Air Implementation Pilot:

Assessing the emission inventories at the local level

ETC/ACM Technical Paper 2012/18
November 2012

Christian Nagl, Cornelia Schenk

European Topic Centre
on Air Pollution and
Climate Change Mitigation

The European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM)
is a consortium of European institutes under contract of the European Environment Agency
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Front page picture:
Index of NO_x and PM_{10} traffic emissions. Source: Senatsverwaltung für Stadtentwicklung und Umwelt, Berlin, http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/db311_06.htm.

Author affiliation:
Christian Nagl, Cornelia Schenk: Umweltbundesamt GmbH (Environment Agency Austria),Air Pollution Control & Climate Change Mitigation Spittelauer Lände 5,A-1090 Vienna,Austria. email: christian.nagl@umweltbundesamt.at homepage: http://www.umweltbundesamt.at

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ETC/ACM Technical Paper 2012/18
European Topic Centre on Air Pollution and Climate Change Mitigation
PO Box 1
3720 BA Bilthoven
The Netherlands
Phone +31 30 2748562
Fax +31 30 2744433
Email etcacm@rivm.nl
Website http://acm.eionet.europa.eu/

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1. Background

This technical report aims at reviewing emission inventories of the eight European cities taking part in the Air Implementation Pilot and to assess their ability to inform the development of air quality management plans (including addressing specific exceedances and source apportionment for concentration levels). Furthermore, their potential for identifying suitable mitigation measures is evaluated.

Out of the eight European cities selected only seven dispose of local and/or regional emission inventories. The cities participating in the project are:

- Berlin (Germany),
- Dublin (Ireland),
- Madrid (Spain),
- Malmö (Sweden),
- Milan (Italy),
- Ploieşti (Romania),
- Prague (Czech Republic) and
- Vienna (Austria).

By means of a questionnaire sent to the participating cities detailed information on the structure, methodologies, data and use of the urban emission inventories has been obtained and will be discussed in the following (the questionnaire can be found in Annex 1).

2. Overview of cities' emission inventories

In the following, the cities' replies to the questionnaire sent out in June 2012 are summarised and presented.
The emission inventory of Dublin is currently being developed as a result of the city's participation in the Air Implementation Pilot; therefore, the questionnaire could not be answered by the city authorities. As soon as information will be available it will be included in an updated version of this report.

Conclusions and recommendations regarding the cities' emission inventories are presented in chapter 3.

2.1 Pollutants covered, spatial and temporal resolution

The pollutants included in the cities' emission inventories (EI) are shown in the table below.
Four pollutants are covered in all emission inventories considered: NO_x, VOC, SO_2, PM_{10}.
Greenhouse gases (GHG) are currently not included in three emission inventories; $PM_{2.5}$ is not included in two emission inventories.

Table 1: Pollutants included in the emission inventories (Annex 2 lists the abbreviations of the pollutants)

City	Pollutants in the emission inventory			
	Gaseous	**PM**	**GHG**	**Other**
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, TCE, PCE, TCB, 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	
Ploieşti	NO_x, VOC, SO_2, CO	TSP, PM_{10}, $PM_{2.5}$	CO_2, CH_4, N_2O	heavy metals, POPs, PAH,
Prague	NO_x, VOC, NH_3, SO_2, CO, benzene	TSP*, PM_{10}, $PM_{2.5}$		selected HMs* and POPs*
Vienna	NO_x, VOC, SO_2, CO, NO_2	PM_{10}	CO_2,	

* stationary sources

The coverage of pollutants laid down in EU legislation is summarized in Table 2. Next to legislation relevant for local emission inventories such as the Air Quality Directive, obligations on the national level such as the National Emission Ceilings Directive are listed as well.

Table 2: Pollutants included in cities' emission inventories in comparison to emission- and air quality-related obligations on local and national level

Pollutant	Obligation	Berlin	Madrid	Malmö	Milan	Ploieşti	Prague	Vienna
NO_x	NEC, AQD (NO_2)	✓	✓	✓	✓	✓	✓	✓
VOCs	NEC, AQD	✓	✓	✓	✓	✓	✓	✓
SO_2	NEC, AQD	✓	✓	✓	✓	✓	✓	✓
NH_3	NEC		✓	✓	✓		✓	
PM_{10}	AQD	✓	✓	✓	✓	✓	✓	✓
$PM_{2.5}$	AQD, GP	✓	✓		✓	✓	✓	
CO	AQD		✓	✓	✓	✓	✓	✓
C_6H_6	AQD						✓	
PAH	DD4		✓			✓		
HM	DD4		✓			✓	✓	
GHG	UNFCCC		✓		✓	✓		✓

NEC: National Emission Ceiling Directive 2001/81/EC
AQD: Air Quality Directive 2008/50/EC
DD4: 4th Daughter Directive 2004/104/EC
GP: revised Gothenburg Protocol under the CLRTAP
UNFCCC: United Nations Framework Convention on Climate Change

All of the cities considered use a bottom-up approach for their emission inventory. In some cities specific source categories are estimated via top-down data.

Table 3: Approach

City	Approach
Berlin	Bottom-up
Madrid	Bottom-up; top down for some industrial activities
Malmö	Bottom-up; consumer data, NRMM top down
Milan	Mainly bottom-up
Ploieşti	Bottom-up
Prague	Bottom-up; top down for area sources
Vienna	Bottom-up

The cities' emission inventories cover at least the city within its administrative boundaries. In the case of Milan, the emission inventory covers the whole region of Lombardy and more than 1500 municipalities altogether.
The spatial resolution for area sources ranges from 50 × 50 m² to 1000 × 1000 m². In most cases, point and line sources are allocated to specific spatial positions and road sections.
In all cities the emission inventories are based on annual emission data. However, additional temporal emission profiles are available for Madrid, Malmö, Milan and Vienna. These temporal profiles are important for air quality modelling.

Table 4: Area covered by the emission inventory, spatial and temporal resolution

City	Area	Spatial resolution			Temporal resolution
		point	line	area	
Berlin	admin. unit (891 km²)	✓	✓	1000 x 1000 m²	annual
Madrid	municipal boundary (635 km²)			250 x 250 m²	annual (hourly profiles)
Malmö	municipal boundary (155 km²), region: 100 x 100 km²	✓	✓	50 x 50 m² (domestic heating) 500 x 500 m² (NRMM)	annual; daily, monthly variation for traffic. Production pattern for LPS. Heating emission pattern
Milan	Lombardy region	1546 municipalities in region			annual; hourly, daily, monthly modulation profiles
Ploieşti	Prahova county	no information provided			annual (LCP quarterly)
Prague	City of Prague	✓	✓	parts of city	annual
Vienna	Admin. unit (415 km²)	✓	✓	100 x 100 m²	annual, monthly, weekly and week-hours profiles

2.2 Classification, sources and database

Table 5 shows emission sources included in the emission inventories. Special attention was paid to fugitive emissions, such as resuspension of road dust and construction activity, which are relevant sources but very difficult to quantify.
Additionally, information on the classification system used is presented.

