European Topic Centre on Air Emissions

REVIEW STUDY ON EUROPEAN URBAN EMISSION INVENTORIES

By

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EXECUTIVE SUMMARY

In the 1995/1996 work programme of the European Environment Agency's European Topic Centre on Air Emissions several tasks have been considered related to urban inventories. This report forms a first outcome concerning these tasks. Subsequent reports could focus on the (preliminary) compilation of "top-down" urban inventories, as described in this report, and a (preliminary) catalogue of existing urban inventories, in co-operation with the ETC on Air Quality (chapter 1).

Urban emission inventories are an essential tool for the management of air quality at this scale (chapter 2). The main aim of this report is to encourage a process of harmonisation of European urban air emission inventories (chapter 3). It contains three main contributions in order to achieve the above mentioned target:

- a first draft of "Guidelines" for harmonised European urban inventory preparation and use (chapter 4);
- a proposal for an information sheet for urban inventories catalogue (chapter 5 and chapter 6), where an attempt is made to collect all the relevant information concerning an urban emission inventory in order to obtain a European view of the present situation;
- from CORINAIR to urban inventories: a top-down approach (chapter 7). The chapter outlines the existing situation in this field and puts forward some methodological considerations, trying to highlight pros and cons of the approach. A classification of CORINAIR activities into 'urban', 'not urban' and 'partially urban' is proposed.

Top-down and bottom-up urban inventories are complementary tools:

- top-down urban inventories as deduced from the CORINAIR inventory (1990/1994) give a complete but not detailed picture of the urban situation at European level;
- bottom-up urban inventories are usually more detailed and reliable if compared with the "top-down" corresponding inventories, but presently give an incomplete and not harmonised picture of the European situation.

To provide a first screening on air emission situations in European urban areas in order to identify "hot spots" where more detailed analysis is needed, it is possible to define an agreed methodology of a top-down approach to estimate emissions in urban areas starting from the existing CORINAIR emission data (90 and then 94) at territorial level NUTS3 and for the compounds included in these inventories.

The long-term target is to have a complete picture of urban emissions through harmonised bottom-up urban inventories throughout Europe. An important way to achieve this is to encourage the use of the joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook (first edition February 1996) also for urban air emission inventories and further to encourage a complete and transparent documentation during preparation of urban inventories in general.

In addition, for specific purposes a cautious use of CORINAIR data may give a complete picture at European level: shortcomings of the approach, however, must not be disregarded.

A European catalogue of bottom-up urban inventories could furthermore give the state of the art of the situation in Europe and could allow a consistency check of the top-down approach and constitutes the first step toward the harmonisation of bottom-up European urban emission inventories.

The ETC/AE produced top-down urban inventories for a number of European cities based on CORINAIR90 (NUTS3) emission estimates. These urban inventories need a validation procedure involving the member states. To this aim the resulting database should be sent for comments to the national focal points and/or CORINAIR experts. A further validation of the ETC/AE top-down urban inventories can be performed comparing the emissions estimated by top-down approach with the results of the bottom-up urban emission inventories collected in the context of various EEA and other projects (for example cities modelled in the Auto Oil I programme).

1. THE CONTEXT

The need to develop a common European strategy for air quality management in urban areas is envisaged in the **EU Framework Directive** on air pollution, which is going to be adopted. The Framework Directive lists the pollutants that have to be considered and explicitly refers to the complementary tools that have to be considered for air quality analysis and evaluation: measurements, modelling and inventories. In art. 4 of the Directive, it is stated that criteria and techniques will be fixed at European level both for air quality measurement networks and models. In particular, models need information concerning emission sources. In the same Directive (Art. 7 and 8) it is stated that Member States must provide Action Plans and Restoration Programs for those areas that do not comply with air quality standards, containing information on pollutant sources (see Annex IV of the Directive), i.e.:

- list of the main sources of emission responsible for air pollution (map);
- total quantity of emission coming from these sources (t/y);
- information concerning pollution coming from outer areas.

It is then necessary to develop guidelines for the compilation of local emission inventories, setting up a specific method allowing consistency between European, national and local inventories and harmonisation among local ones.

Among local inventories a special role is played by urban ones. As a matter of fact, urban areas are those for which more often than for other contexts, air emission inventories are set up and used in the frame of air quality management plan, e.g. as input for air quality models.

These needs have already been addressed by the “Multiannual work programme (mid 1994 - mid 1999) of the European Environment Agency: Project IA 9”, concerning the compilation and use of environmental information in urban areas. The Project has the target of contributing to the production of information for implementing sustainable development policies in urban areas.

In the 1995/1996 work programme of the ETC on Air Emissions furthermore several tasks have been described related to urban inventories. This report forms the first result of these tasks. Subsequent reports will focus on the (preliminary) compilation of “top-down” urban inventories, as described in this report, and a (preliminary) catalogue of existing urban inventories, in co-operation with the ETC on Air Quality.

2. THE ROLE OF URBAN EMISSION INVENTORIES IN AIR QUALITY MANAGEMENT

2.1 Specificity of urban inventories

Urban areas have long been characterised by serious air pollution problems because of the amount and the density of pollution sources, particularly vehicles, residences and industries. Although the present situation seems to be less serious, at least for some pollutants and areas, thanks to the improvement in abatement strategies, pollution concentrations in many European urban areas still often exceed air quality standards and guidelines.

National and local Governments are reacting with a range of control measures. At national level focus is mainly on technology measures, either directly or through the fixation of emission standards (catalytic converter, clean fuels). At local level focus is mainly on traffic management and collective transport promotion. The setting up in some countries of air pollution alert thresholds with special reference to urban areas has stressed the need to have complete and reliable analysis of air quality in urban areas in order to improve air quality management techniques.

