps/data/airbase-the-european-air-quality-database-7.

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