Table 5: Emission sources included in the inventory and classification scheme

city	Stationary	Large industrial	Small industrial and commercial	Residential	Road transport	Other transport	Agriculture	Fugitive					Classification System	Comment
								Wear	Resuspension	Evaporative loss	Construction	Solvents		
Berlin	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	×	national classification	
Madrid	✓	✓	✓	✓	✓	✓	×	✓	×	✓	≈	✓	SNAP (CRF possible)	construction: exhaust emissions
Malmö	✓	✓	✓	✓	✓	✓	×	×	×	✓	≈	✓	custom classification	road surface emission model is under construction. construction: exhaust emissions
Milan	×	✓	✓	✓	✓	✓	✓	✓	×	✓	×	✓	SNAP	
Ploieşti	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	×	✓	NFR	
Prague	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	NFR national classification	fugitive: only totals for whole city. resuspension only for ATEM AQ model
Vienna	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	≈	✓	SNAP ÖNACE (national classification)	construction: exhaust emissions

(Notation keys: ✓ included/ × not included/ ≈ partly included)
SNAP – Selected Nomenclature for Air Pollution
NFR – Nomenclature For Reporting

The coverage of source categories in the emission inventory reflects on the one hand the relevance of the sectors for urban regions, and on the other hand the availability of reliable activity data and/or emission factors. This is indicated by the fact that agriculture, resuspension of road dust and emissions of construction activity (save exhaust emissions) are not included in the emission inventory of four cities.
In two cases (Berlin and Malmö) a custom classification scheme is used in the emission inventory. These two cities will be addressed once more to receive further information, which will allow estimating the effort of mapping the source categories to the NFR (Nomenclature For Reporting) system.

As an underlying database, MS Excel and Oracle are used in two cases each (Table 6). Three cities use a combination of different programs, the interaction of which will be further discussed with the city authorities.

Table 6: Spreadsheet, database used

City	Database
Berlin	MS Excel
Madrid	Microsoft Office Applications (MS Access, Excel, etc.)
Malmö	MS Excel and EnviMan AQEmissioner (Opsis AB, www.opsis.se)
Milan	Oracle
Ploieşti	MS Excel
Prague	BDF, MS Access (HO BASE), Oracle (CHMI)
Vienna	Oracle

2.3 Quality assurance and quality control

This chapter describes the QA-procedures in place, existing difficulties and improvement options.

Table 7: QA/QC procedure in place

City	QA / QC
Berlin	Plausibility checks are performed. The source apportionment is based on air quality monitoring representative for different environments and sources.
Madrid	Quality assurance procedures are performed. Criteria for the selection of estimation methodologies according to IPCC are applied. The principles of consistency and homogeneity over time are applied in inventory preparation. QA/QC procedures include the following: checking of data for anomalies, contradictions and missing information. In case of anomalies, their origin is investigated and any errors identified are resolved
Malmö	Each year air quality modelling is performed for about 15 locations and compared to simulations of previous years. This provides an end-of-the-line test of the whole system. Every 5 years passive sampling campaigns for NO_2 and VOC are performed to compare with modelled concentrations. A formal QA/QC procedure is under development and is estimated to be implemented in March 2013.
Milan	The data are compiled in the SNAP nomenclature. The data set also includes information on data source and methodology applied. Cross-check tests are performed for emissions from the main SNAP groups, by comparing them with national emission inventory results and previous editions of the regional emission inventory results.

Ploieşti	QC procedures cover three areas: 1. Data and information for the emission inventory: - Identification of all activities and processes which generate emissions and the associated NFR code; - Identification of emission sources, the physical parameters, the temporal variations of processes and emitting activities; - Data collection, - Checking of the data source, - Checking for errors and transmission of data, - Checking for proper registration, units and conversion factors. 2. Input data: - Selection of the method for estimating emissions: direct measurements, emission factors, mass balances, emission modelling, etc.; - Identification of the level of approach to estimate emissions: based on the availability of data, quality data collected, etc.; - Development of the emission inventory; - Checking of the inventory (cross checking of input data, emission factors) 3. Reporting and use of the emission inventory a) Preparation of reports b) Use: identification of sources of elevated pollutant levels in ambient air, air quality modelling, development of strategies and regulations, definitions of environmental priorities, etc. QA procedures include all checks, audits and reviews for quality assessment of the emission inventory by independent experts or third parties.
Prague	Cross-checks with the previous emission inventory database are performed
Vienna	The quality of the inventory is entrusted to the external partner (AIT Austrian Institute of Technology, Department of Foresight and Policy Development, http://www.ait.ac.at/departments/foresight-policy-development/). All activity data, emission factors and models are documented in a transparent way, and are open for scrutiny by all expert users. All assumptions are described and documented.

As a first step to assess the comparability of emission inventories, the cities were asked whether their emission inventories are comparable to other cities within the country, or comparable to regional emission inventories. This is – to some extent - the case in about half of the cities considered.

Table 8: Comparability to other cities within the country

City	Comparability
Berlin	Not comparable to other cities Results of the city emission inventory are comparable to other emission data from regional inventories and used in modelling exercises (e.g. PAREST Project; http://www.umweltbundesamt.de/luft/infos/veranstaltungen/parest2010/index.htm)
Madrid	Theoretically yes: The Municipal Inventory is contrasted with the national and regional inventories; it is comparable, if the same methodology is applied in other cities. No specific examples are given.
Malmö	Fully comparable with the regional (Scania) emission inventory and the Göteborg emission inventory, partly comparable to the Stockholm emission inventory (bottom-up), but not directly comparable to the national emission inventory (mostly top-down)
Milan	Yes (regional inventory containing data on each city in the region; the methodology is shared with 6 further regions and 2 provinces)
Ploieşti	No
Prague	No
Vienna	Yes

Possible solutions to improve consistency and comparability of the emission inventories of European cities can be found in Table 9.
A harmonisation of cities' emission inventory is deemed possible when the source categories (and their definitions), the methodology and the emission factors (which essentially covers the whole process) are harmonised. A working group is seen as necessary to exchange best practices.