Because of the complexity of urban systems, air quality management in these areas is still a serious problem. Since the 1970s, national air pollution policies have tended to focus on the control of six of the most serious urban pollutants: particulate (smoke and soot), sulphur dioxide (SO_2), nitrogen oxides (NO_x), ozone (an indicator of photochemical smog), carbon monoxide (CO) and lead. Since these substances cause effects on health and environment, most industrialised nations, and many developing countries, have set legal air quality standards for some or all of them. There is now increasing attention towards micropollutants, like toxic organics and heavy metals.

Urban emission inventories are an essential tool for the management of air quality at this scale. They are one of the input required for running dispersion and transformation models. To this aim a high temporal and spatial resolution is normally required. Moreover, for local administrations urban inventories represent, a useful diagnostic tool through the identification of the main sources responsible for air quality deterioration. In this way, decision-makers are able to identify those sectors and pollutants in which control actions are more cost-effective or, more generally, best suited to be implemented. Inventories detailed in space and time resolution are useful to local Government to identify critical areas and time periods in which to focus the interventions. The possibility, when time series are available, to make comparisons among emissions calculated in different years, may allow local decision makers to assess the results of the abatement policies adopted.

An information system related to urban emission inventories, should be able to supply:

- a reliable estimate of total emissions of most relevant substances;
- their spatial and temporal distribution;
- their distribution by economic sectors and human activities;
- the evolution in time of emissions and their distribution;
- identification and characterisation of main relevant point sources in urban areas.

Table 1 (reported in "Europe's Environment: The Dobris Assessment" published by the European Environment Agency) shows the main sources for the different pollutants affecting air quality in urban areas. In non-industrial cities, the largest contributions come from local traffic and domestic heating especially when oil, coal or wood are used.

Table 1 - Main emission sources for the different pollutants

Source category	*SO_2*	*NO_2*	*CO*	*PM[1]*	*Organics*	*Pb*	*Heavy metals[2]*
Power generation (fossil fuel)		Δ	Δ				Δ/•
Space heating							
- coal	•	Δ	•	•	•/Δ		Δ/•
- oil	•	Δ					
- wood				•	•/Δ		
Road transport							
- petrol		•	#		•	#	
- diesel	Δ	•		•	•		
Solvents					Δ		
Industry	Δ	Δ	Δ	Δ	Δ	Δ	•/#

Notes:

Δ Between 5 and 25% of total emissions in commercial non-industrial cities

• Between 25 and 50% of total emissions in commercial non-industrial cities

More than 50% of total emissions in commercial non-industrial cities

1 Particulate matter

2 With the exception of lead

Source: RIVM (in Europe's Environment: The Dobris Assessment)

2.2 Integrated assessment of air quality using models, inventories and measurements

It is widely accepted that air quality management at local level and particularly in urban areas must be based on the following three main tools:

Air quality measurements are usually performed by means of air quality networks, consisting of a number of fixed measuring points, whose measurements are systematically collected and analysed. These continuous measurements can be integrated by "ad hoc" measurements performed via mobile stations or devices. Usually air quality networks are managed at local level (urban areas or provinces); therefore there is a need for harmonisation at regional, national and European level.

Dispersion models are mathematical tools that, starting from emission inventories and meteorological description of the area under analysis, allow an estimate of the air concentration and soil deposition of the considered pollutants.

Emission inventories are the third essential tool for the management of air quality at local level. These are in fact, as already pointed out, one of the input required for running dispersion models. To this aim an high level of spatial and temporal disaggregation of data is usually required.

Accurate emission inventories are also important in emission forecasting and scenario analysis, when changes in technologies, vehicle use and fuel consumption are to be incorporated into urban air quality models.

3. AIMS OF THE REPORT

Consistent information on pollution sources, emissions, air concentrations, exposure and health effects, and their interconnections is not yet available at a satisfactory level at urban scale in Europe. In particular emission information for major European cities (more than 250.000 inhabitants) is often of poor quality: missing entirely, or incomplete, non-documented, non-harmonised, and often inconsistent with air quality information. In order to obtain a consistent and regular assessment of air quality for European cities, there is a need to monitor, collect and evaluate data on emission sources, air pollution, human exposure and health effects in an harmonised manner at European scale.

The main aim of this report is to start a process of harmonising European urban air emission inventories. It contains four main contributions in order to achieve the above mentioned target:

- a first draft of "Guidelines" for harmonised European urban inventory preparation and use (chapter 4). The chapter can also be considered as a first draft of the ETC/AE contribution to the "Guidance report on supplementary assessment under EC Air Quality Directives";

- a proposal for an information sheet for urban inventories catalogue (chapter 5), where an attempt is made to collect all the relevant information concerning an urban emission inventory in order to obtain an European view of the present situation;

- an example catalogue (chapter 6) of urban inventories: to test the proposed information sheet an application is made with few existing urban inventories (already available to ETC/AE);

- from CORINAIR to urban inventories: a top down approach (chapter 7). The chapter outlines the existing situation in this field and put forward some methodological considerations, trying to highlight pros and cons of the approach.

4. GUIDELINES

The aim of this chapter is to provide general guidelines for the compilation and the utilisation of urban emission inventories. The contents of the chapter are to provide basic material to the preparation of the "Guidance Report on supplementary assessment under EC Air Quality Directives" Chapter 3 (Human activity and emission inventories).