Table 9: Suggestions for improving the consistency and comparability of emission inventories

City	Suggestions
Berlin	No information provided
Madrid	Harmonisation and clear definition of emission source categories and subcategories Quality control comparison Presentation of results (index, indicators…)
Malmö	Guidelines
Milan	No information provided
Ploieşti	Harmonization of methodology and emission factors
Prague	Stronger use of a bottom-up approach for line sources
Vienna	Establishing a working group to discuss best practice methods

Table 10 summarizes the difficulties and main challenges encountered by the cities in the development of the emission inventory. Fugitive sources and uncertainties of emission factors are a common problem. Especially emission factors for fugitive sources are seen as a major challenge in most cities. This poses considerable problems in quantifying PM_{10} emissions, for which widespread exceedances of the air quality limit value occur. Also traffic data, esp. for heavy duty vehicles, is often not available with suitable quality.

Table 10: Challenges and suggestions for improvement of the emission inventory (EI).

City	Difficulties & Challenges	Suggestions for improvement
Berlin	Main uncertainties in emission estimates: - Wood burning for domestic heating - Construction site activities: diffusive sources, machinery - Emission factors for EEV-Euro-5 vehicles Main challenges: - Uncertainty of emission factors - No formal database structure	- Emission inventory training and guidance - Common emission factors
Madrid	Main uncertainties: - Emission factors - Activity data quality could be improved with better local statistics (gasoil boilers, railways information, etc.) Main challenges: - Quality of input data - Standardisation of methodologies	- Taking into account GHG SCOPE 3 emissions would improve the quality of the EI. Efforts are underway in order to improve the reliability of traffic and household heating system data set
Malmö	Difficulties: Each data source is evaluated on the level of usefulness for the purpose of emission calculations (usually data sources have been put together for a completely different purpose). The expected share of the total emission in the city determines how much work is spent on securing the data quality. An example is the share of heavy vehicles on a certain road: The data from the street department is often of a very low quality due to the method of measurement, so extensive data examination and correction has to be done to provide an acceptable level of accuracy. Main challenges: Quality of data for freight transport	- Emission factors: HBEFA and earlier Artemis are quite complicated systems with even some missing data for some classes. This leads to a great deal of efforts being spent on finding the right emission factors and testing the sets of factors used in the system. - Guidance on a QA/QC system
Milan	Difficulties: National/regional statistical data are not always available for the current EI reference year. Then, it is not always simple to get relevant traffic flow data from some institutions (in particular from highways licensees/concessionaries)	Improvement of emission factors and activity data

Ploieşti	Difficulties: - Data collection, - Checking of the data source, - Checking for errors and transmission of data, - Checking for proper registration, units and conversion factors - Fugitive sources – in construction activity Main challenges: Completeness of the EI (fugitive sources)	- Using methods based on direct measurement (continuous) can provide a high degree of data certainty when measurements are made correctly and with performance devices. - The use of "class A" emission factors with a small probability error - Inventory training
Prague	Difficulties: Lack of precise traffic load data, fleet composition and emission factors Main challenges: Traffic and fugitive emissions	Improvement of emission factors and activity data
Vienna	Difficulties: Urban emission inventories follow a different purpose than national emission inventories. In cities, the major goal of an inventory is the application for urban air quality management rather than accounting pollutants for international agreements (NFC, UNFCCC etc.). Thus, a very high spatial and a minimum (e.g. monthly) temporal resolution of the EI, reflecting the highly variable emission patterns in cities, are needed for air quality management. Main challenges: - Costs - Uncertainties of emission factors (esp. for fugitive sources)	Scientific research concerning emission factors (e.g. diffuse emissions, real life emission factors for domestic heating)

Confidentiality of input data is only of minor concern to the cities. Where information was provided by the cities, emission data are publicly available. Data for large point sources or received by economic agents are in most cases confidential, and are thus aggregated to census units and/or a gridded representation (Table 11).

Table 11: Confidentiality

City	Difficulties
Berlin	No
Madrid	Emission data are public, but the activity data for each large point source is confidential
Malmö	Possibly in very few cases of handling confidential emission data from certain companies. All other data are either open source or anonymized as a grid source.
Milan	No information provided
Ploieşti	All data received by economic agents are confidential
Prague	No
Vienna	All survey data that relate to point sources are confidential. On the other hand, there are no confidentiality restrictions for emission inventory results in which point sources and line sources are aggregated to census units and/or to a 100x100 m² grid system.

2.4 Integration across environmental areas

In most cities, the authorities responsible for the preparation of the GHG (and air pollutant) inventory and for the development of air quality management strategies cooperate closely. Only in one case no local climate change measures are foreseen (Table 12). However, only four cities consider air quality issues in climate change policies and vice versa (Table 13). At least the input data for air quality management and climate change policies is the same in most cases (Table 14).

Table 12: Greenhouse Gases

City	Authority responsible for GHG	Local GHG reduction measures
Berlin	Statistic units (CO_2 calculation);	Berlin energy programme / climate task force: http://www.stadtentwicklung.berlin.de/planen/stadtentwicklungsplanung/de/klima/download.shtml BERLIN (2006): Landesenergieprogramm BERLIN (2011): Klimaschutzbroschüre
Madrid	Same unit (Sustainability General Directorate)	MADRID (2008): Plan for the Sustainable Use of Energy and Climate Change Prevention 2008-2012; new plan 2013 – 2020 under development Party to the Covenant of Mayors and thus commitment to a GHG reduction for 2020.
Malmö	Under development	Local measures have been implemented
Milan	Same unit	No information provided
Ploieşti	Same authority (NEPA Bucharest)	Information provided for national measures
Prague	Only on national level	No local measures implemented
Vienna	Close cooperation with different department within City of Vienna	Yes, (WIEN 2009): KLiP Vienna, http://www.wien.gv.at/umwelt/klimaschutz/programm/

Table 13: Consideration of air quality issues in climate change programs and vice versa

City	AQ in climate change	Climate change in AQ
Berlin	✓	✓
Madrid	✓	Partly
Malmö	No information provided	Partly
Milan	No information provided	✓
Ploieşti	✓	✓
Prague	Not applicable (no climate change program)	Not applicable
Vienna	✓	✓

Table 14: Same input data for different environmental topics

City	Input data across topics
Berlin	✓
Madrid	✓
Malmö	✓ (traffic data)
Milan	✓ (regional territorial plan)
Ploieşti	unknown
Prague	✓ (spatial planning)
Vienna	✓

2.5 Updates, guidance and references

The frequency of complete updates of the whole emission inventory data series is shown in Table 15: The majority of emission inventories is updated on an annual basis, although the frequency for certain sources varies from one to five years. In some cases, an update depends on significant changes to specific sources. The latest emission data available also show a broad time range between 2005 and 2013.

Table 15: Complete update of whole data series, frequency of updates and latest emission data.

City	Frequency	Last update	Latest emission data
Berlin	mostly annual, small sources every 4 years	2009	2009
Madrid	whenever a substantial change occurs	2011	2009
Malmö	annual, domestic heating every 5 years	2013	2011
Milan	every 2 to 3 years	2011	2008
Ploieşti	annual	2011	2010
Prague	annual	2012	2011
Vienna	as required, industry every 5 years	2012	2005 (2010 next year)

For the cities' emission inventory, a recalculation of emission inventories (e.g. due to changes in emission data or methodology) is hardly undertaken in the same way as it is done for national emission inventories (Table 16). The time interval of a recalculation varies from annual to irregular intervals of up to 5 years. Therefore, the time series obtained are not comparable to those in national emission inventories.

Table 16: Recalculation of emission inventories.

City	Recalculation	Fluctuation
Berlin	approx. every 5 years	± 30 %
Madrid	Annual	5 to 10 %
Malmö	Old emission data is not saved in the system for time series. Therefore previous calculations of emissions, put in a time series, reflect both changes in emissions and in methodology. As a consequence, changes in the methodology are implemented quite seldom (every 5 years or less).	Unknown
Milan	A preliminary version is publicly reviewed in order to collect all available information from stakeholders. Thereafter the final version is released. The inventories referring to previous years are currently not recalculated, but a tool to evaluate the emission trends on the basis of new assumption is being developed	Not exactly specified
Ploieşti	Dependent on necessity	No information provided
Prague	Whenever necessary due to changes in traffic routes or volumes	Dependent on magnitude of changes in volumes
Vienna	Irregular updates depending on new input data, methods and models; typically 2 to 3 updates within 5 years	± 10 % (activity data)

The main references used in developing the emission inventories are the IPCC guidance documents for GHG and the EMEP/EEA air pollutant emission inventory guidebook ([1]) for air pollutants (Table 17). For traffic emissions either HBEFA 3.1 ([2]) or COPERT 4 ([3]) is used. In Prague a program called MEFA ([4]) is used.
The estimation of traffic volumes as well as the modelling of traffic (Table 18, Table 19) is rather diverse.

Table 17: General references used

City	References
Berlin	traffic: IMMIS-em: (modelled), HBEFA 3.1 (www.hbefa.net) tyre abrasion and resuspension: DÜRING & LOHMEYER (2004) evaporative losses: HBEFA3.1 heating: UMEG (2000) construction machinery: IFEU (2004)
Madrid	GHG: IPCC; AP: EMEP/CORINAIR; traffic: COPERT 4
Malmö	no information provided
Milan	GHG: IPCC; AP: EMEP/CORINAIR
Ploieşti	GHG: IPCC; AP: EMEP/CORINAIR
Prague	EMEP/CORINAIR, national guidance for traffic emissions
Vienna	EMEP/CORINAIR, HBEFA

([1]) http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009
([2]) http://www.hbefa.net
([3]) http://www.eea.europa.eu/publications/copert-4-2014-estimating-emissions
([4]) http://www.mzp.cz/cz/vypocet_emisnich_faktoru

Table 18: References and models used for traffic emissions

City	Emission factors	Model
Berlin	HBEFA 3.1: exhaust, evaporative DÜRING & LOHMEYER (2004): non exhaust	IMMIS-em
Madrid	COPERT 4	COPERT IV
Malmö	HBEFA 3.1	No
Milan	COPERT 4	INEMAR (INventario EMissioni ARia) http://www.inemar.eu/xwiki/bin/view/Inemar/
Ploieşti	COPERT 4	Model by NEPA
Prague	MEFA – výpočet emisních faktorů www.mzp.cz/cz/vypocet_emisnich_faktoru	MEFA 06 - model
Vienna	HBEFA 3.1	VISUM, operated by Traffic Planning Authority

Table 19: Estimation of traffic volumes

City	Traffic volume
Berlin	Daily traffic volume, fleet composition based on license plate km driven from www.vmzberlin.de
Madrid	Statistical yearbook, regional and national statistics. Study on fleet inside M30
Malmö	Measured traffic data
Milan	Traffic flow monitoring and simulation on a road network. Mileage vs. vehicle age. Fuel sale statistics.
Ploieşti	Fuel use
Prague	TSK-UDI Counting campaigns for Prague, VISUM model. Fuel sold for country
Vienna	VISUM model, HBEFA 3.1, "level of service" calculations

Internal guidance documents for supporting the emission inventory team are available in four cities (Table 20). These guidance documents might be used inter alia when developing an emission inventory (chapter 3).

Table 20: Internal guidance

City	Guidance
Berlin	No
Madrid	No
Malmö	GUSTAFSSON (2007), "Building and validation of an air pollution emission database for Skane", licenciate thesis, Lund University
Milan	Methodology and information available at: http://www.inemar.eu/xwiki/bin/view/InemarDatiWeb/Metodologia+utilizzata
Ploieşti	Report - guidance on developing local and national emission inventories in conformity with EMEP/EEA – 2009
Prague	URM Internal Guidelines for emission inventories "Jednotné datové úložište REZZO Praha"; CHMI Internal Guidelines for REZZO "Provozní řád datové správy emisních údajů ISKO"
Vienna	No

2.6 Use of emission inventory and public accessibility

Technical documentation is available in four cities. The results of the emission inventories are publicly available in all but one city (Table 22). In most cases the results are available as tables or pie charts. In Berlin, traffic emissions are presented via a GIS-based website, where these data can be selected from a variety of environmental data.
Emission data is available for interested parties from all cities, at least in a summarized way.
Examples of the representation of emission inventory results are shown in Figure 1 (Berlin) and Figure 2 (Czech Republic).