The contents of this chapter will be oriented to the scope of the Guidance Report, which are schematically to provide criteria, procedures and methodology for:

- preliminary assessment (following FWD, article 5);
- assessment supporting further station siting optimisation of (mandatory) measurements;
- assessments supporting generalisation of (mandatory) measurements.

Referring to the environmental theme "air quality", the joined and the integrated use of emission data, measures and modelling will be emphasised.

Concerning emissions, the primary objectives are to produce an emission map of the zone. This map provides basic information needed to run simple models for calculation of the concentration of air pollutants. This means that the specifications of the emission inventory should be determined by the input requirements of the model and hence indirectly by the chemical, spatial and temporal resolutions of the air quality characterisation requested by the directives.

In a number of cases peak concentrations (both in space and in time), whose calculation in principle requires emission inventories with very high space and time resolution, may be assessed on the basis of more aggregated emission information using statistical information on the time and space variation of these emissions. For secondary pollutants, such as ozone, nitrogen dioxide, and sulphate or nitrate particulates, more complex models are needed requiring data on emissions of so-called precursors, from which the pollutant is formed by chemical conversion.

For the purpose of comparability of the data, it is necessary to use a standard methodology, harmonised at the European level.

The supplementary assessment has to be done using specific local inventories, where available. For the areas, particularly the urban ones, where specific inventories do not exist, indications on the way to use CORINAIR data should be provided, due to the fact that this is the main programme on emissions inventories harmonised at the European level and maintained by the EEA/ETC.

Within CORINAIR project a complete, consistent and transparent emissions database for all of the European territory for the base year 1990 and 1994 is available. As from now, this database will be updated every year.

It is recommended to use the CORINAIR database directly to calculate background concentrations, resulting from emissions outside the region under study.

The contents of this chapter will also provide the basis on which to define the activities for setting up the *"Guidelines for the compilation of urban inventories"* at the European level.

4.1 General Methodology

An emission inventory can be defined as a collection of data representing an emission (to air) each having a certain relevance along the following dimensions:

- chemical identity: characterises the chemical properties of the pollutant;
- activity or technology: characterises the cause of the emission and relates it to (human economic) activity;
- emission type and location (e.g. (elevated) point, line, area source): describe the location on the map and the height of the release (stack height);
- space distribution of the emission;
- time distribution of the emission.

Below these dimensions will be shortly discussed in relation to the use of the inventory for air quality assessment.

Chemical identity: the pollutants (or pollutant classes) considered in the inventory. Which pollutants (or pollutant classes) are included in the inventory depends on the considered environmental theme. Air emission data are relevant for five themes:

- climate change
- ozone depletion
- acidification
- air quality
- tropospheric ozone.

Focusing on the air quality theme, the relevant pollutants (or pollutant classes) to be considered are: SO_2, NOx, VOCs, (fine) Suspended Particulate Matter (SPM), CO. Among VOCs, some substances are relevant with regard to their effects on health (e.g. Benzene), others for their chemical reactivity (ROGs reactive organic gases) related to ozone and other photochemical pollutants production. For the last mentioned phenomena speciated VOC-emissions are required. Other relevant pollutants for their effects on health are heavy metals (HM) such as Pb, Hg, Cd, As, Ni, and persistent organic pollutants (POP) such as policyclic aromatic hydrocarbons (PAH) and dioxins. A number of these pollutants is available in CORINAIR90, more will be available in CORINAIR94. In some cases however (benzene, speciated VOCs) additional information is needed. No standardised methodology has been developed so far.

Activity or technology: an emission source nomenclature is needed that includes anthropogenic and natural activities. The SNAP94 (Selected Nomenclature for Air Pollution) developed by the EEA (ETC/AE) is the most complete list presently available. This nomenclature is used for the CORINAIR94 inventory by the 18 EEA member countries. Together with SNAP94, use of the joint EMEP/CORINAIR "Atmospheric Emission Inventory Guidebook" is advised.

Emission type and location: in air quality assessment point, line and area sources are usually considered. Mobile sources on main transportation networks can be treated as line sources, while many small size fixed sources (e.g. stacks for domestic heating) and mobile sources on local network are included in area sources, and their relevant emissions can be reasonably distributed on a surface. A line source and an area source are a statistical description of a large number of relatively small point sources. Whether or not such a group of small sources can be described as line or area source, depends on the spatial solution required. Hence, the classification of point, linear and area sources is not strict: it depends on the scope of the assessment and on cost-effective considerations. In fact, line sources at microscale level (urban canyon) can be assimilated into an area source at local and regional level; a point source at local level can be assimilated into an area source at transboundary level. A point source is characterised, as well as by localisation, by the stack height and diameter, flue gases temperature and velocity. In the frame of the supplementary assessment there is the need to define point sources thresholds.

Space distribution of the emission: high or low spatial resolution of emission data is one of the most important dimensions which characterise emission inventories. To provide a microscale or a local scale assessment, an inventory with high spatial resolution is needed. To estimate background concentration, inventories with not very high spatial resolution are sufficient. The estimate of the total amount of pollutant emitted per year per any single city of more than 250.000 inhabitants can be acceptable as preliminary assessment referring to the situation in European cities.

Time distribution of the emission: also in this case the distinction between high and low time resolution of emission data is important. For microscale or local scale estimation, as well as for the simulation of air pollution episodes, high time resolution emission inventories are needed. To estimate background concentration of primary pollutants a lower temporal resolution is sufficient. To this aim, the distinction between continuous and discontinuous sources, taking into account seasonal variations, can be the appropriate one.

Data used to compile emission inventories can originate from a wide range of sources: in the case of large point sources, actual continuous measurements are usually available; emission estimate may also be based on discontinuous measurements or on emission factors. For many activities direct measurements are not available, therefore there is a wide utilisation of emission factors in the compilation of emission inventories, especially referring to those activities characterised by distributed emission (e.g. traffic, domestic).

Generally, emission factors depend on a series of parameters which characterise the activity and/or the technology, or in the case of natural emissions, the specie type and meteorological

conditions. Emission factors allow estimation of the emission on the base of activity indicators which are quantitative parameters strictly related to the emission (i.e. fuel consumption for energy production, traffic car mileage for road transport, production in industrial processes); the joint EMEP/CORINAIR "Atmospheric Emission Inventory Guidebook" published by the European Environment Agency represents a rather comprehensive guide to the state of the art of atmospheric emission inventory methodology, including emission factors related to the SNAP94 activities. For some activities (e.g. traffic) the emission estimate needs an iterative process to calculate the indicators (vehicles mileage) and the emission factors (as a function of average speed for different vehicle categories and classes); in these cases the development of specific models for emission estimates is suitable (see COPERT for traffic emission estimate in CORINAIR).

4.2 Uncertainty Assessment

Uncertainty is a statistical term that is used to represent the degree of accuracy and precision of data; it often expresses the range of possible values of a parameter or a measurement around a preferred value. However, the available data is not always sufficient to develop statistical measures of the data accuracy; in these cases subjective rating schemes and evaluations are used to describe the relative confidence associated with specific estimates. In the joint EMEP/CORINAIR "Atmospheric Emission Inventory Guidebook" and particularly in the chapter on "Verification concepts" suggestions are provided in detail for procedures and techniques that can be used to assess the validity of the emission data included in inventories. Below are reported from the Guidebook some relevant definitions of key terms used in the inventory verification.

Accuracy Accuracy is a measure of the truth of a measurement or estimate. The term accuracy is often used to describe data quality objectives for inventory data, however, accuracy is hard to establish in inventory development efforts since the truth for any specific emission rate or emissions magnitude is rarely known.

Precision The term precision is used to express the repeatability of multiple measurements of the same event. In experimental applications a measurement or measurement technique could have high precision but low accuracy. The term precision is also used to describe the exactness of a measurement. The term precision is not well suited for use in emissions inventory development.

Confidence The term confidence is used to represent trust in a measurement or estimate. Many of the activities discussed in this chapter are designed to increase the confidence that inventory developers and inventory users have in the databases. Having confidence in inventory estimates does not make those estimates accurate or precise, but will help to develop a consensus that the data can be applied to problem solving.

Reliability Reliability is trustworthiness, authenticity or consistency. In the context of emissions inventories reliability and confidence are closely linked. If the approaches and data

sources used in an inventory development project are considered reliable, then users will have an acceptable degree of confidence in the emissions data developed from those techniques.

Uncertainty Uncertainty is a statistical term that is used to represent the degree of accuracy and precision of data. It often expresses the range of possible values of a parameter or a measurement around a mean or preferred value.

Validation Validation is the establishment of sound approach and foundation. The legal use of validation is to give an official confirmation or approval of an act or product. Validation is an alternate term for the concept of verification as used in this context.

Verification The term verification is used to indicate truth or to confirm accuracy and is used in this chapter to represent the ultimate reliability, and credibility of the data reported.

The reliability of the information provided by emission inventories is strongly biased by a wide range of causes. Particularly, when the emissions are estimated through emission factors the following points have to be taken into account:

i) uncertainty related to the choice of the indicators;

ii) uncertainty related to the quantitative value of the indicators;

iii) uncertainty related to the emission factors;

iv) uncertainty related to the structure of emissions estimate models (e.g. in the case of traffic or natural emissions).

A careful assessment of the elements listed above allows identification of the substances, the activities and the areas where, on the basis of the primary information used (indicators, emission factors), data on emissions are more or less reliable. The reliability of data usually decreases (growing uncertainty) according to the fact that emission factor is drawn from:

- *in situ* measurements on similar sources;
- national "handbook";
- joint EMEP/CORINAIR "Atmospheric Emission Inventory Guidebook", other international information sources (e.g. US-EPA).

Further evaluations on the uncertainty linked to the emission estimates can be performed on the basis of:

- completeness and coverage (for each substance are all relevant sources included? What is the relative weight of the missing sources?);
- analysis of the relative weight of different activities/emission sources typologies, with respect to the total emission;
- sensitivity analysis;
- uncertainty analysis;
- comparison of alternative estimates;

- use of dispersion models and comparison with concentration measurements;
- joined use of two or more of the above mentioned methods.

Completeness: the aim of this analysis is to verify that all the activities, anthropogenic as well as natural, generating emission of a certain substance have been considered; or at least, that the activities not considered are negligible with respect to the spatial and time scale under consideration.

Relative weight of different activities or emission sources typologies: different activities and emission sources (point/area sources; elevated/low sources) may play quite a different role as regards to the substances and the scale of pollution phenomena in the spatial context under analysis; assessment studies are generally intended to provide the background understanding of the primary causes of the air quality problems being evaluated; they are useful to confirm that the largest or most significant sources have been identified in the emission inventory. For the most important sources in terms of activity/typology a more refined uncertainty analysis will be carried out.

Sensitivity analysis: this is particularly useful to assess the estimation carried out by emission models (e.g. emissions from road transport vehicles and from nature). Through the variation of emission estimates obtained by changes in the value of single parameter it is possible to identify the "critical parameters" whose variations are relevant on emission estimate. The attention should be focused on these parameters to improve the emission estimates.