Table 21: Availability of technical documentation

City	Documentation
Berlin	No
Madrid	Available on request
Malmö	GUSTAFSSON (2007)
Milan	http://www.inemar.eu/xwiki/bin/view/InemarDatiWeb/Metodologia+utilizzata
Ploieşti	No
Prague	http://portal.chmi.cz/files/portal/docs/uoco/oez/emisnibilance_CZ.html
Vienna	No

Table 22: Availability of emission inventory and summarized results

City	Emission data
Berlin	http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/ http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/db311_06.htm
Madrid	A brief report was published: http://www.mambiente.munimadrid.es/opencms/opencms/calaire http://www.mambiente.munimadrid.es/opencms/opencms/calaire/SistIntegral/InventarioEmisiones.html MADRID (2011)
Malmö	annual report and a web tool: http://malmo.se/Medborgare/Miljo--hallbarhet/Miljolaget-i-Malmo/Miljo--och-livsmedelsrapporter/Luft.html
Milan	http://www.inemar.eu/xwiki/bin/view/Inemar/HomeLombardia http://www.inemar.eu/xwiki/bin/view/InemarDatiWeb/Fonti+dei+dati
Ploieşti	Emission inventory for Prahova county (total emissions per SNAP category): (http://apmph.anpm.ro/articole/inventare_emisii_de_poluanti_atmosferici-53)
Prague	http://portal.chmi.cz/files/portal/docs/uoco/oez/emisnibilance_CZ.html http://portal.chmi.cz/files/portal/docs/uoco/web_generator/plants/index_CZ.html www.geoportalpraha.cz www.premis.cz/atlas
Vienna	No

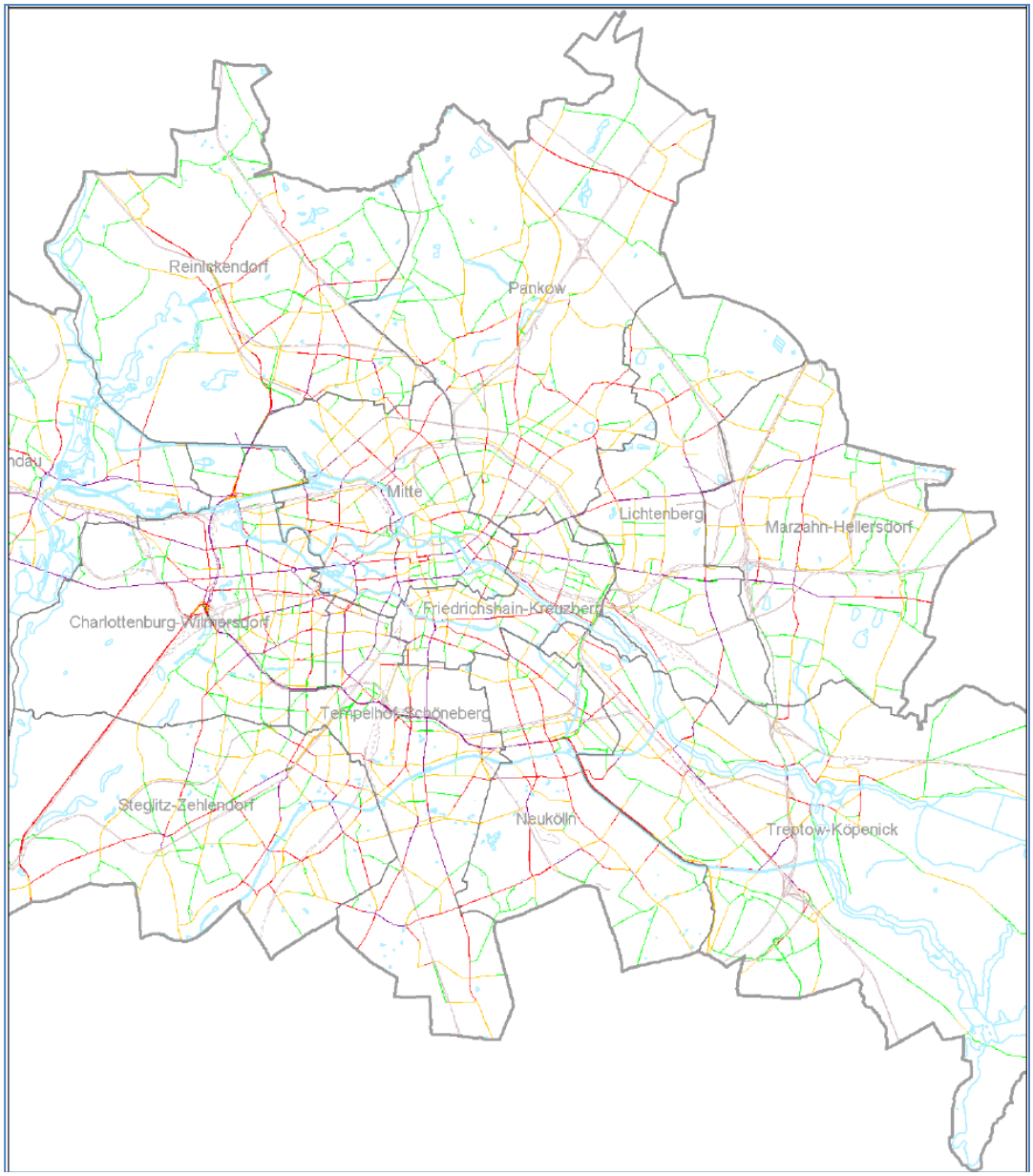

Figure 1: Traffic emissions in Berlin (source: http://www.stadtentwicklung.berlin.de/umwelt/umweltatlas/db311_06.htm)