Uncertainty analysis: uncertainty estimates for emissions data are important for assessing both the inherent uncertainty of the emissions estimates for individual facilities and the range of emissions magnitude represented by all sources in a study area; to proceed in these analysis, information on the distribution of parameter values, or at least on their range, is needed. The aim is to evaluate the variability, and hence the uncertainty, related to the emission estimation. The reliability of the estimation depends on the quality of the existing information on the parameters; the distribution/range of the values of these parameters can be inferred:

- from experimental measurements more or less *close* to the case under study;
- on the basis of experts' *subjective* evaluation;
- from a *mix* of the two approaches.

The chapter Verification concepts of the "Atmospheric Emission Inventory Guidebook" provides a methodology for representing the overall quality of the databases; when it is not possible to apply probabilistic methods (i.e. Monte Carlo procedures), a data quality rating procedure is recommended. Each emission factor is assigned a data quality rating according to the following definitions:

A. an estimate based on a large number of measurement made at a large number of facilities that fully represent the sector;

B. an estimate based on a large number of measurements made at a large number of facilities that represent a large part of the sector;

C. an estimate based on a number of measurements made at a small number of representative facilities, or an engineering judgement based on a number of relevant facts;

D. an estimate based on a single measurements, or an engineering calculation derived from a number of relevant facts and some assumptions;

E. an estimate based on an engineering calculation derived from assumptions only.

Each activity data is assigned a letter data rating (A to E) giving an idea of high or low precision. Letter C is applied if the data are taken from a published source such a Government statistics or Industry Trade Association figures; other ratings apply relating to C value.
The combination of these ratings supply the overall quality rating of emission data; "Atmospheric Emission Inventory Guidebook" contains the schedule list of combination of the ratings and some more consideration about the methodology approach.
It is possible to associate to each final rating (from A to E) percentages that define a range of possible values of the estimation, as follows:

Rating	**Typical error ranges**
A	± 10 to 30 %
B	± 20 to 60 %
C	± 50 to 150 %
D	± 100 to 300 %
E	± order of magnitude

The "Atmospheric Emission Inventory Guidebook" presents a default table for quality ratings for each relevant pollutant at the level of the 11 main activity sectors in CORINAIR.

Comparison of alternative estimates: various alternative approaches for estimating emissions can be used to derives independent estimates of emissions. These estimate can then be compared to each other to obtain information about the degree of agreement among them. A list of possible data comparison type includes top-down versus bottom-up approach comparison, alternative estimates methods and emission factors comparisons.

Use of dispersion models and comparison with concentration measurements: a possible verification of the emission inventory consists in the utilisation of the inventory as input for dispersion and transformation models and in the comparison of the model output with experimental concentration measurements. For a correct application of this procedure several elements have to be taken into account:

- uncertainty linked with meteo information and model structure: the final objective is the evaluation of the emission data uncertainty, but uncertainty related with meteorological data and with the model structure must not be disregarded; meteo data can be affected by uncertainty as well as emission data; moreover the uncertainty linked to the assumptions and the approximations of the model itself must be accounted for. Summing up, there are at least three sources of uncertainty respectively related with emission data, meteorological data and the model structure: all the causes must be considered in a uncertainty assessment;

- consistency, reliability and representativity of the measurements with which to compare the model output: measurements must be of a good quality; the comparison between estimate/measured concentrations has to be done on a relevant number of points; spatial representativity of the measurements must be homogeneous with spatial resolution of the model.
- "performance" indicators are needed to evaluate the output of the model.

Actually the uncertainty assessment requires an integrated utilisation of an *appropriate mix* of the above mentioned methods. The choice of the methods depends on the availability of information and resources. As mentioned above, in any uncertainty assessment the sources and quality of information used to provide emission data cannot be ignored; this screening analysis consent to identify emission data more or less reliable in terms of quality. Direst test or series of direct source testing is the preferred emission validation technique; in combination with statistical uncertainty estimates are the most desirable and highest priority methods for emission inventory validation. When information and data are not available to apply statistical uncertainty estimates, quality rating approach is useful and supply a desired approach to emission validation. The analysis of the relative weight of different activities/typologies of emission sources is a further step which should be done in any case within the process of uncertainty assessment. Other analyses among the mentioned ones are desirable depending, as already said, on the availability of information and resources.

5. PROPOSED INFORMATION SHEET FOR URBAN INVENTORIES

For several purposes it is useful to have an overview of existing information on urban inventories (or “meta-data”, for example about what is where). Here a proposal is presented for relevant information which could be collected by ETC/AE. The results could then be stored in a “catalogue”, as a (“meta”-) database. This could for example be linked to the EEA’s general project on catalogue of data sources (CDS). It still has to be decided by the EEA whether such a database should be developed and if so in what form.

Emission inventories are characterised by the following elements:

General references:

a) City;

b) Agency and Office in charge for the inventory and contact person;

c) Year;

General elements:

d) Spatial domain (i.e. urban area, municipality, province, region);

e) Time domain (i.e. years considered);

f) Pollutants (conventional pollutants, micropollutants, greenhouse pollutants);

g) Emission sources classification:
   - g1) per activities (i.e. SNAP nomenclature)
   - g2) per typology (point, linear, area)

h) Space resolution (i.e. 1 km x 1 km grid, municipalities, provinces.);

i) Time resolution (i.e. 1 hour, 1 months, 1 year);

Usability:

l) Aims (i.e. model input, check/verification of emission levels);

m) Sources of emission data: activities/sources whose emission are:
   - m1) continuously measured;
   - m2) estimated on the basis of discontinuous measurements *in situ*;
   - m3) estimated on the basis of emission factors drawn by:
     - m3.1) on the basis of measurements on similar sources;
     - m3.2) national "handbook";
     - m3.3) joint EMEP/CORINAIR "Atmospheric Emission Inventory Guidebook", other international information sources (e.g. US-EPA)

n) completeness: if for any substance all relevant sources have been included or if the explained" share of emission has been calculated;

p) Uncertainty: for any pollutant and activity/source:

- p1) sensitivity analysis related to the parameters which influence the emissions: it aims to identify, for any activity/source, the "critical parameters" in the emission calculation;
- p2) uncertainty assessment (i.e. in terms of percentage range +/-x%, in terms of probability distribution, data quality ranking;

q) Characterisation of sources typology:

- q1) point sources: localisation, height and diameter of stacks, smoke temperature and speed, average height of surrounding buildings;
- q2) linear sources: localisation, average width, typology (canyon), average roughness of surrounding area, land use of surrounding area (urban, rural);
- q3) area sources: localisation, average roughness of surrounding area, land use of surrounding area (urban, rural);

r) Kind of equipment:

- r1) personal computer, software standard (i.e. excel, DB3)
- r2) personal computer/workstation with DBMS (i.e. ORACLE)

s) Links with GIS (i.e. ARC-INFO)

t) Links with models:

- t1) at microscale level (i.e. urban canyon)
- t2) at local scale (i.e. single or multiple point sources, multisources models)
- t3) at regional scale (i.e. photochemical models)

u) Operativity/maintenance/updating:

- u1) information updating (i.e. not up-to-date, by "ad hoc" survey, through consolidate protocols and continuous information flows, mixed;
- u2) time range of information updating (i.e. yearly, four years);
- u3) hardware and software maintenance/updating (i.e. periodical, episodic);
- u4) kind of users;

v) Accessibility (data access facility/network system/internet);

Performances

w) Quality control/quality assurance, check of information;

y) Assessment/validation of information by:

- y1) completeness;
- y2) relative weight of different activities or emission sources typologies;
- y3) sensitivity analysis;
- y4) uncertainty analysis;
- y5) use of models and comparison with concentration measurements;
- y6) comparison of alternative estimates (top-down versus bottom-up approach, alternative estimates methods, emission factors comparisons);
- y7) use of mixed methods.

6. EXAMPLE INFORMATION SHEET

General references:

a) City: *ROME*

b) Agency and Office in charge for the inventory and contact person:
AMMINISTRAZIONE PROVINCIALE ROMA - SERVIZIO TUTELA ARIA
dott.POLESI/ing.VESSELLI tel.+39-6-4511212/4513098, fax.+39-6-4512534,e-mail

c) Year: *1993*

General elements:

d) Spatial domain (i.e. urban area, municipality, province, region): *PROVINCE*

e) Time domain (i.e. years considered): *1990*

f) Pollutants (conventional pollutants, micropollutants, greenhouse pollutants):
SOx, VOC, NOx, CO, TSP

g) Emission sources classification:

g1) per activities (i.e. SNAP nomenclature):
ECONOMICAL ACTIVITIES CLASSIFICATION (from National Statistical Institute- ISTAT) + SNAP 90

g2) per typology (point, linear, area):
POINT SOURCES (>25 TONS PER POLLUTANT; >5MWt)
LOCALISED (25> t >5 TONS PER POLLUTANT)
LINEAR (HIGHWAYS; NATIONAL ROADS)
AREA (ALL OTHER)

h) Space resolution (i.e. 1 km x 1 km grid, municipalities, provinces.):
MUNICIPALITIES + ROME ADMINISTRATIVE DISTRICTS

i) Time resolution (i.e. 1 hour, 1 months, 1 year): *YEAR*

Usability:

l) Aims (i.e. model input, check/verification of emission levels):
AIR QUALITY RESTORATION PROGRAM;
INDUSTRIAL PERMITS DATA MANAGEMENT;

m) Sources of emission data: activities/sources whose emission are:

m1) continuously measured: *NOT AVAILABLE*

m2) estimated on the basis of discontinuous measurements *in situ*:
LARGE POINT SOURCES

m3) estimated on the basis of emission factors drawn by:
m3.3)**:** *ALL OTHER SOURCES: CORINAIR, US EPA*

n) Completeness: if for any substance all relevant sources have been included or if the "explained" share of emission has been calculated: *QUITE GOOD*

p) Uncertainty: for any pollutant and activity/source:

p1) sensitivity analysis related to the parameters which influence the emissions: it aims to identify, for any activity/source, the “critical parameters” in the emission calculation:

NOT PERFORMED

p2) uncertainty assessment (i.e. in terms of percentage range +/-x%, in terms of probability distribution, data quality ranking):

DATA QUALITY RANKING

q) Characterisation of sources typology:

q1) point sources:

ANNUAL EMISSIONS, LOCALISATION, HEIGHT AND DIAMETER OF STACKS, SMOKE TEMPERATURE AND SPEED

q2) linear sources:

ANNUAL EMISSIONS, LOCALISATION, TYPOLOGY (URBAN, EXTRAURBAN, HIGHWAY), TRAFFIC FLOWS

q3) area sources:

ANNUAL EMISSIONS

r) Kind of equipment:

r2) *IBM RISC 6000, AIX V.3*

s) Links with GIS (i.e. ARC-INFO): *GEODIS 6000*

t) Links with models:

t3) at regional scale (i.e. photochemical models): *IN PROGRESS*

u) Operativity/maintenance/updating:

u1) information updating (i.e. not up-to-date, by "ad hoc” survey, through consolidate protocols and continuous information flows, mixed): *AD HOC*

u2) time range of information updating (i.e. yearly, four years,..): *NOT YET SCHEDULED*

u3) hardware and software maintenance/updating (i.e. periodical, episodic): *EPISODIC*

u4) kind of users: *PROVINCE OFFICIAL*

v) Accessibility (data access facility/network system/internet)