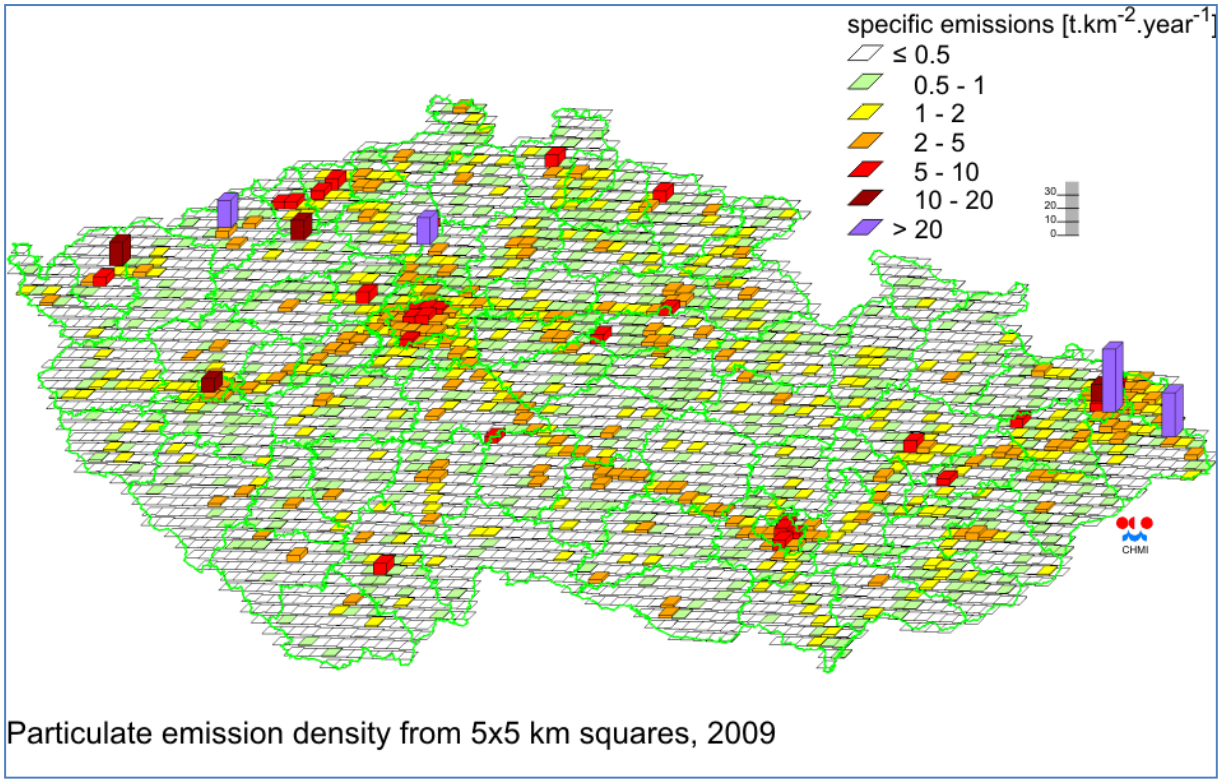

Figure 2: PM emissions in the Czech Republic 2009 (source: CHMI)

emission inventories are used in all cities in order to identify measures for air quality improvement and for modelling purposes (Table 23). The identification of emission sources is another application used in most cities.

Table 23: Main use of emission inventory

City	Identification of sources	Modelling	Identifying measures	Other
Berlin	✓	✓	✓	
Madrid	✓	✓	✓	Monitoring of policies' targets; sustainability index
Malmö	×	✓	✓	for graphic representation of sources (identification beforehand)
Milan	✓	✓	✓	
Ploieşti	✓	✓	✓	
Prague	✓	✓	✓	
Vienna	✓	✓	✓	

Apart from Malmö and Ploieşti, the emission inventory has been used for the time extension notifications by all cities (Table 24).

Table 24: Use of emission inventory for time extension notifications

City	
Berlin	✓
Madrid	✓
Malmö	No time extension necessary
Milan	✓
Ploieşti	Not used
Prague	✓
Vienna	✓

The impact of measures is reflected in five emission inventories, at least for traffic measures (Table 25). In one city specific studies are undertaken.

Table 25: Quantification of changes due to actions

City	
Berlin	Traffic data and fleet composition allow for a detailed emission estimate, which leads to detailed ambient air pollution calculations
Madrid	In general not. Specific studies are undertaken to evaluate the impact of measures
Malmö	For specific sectors (e.g. traffic)
Milan	✓
Ploieşti	No. An emission monitoring program would be necessary
Prague	✓
Vienna	✓

There is hardly any information exchange between European cities concerning the methodology used. Nonetheless, some cities participate in European projects where experiences are discussed (Table 26).

Table 26: Exchange of information with other European cities

City	Methodology	Exchange
Berlin	Source apportionment approach	CityDelta (http://aqm.jrc.it/citydelta/), HEAVEN (http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RCN=5196314)
Madrid	No exchange of information	c40 network and Carbon Disclosure Project (www.cdpproject.net)
Malmö	No exchange of information	No exchange of information
Milan	No information provided	No information provided
Ploieşti	No exchange of information	No exchange of information
Prague	No exchange of information	CITEAIR II project
Vienna	Within Austria	Within Austria

The annual resources for compiling city level emission data and for updating the emission inventory vary considerably between the cities: they range from about 0.25 to 3 person years (Table 27).

Table 27: Annual resources

City	Resources
Berlin	-
Madrid	2 full time technicians
Malmö	1.5 full time positions
Milan	3 full time positions
Ploieşti	-
Prague	400 person hours
Vienna	200 person hours staff + approx. € 25,000

3. Conclusions

Based on the replies of the participating cities to the questionnaire, several central questions may be answered:

1. Are the emission inventories used for modelling, source apportionment and management practices, and thus support the implementation of air quality (AQ) policies?

   The emission inventories used in the seven cities clearly support the implementation of the AQ policies relevant for the local and regional scale. The emission inventories are used for modelling, for identifying sources of elevated pollutant levels and suitable measures, and partly also for quantifying and monitoring their impact.
   One of the participating cities is currently in the process of developing an emission inventory and an air quality model, which has been initiated by the Air Implementation Pilot, so the Pilot project is regarded as highly beneficial.

2. Are interactions between different policy areas sufficient? How can interactions be improved?

   There is a reasonable amount of interaction between policy areas such as air pollution, climate change and noise. However, GHG are not covered in all emission inventories; climate change policies are not considered in AQ programs in all cases and vice versa, even though the input data is mostly the same.
   The first step in improving this interaction would be to combine the different inventories, or to include GHG in the emission inventory. Based on common underlying data, a common database and thereby a common emission inventory, an integrated programme to reduce GHG emissions and air pollutants could be developed. The EEA could support this process by providing guidance on ways to harmonize data collection and methodologies.

3. Is the emission inventory data available for ETC/ACM and other institutions?

   Summarised results of the emission inventory are readily available for most cities. The underlying emission inventory data itself is usually not available. Therefore, negotiations on ways to establish interfaces to the emission inventory data should start in parallel with a process to harmonize the emission inventories across different cities. This process could be guided by the EEA in close cooperation with the cities.

4. Are the emission inventories comparable to each other and to national inventories? Which aspects are comparable, which not?

   Currently, the emission inventories are not directly and easily comparable with each other due to different source classification schemes, pollutants covered, spatial resolutions, years of latest data, emission factors, inclusion of fugitive sources and the underlying type of database. The QA/QC procedures in place are rather different as well. For this reason only some emission inventories are comparable to regional inventories or to emission inventories from other cities within a member state. Generally speaking, the cities' inventories are also not comparable to national emission inventories. Furthermore, the effect of measures is only visible in some but not all emission inventories.

5. Can these emission inventories be used for certain tasks on a European scale? If not, how much effort would be necessary to make the emission inventories comparable and usable on a European scale?

In their current state, the European emission inventory could mainly be used for a qualitative assessment of relevant pollutant sources in different cities, as they differ in many aspects (see above). Using the emission inventory in a common modelling exercise or quantitative source apportionments would thus require a considerable effort. The actual effort depends on the flexibility of the systems currently used, the completeness of the emission inventory with respect to pollutants and sources, the being up-to-date of the emission inventory and the spatial resolution it uses.

6. How can cities be supported to set up an emission inventory and to improve comparability?

   All but one city have already established an emission inventory. Different aspects in these emission inventories can be regarded as best practice, so city administrations should make beneficial use of this vast experience when establishing an emission inventory.
   A guidance document might be set up in close collaboration with the cities to improve the comparability of emission inventories. This harmonization effort concerns all aspects of the emission inventories, namely source categories (and their definitions), the methodology and the emission factors. Moreover, the effect of measures on emissions should be made visible in all emission inventories. A working group within the Air Implementation Pilot might develop a process for harmonization in cooperation with the cities.
   PM_{10}, $PM_{2.5}$ (and partly benzo(a)pyren) are of major concern in many cities. However, emission factors for fugitive sources should be improved and uncertainties of emission factors for these pollutants reduced.
   Nonetheless, the foreseen use of the emission inventories on a European scale should be laid down in more detail, as it will have a determining influence on the structure and methodology of the emission inventories.

7. What are the main challenges for the cities to improve the emission inventories?

   The cities' main challenges relate to the uncertainties in emission factors for wood burning, construction activity and fugitive sources in general, as well as to real world emissions and future vehicles (e.g. Euro 5 and 6). In some cases the low quality of input (activity) data and difficulties to obtain these data pose a challenge to the cities.
   One of the main future challenges will be to develop a more standardized methodology for the development of urban emission inventories.

8. Which suggestions can be made to improve the emission inventories?

   The cities suggested improving the emission inventories by providing common emission factors, by simplifying the databases for emission factors (e.g. HBEFA) and especially by improving the quality of emission factors of the sources mentioned in question 7. The improvement of emission factors might be achieved through common research programs.
   The cities might be supported with guidance on setting up QA/QC systems, by training and guidance on compiling activity data and on emission inventories in general. A regular exchange of best practice might be helpful as well.
   The EEA could facilitate these processes by chairing them and providing further support to the member states.

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Annex 1: Questionnaire to pilot cities

Assessing emission inventories at the local level

Questionnaire to partner cities of the Air Pilot Study

The aim of the Air Pilot Study sub-project on local emission inventories is to compare emission inventories from the partner cities to assess their ability to inform the development of air quality management plans (including addressing specific exceedances and source apportionment for concentration levels) to help identify mitigation measures.

Objectives

1. **Describe** the quality and level of detail of the **emission inventories** and source apportionment data for air quality in the selected cities (with a potential focus on road-transport and other diffuse sources).
2. **Assess inventory comparability** across the selected cities of the pilot study, which may identify examples of good practice, needs for improved guidance, links with local climate change mitigation measures, etc.
3. **Explore with the nominated city contacts the possible sharing of local emission data with EEA**, at least for ad-hoc needs.

Steps

a) Distribution of questionnaire on the local city emission inventories to the nominated city contacts (1 June 2012)

b) Presentation of emissions questionnaire and discussion at the Air Quality Pilot kick-off meeting (6-7 June 2012)

c) Completion of questionnaire by the nominated city contacts (30 June 2012)

d) Follow-up interviews/questions (by telephone/email) if needed, to further understand the city experiences in developing and using local emission inventories (June/July)

e) Drafting of report assessing the ability of local emission inventories to inform air quality assessments, management practices, source apportionment, etc. (September 2012)

Outputs

EEA will be assisted in the study by experts from its European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM). These experts will compile a draft working paper that will provide:

- A description of the local inventories in the pilot cities,
- Their comparability,
- Conclusions about how the quality of city-level inventory data might be improved,
- The potential need for additional guidance, technical support etc.

A qualitative assessment will provide comment on the potential ability of the selected city emission inventories to be used, for example in AQ modelling activities, in source apportionment studies and to inform/develop management practices, etc.

The draft report will be shared with the nominated city contacts and will provide a starting point for the sharing of experiences concerning local emission inventories.

Contacts

ETC/ACM questionnaire leader (& contact for any questions concerning the questionnaire)

Christian Nagl

Air Pollution Control & Climate Change Mitigation
Umweltbundesamt GmbH, Austria
T: +43-(0)1-313 04/5866
christian.nagl@umweltbundesamt.at

EEA Task coordinator

Martin Adams

Air and Climate Change Programme
European Environment Agency (EEA)
T: +45 3336 7277
Email: Martin.Adams@eea.europa.eu

EEA Air Quality Pilot project manager

Alberto González Ortiz

Air and Climate Change Programme
European Environment Agency (EEA)
T: +45 3336 7255
Email: Alberto.Gonzalez@eea.europa.eu

Please return the completed questionnaire by 30 June 2012 to the three email addresses provided above.

Questionnaire form

The questionnaire consisted of the following sections numbered from 0 to 6:

0. Contact details

0	Please provide the contact details of the responsible authority in case of further enquiries (in case it is different from the address already provided. For internal use only)	
0.1	Name	
0.2	Organisation	
0.3	Address	
0.4	Telephone	
0.5	Email address	

1. General questions

1.1	Which pollutants are included in the Emission Inventory (EI)
	list of all pollutants (both air pollutants and greenhouse gases if relevant)
1.2	In general do you estimate your emissions using a 'bottom up' approach – or do you downscale from e.g. a regional or national emission inventory?
	descriptive text
1.3	Which area is covered by the EI?
	km x km, Air Quality Zone, or administrative unit
1.4	What is the spatial resolution of the EI?
	m x m
1.5	Air quality modelling often requires input data on hourly or daily basis, whereas emission inventories are most often based on annual data. If emission data is provided on smaller time scales as annually, which timescales are provided? How is the downscaling done?
	descriptive text
1.6	How often are input data and emission data of relevant sectors (traffic, residential heating, industry) updated?
	traffic: once a year; every x year *residential heating: once a year; every x year* *industry: once a year; every x year*
1.7	When was the EI last updated (complete update of whole data series)?
	date
1.8	For what year is the latest emissions data available in the inventory?
	date
1.9	Do you use any general reference sources (national, international etc) to guide the methods and emission factors used in your inventory? If yes, which?
	descriptive text (hyperlink, website, report)
1.10	Are internal guidelines or manuals used for the city authorities to prepare the inventory?
	hyperlink, website, report
1.11	Approximately how many resources do you spend each year on emissions data?
	estimate of staff time – estimate of budget (if contractors are used)