COMPATIBILITY WITH SINA (INFORMATIVE SYSTEM OF THE MINISTRY OF THE ENVIRONMENT)

Performances

w) Quality control / quality assurance, check of information;

CHECK OF THE PROVINCIAL FUEL CONSUMPTION BY SECTOR

y) Assessment/validation of information by:

- y1) completeness: *YES*
- y2) relative weight of different activities or emission sources typologies and assessment studies: *YES*
- y3) sensitivity analysis: *NO*
- y4) uncertainty analysis: *NO*
- y5) use of models and comparison with concentration measurements: *NO*
- y6) comparison of alternative estimates (top-down versus bottom-up approach, alternative estimates methods, emission factors comparisons): *NO*
- y7) use of mixed methods: *NO.*

7. FROM CORINAIR TO URBAN INVENTORIES: TOP-DOWN APPROACH

Local inventories are being compiled for urbanized areas in the frame of specific projects across Europe. Most of them have been prepared for air quality management purposes, although some have different objectives (e.g. energy planning, industrial permits data management, etc.). Thus, the inventory structure changes according to the specific purpose of the inventory: this makes verification and comparisons very difficult. Another difficulty is that the CORINAIR 85 and 90 inventories have seldom been used as general reference methodology or for consistency checks in the preparation of emission data at regional/local level: the 1987 inventory for Alsace and the 1990 Italian provincial inventories for Bologna, Florence, Rome and Venice are among the few examples where CORINAIR methodology has been adopted.

To provide a first screen on air emission situations in European urban areas in order to identify "hot spots" where more detailed analysis is needed, it is possible to define an agreed methodology of **a top-down approach** to estimate emissions in urban areas starting from the existing CORINAIR emission data (90 and then 94) at territorial level NUTS3 and for the compounds included in these inventories. This approach will have to take into account the most important methodological differences existing in compiling an urban inventory and a national one (as described in paragraph 7.1), in order to obtain more reliable figures.

7.1 General issues

Spatial coverage of the inventory
The spatial disaggregation used by CORINAIR is based on 'NUTS' level 3. These have the advantage to be defined throughout EU. However, as already mentioned in the "Review of CORINAIR 90 - Proposals for Air Emissions 94" published by the European Environment Agency, the NUTS regions may not be ideal for air pollution assessment at urban scale, as they may not coincide with urban areas. For example, the NUTS level 3 region for London (UK) or Milan (Italy) is more or less coincident with the urban area. However, in Spain the area including Barcelona includes also a large rural area. Thus, the CORINAIR 90 inventory, as it is, cannot be used to supply good information about urban areas throughout EU. It needs some further characterisation beyond NUTS3 level to know the degree of "urbanisation" of these areas.
A general definition of urban areas could facilitate the preparation of comparable inventories in terms of spatial coverage (of course, such a definition should be established according with official legislative rules).

Substances
Besides differences in the above-mentioned spatial coverage, local inventories may differ from CORINAIR 90 inventories in several other ways. For example, they may consider additional pollutants, e.g. particulate, heavy metals, POPs, HCl. These are not included in CORINAIR 90, but they are interesting at a local level. CORINAIR 94 includes the most

important HM and POPs; problems will arise regarding benzene, PM10, and NMVOCs speciation e.g. with reference to chemical and photochemical reactivity. There is a need for some more information on emission of these compounds.

Emission generating activities
Concerning the nomenclature of activities, SNAP is a flexible tool for identifying air pollution sources. Local inventories often consider other more specific source categories, identified on the basis of the relative importance of each category's contribution to total emissions of a particular pollutant. Emissions from new activities, proposed by CORINAIR experts, have often proved negligible, both at national and local level: e.g. emissions from skin and leather industry and shoes industry account respectively for 2.2% and 0.4% of total NMVOC emissions in the inventory for the province of Florence, where these activities are particularly relevant; probably, these emissions may be significant at a more local level. As SNAP 94 has been further on extended with respect to SNAP 90, and now includes more than 300 emission generating activities, it seems detailed enough to satisfy the needs of most local inventories. Furthermore CORINAIR 94 revised system will permit to relate SNAP to ISIC classification; this will increase the possibilities of comparison among local inventories, due to the fact that several of them refer to economic sector nomenclature. It should be noted that the EEA is working together with Eurostat on several projects (pollutant and source nomenclatures) which will result in a consistent and commonly accepted transformation of all SNAP categories (technologically oriented) into economic source sectors by the end of 1996.

A shortcoming of SNAP is that different abatement and/or process technologies within a certain SNAP activity are presently not systematically dealt with. This will be improved in the future. It will consent to evaluate the effects of alternative technological options.

Types of sources
Area sources and point sources are insufficient for most uses of urban and regional inventories. Italian provincial inventories have also considered line sources, corresponding to the main communication ways (roads, railways, rivers, seaways).

Thresholds must be defined for linear and point sources. In principle, they should be identified case by case, considering the specific nature of pollution problems in the area; this has proved quite difficult without any previous information on emission sources. For this reason, standard thresholds have been defined for linear sources, for point sources and for point combustion sources as for example in the Clear Air Act Amendments of 1990 approved by the U.S. Congress, or as in the Italian Ministry of Environment Decree on criteria for air quality management of 1991; in the last one, for example, thresholds at an urban level are suggested to individuate point sources (25t of emissions per year) and point combustion sources (1 MWt). To facilitate comparability it could be useful to identify thresholds according to general classification of the area under consideration (urban, industrial, rural, etc.).