2. Technical questions

2.1	What sources are included in your emission inventory		
2.1.1	Stationary sources (e.g. large power plants)		*yes/no – descriptive text*
2.1.2	Large industrial sources		*yes/no – descriptive text*
2.1.3	Small industrial and commercial sources		*yes/no – descriptive text*
2.1.4	Residential sources		*yes/no – descriptive text*
2.1.5	Road transport		*yes/no – descriptive text*
2.1.6	Other transport (railways, aviation etc)		*yes/no – descriptive text*
2.1.7	Agriculture		*yes/no – descriptive text*
2.1.8	Fugitive sources		
2.1.8.1		non-exhaust traffic emissions (road, tyre, brake wear, particulate matter resuspension, evaporative losses from vehicle tank)	*descriptive text*
2.1.8.2		construction activity, generators etc	*descriptive text*
2.1.8.3		solvents	*descriptive text*
2.2	Which classification system do you use to describe the different source sectors (SNAP, NFR, CRF, any other?)?		
	descriptive text		
2.3	Which general data sources are used for emission factors?		
	(e.g. CR-CORINAIR, CS-country specific, OTH-other, PS-plant specific, M-modelled, D-default)		
2.4	Road transport sector		
2.4.1	What is the source of the emission factors used?		*descriptive text*
2.4.2	If you use a model to estimate road transport emissions, which model is used?		*descriptive text*
2.4.3	How do you estimate road traffic volumes, driving km, fuel use etc? (esp. NO_x, NO_2)		*descriptive text*
2.5	Recalculations of input data		
2.5.1	How often do recalculations of input data leading to changes in the time series of emissions, or methodological changes occur?		*descriptive text*
2.5.2	How high are data fluctuations due to these changes		*%*
2.6	What type of spreadsheet or database (Oracle, MS Access,...) is used?		
	descriptive text		

3. Documentation and information for the public

3.1	Is a technical documentation of the EI, its methods and description of data sources etc available?
	hyperlink, website, report
3.2	Is the emissions inventory data published?
	hyperlink, website, report
3.3	Is a report available describing the main results of the EI?
	hyperlink, website, report
3.4	If not, is the emission inventory/data accessible to interested parties upon request?
	descriptive text

4. Quality assurance and quality control

4.1	Please describe the QA/QC procedures in place – how do you ensure the quality of your emission inventory?
	descriptive text
4.2	Are the results of the city EI comparable to emission data derived from other sources such as regional inventories?
	descriptive text
4.3	Is the EI of your city comparable to the EI of other cities within your Member State?
	descriptive text
4.4	What difficulties did you encounter in taking stock, e.g. compiling relevant data sets (on city level), concerning data quality or other issues?
	descriptive text
4.5	Are there any issues of data confidentiality?
	descriptive text
4.6	What specific actions do you think would be useful to improve the quality of your inventory? *(e.g. inventory training, improved guidance, better emission factors, activity data etc)*
	descriptive text

5. Integrating across environmental areas

5.1	Does the same authority, which is involved in the development of air quality management strategies, compile or contract GHG and air pollutant emissions? If not, how do they cooperate and how is (background) information exchanged?
	descriptive text
5.2	Does your city also estimate GHG emissions?
	descriptive text
5.3	Many cities have targeted actions to reduce GHG emissions. Has your city implemented local measures to reduce GHG emissions? If yes, please provide a list of measures, link to documents etc
	descriptive text
5.4	If local GHG reduction measures have been implemented in your city, was the potential impact on air quality taken into account? (if relevant)
	descriptive text
5.5	Conversely, does the introduction of local air quality measures also take their impacts on GHG emissions into account?
	descriptive text
5.6	Is the same input data (e.g. traffic model and activity data) used for different activities such as noise maps, spatial land-planning etc.?
	descriptive text

6. Other

6.1	What is the emission inventory mainly used for?	
6.1.1	identification of sources of elevated pollutant levels in ambient air	*% – descriptive text*
6.1.2	ambient air quality modelling	*% – descriptive text*
6.1.3	identifying mitigation measures to reduce pollutant levels	*% – descriptive text*
6.1.4	other	*descriptive text*
6.2	Do you consider your emission inventory sensitive enough to quantify changes in emissions that occur after implementing actions at the local scale? If not, how do you quantify the effects of different emission reduction policies?	
	descriptive text	
6.3	Has the inventory been used for time extension notifications (if relevant)?	
	descriptive text	
6.4	Is the methodology exchanged with other cities within Europe?	
	descriptive text	
6.5	Do you already exchange experiences on local emission inventories with other European cities?	
	descriptive text, names of networks etc	
6.6	What do you consider are the difficulties and main challenges in developing an EI for your city?	
	descriptive text	
6.6	Your suggestions for improving the consistency and comparability of EI in European cities	
	descriptive text	

-/-

Annex 2: Abbreviations of pollutants

As ..... Arsenic
BC..... Black carbon
benzene..... benzene
Cd ..... Cadmium
CH_4 ..... Methane
CO ..... carbon monoxide
CO_2 ..... carbon dioxide
Cr..... Chromium
Cu ..... Copper
DIOX ..... Dioxine
HCB..... Hexachlorobenzene
HCH ..... Hexachlorocyclohexane
HFCs..... hydrofluorocarbons
Hg ..... Mercury
N_2O..... Nitrous oxide
NH_3..... Ammonia
Ni..... Nickel
NO_2..... nitrogen dioxide
NO_x..... nitrogen oxides
PAH..... Polycyclic aromatic hydrocarbons
Pb..... Lead
PCE..... perchloroethylene
PCP..... Pentachlorophenol
PFCs ..... perfluorinated compounds
PM_{10}..... particulate matter < 10 µm
$PM_{2.5}$..... particulate matter < 2.5 µm
POPs..... persistent organic pollutants
Se..... Selenium
SF_6 ..... Sulfur hexafluoride
SO_2 ..... sulfur dioxide
TCB ..... Trichlorobenzene
TCE ..... trichloroethylene
TCM ..... Trichloromethane
TSP ..... Total suspended particles
VOC ..... Volatile organic compounds
Zn ..... Zinc