Further information, required for modelling purposes, concerns the effective emission height.

Traffic emissions
Urban inventories are often used to assess the effects of different measures aimed at reducing emissions from the transport sector (traffic restrictions or fluidity, improving the collective transportation system, renewal of car fleet, etc.).

Specific tools for the estimation of traffic emissions at local level need to be developed. It must be clarified, however, whether and where microscopic (street) or macroscopic (urban network) approaches for the description of vehicular traffic should be chosen and what kind of relationship can be established between macro and micro descriptions. Having in mind harmonisation also in this field, ETC/AE could define a set of common features for models aimed at the estimation of traffic emissions to be used for assessment of urban air quality, including the best available scientific information on a cost-effective basis.

Spatial and temporal disaggregation
Local inventories always require very detailed spatial and temporal disaggregation of emissions. Some refer to a standard grid, e.g. the 1 km x 1 km grid used in Austria for inventories prepared to forecast and control ozone concentrations; others may refer to administrative units within urban territory. Time scale often refer to 1 hour basis. Criteria for spatial and temporal disaggregation for each activity are defined within the EMEP/CORINAIR "Atmospheric Emissions Inventory Guidebook". The selection of proxy variables to be used for disaggregating pollutant emissions from the lowest Administrative level to the grid cell level is very important.

Consistency and completeness
Information required for compiling very detailed local inventories may not be so complete and reliable as that used at national level. This increases the need for systematic consistency checks (e.g. the available information on total energy consumption at local level should always be used to check data on combustion sources).

7.2 Methodology

In this chapter a methodology of **a top-down approach** is outlined to estimate emissions in urban areas starting from the existing CORINAIR emission data (90 and then 94) at territorial level NUTS3 and for the compounds included in these inventories; this approach will enable to realise, in a short time, an emission inventory of the main urban areas in Europe using already available data and taking into account the most important methodological differences existing in compiling an urban inventory and a national one (as described in paragraph 7.1), in order to obtain more reliable figures. Furthermore urban emission data will take into account the specifications required by ETC/AQ.

Top-down approaches
ETC/AE proposal to produce an inventory of urban emission could be based on WHO (World Health Organisation) developed methods on compiling urban inventories on the basis of CORINAIR data integrated with a top-down *pro-rata* approach, often used by CORINAIR to infer disaggregated regional/local emissions starting from national data using *proxy* variables.

Here first the WHO approach is described and then the proposed improved ETC/AE method, called “pro-rata” approach.

The **WHO approach** consists of:

- determining urban area and its geographic size on the basis of size of its population as in the following formula:

$$Radius\ (city) = constant * \sqrt{Population}$$

  where constant value 0,01km;

- allocating the contribution of **large point sources** to urban emissions, depending on whether their position is inside or outside a circle with the above radius;
- calculating the contribution of **area sources** on the basis of an interpretation of SNAP codes, dividing them in urban or non urban activities.

ECEH/WHO calculated emission of EU-12 main cities using an earlier CORINAIR 90 database, at level NUTS3.

The need for an improved method derives from two relevant problems in applying the WHO approach:

- more than one city may be situated in a NUTS3 area, and we need to know the share of the total urban emissions that has to be attributed to the selected cities;
- some SNAP activities must be considered (partially or totally) as urban in some context and not urban in others and we need to determine the amount of emissions that will be associated to the selected cities.

The **top-down *pro-rata* approach** involves disaggregating NUTS3 emission estimations to a local level (e.g. NUTS4) through the use of indicators of the proportion of a particular activity occurring in the specified local area using the following formula:

$$E_{urb,I} = E_{NUTS3,I} * S_{urb,I}/S_{NUTS3,I}$$

where:
$E_{urb,I}$ = urban emission amount (t/year) related to the activity I;
$E_{NUTS3,I}$ = NUTS3 emission amount (t/year) related to the activity I;
$S_{urb,I}$ = urban statistic (x/year) related to the activity I;
$S_{NUTS3,I}$ = NUTS3 statistic (x/year) related to the activity I.

It follows that the total urban emission, for each city, can be found by summing the estimates of the activities included in the inventory related to that city.

It is possible to identify proxy variables correlated to each sector, sub-sector or activity of the SNAP activities classification, for example: energy balance statistics on fuel consumption, that are well related to combustion sources of emissions, sectoral industrial production indexes, that are related to SNAP sectors such as production processes, solvent use, waste

treatment and agriculture. Furthermore indicators such as population data, car registration, air-ship-passengers traffic, products consumption (e.g. paint consumption), GWh of electricity generated and sectoral economical indicators have a high correlation with sector or specific activities of SNAP classification. When this information is available at a urban level, this allows to provide estimates of local emission magnitude and characteristics, which is more accurate than the WHO approach.

Urban activities

It is possible to supply a provisional list of typically urban activities or sub-sectors divided by sector following the SNAP classification (90 and 94) and referring to the area sources (point sources are allocated to urban areas following the "ad hoc" method proposed by WHO):

Public power, cogeneration and district heating plants
010200 District heating plants

Commercial, institutional and residential combustion plants
020002 Commercial, institutional and residential combustion plants (020100 and 020200 in SNAP94)

Solvent use
060103 Paint application - construction and buildings
060104 Paint application - domestic use
060408 Domestic solvent use
only in SNAP94:
060411 Domestic use of pharmaceutical products
060500 Use of N2O

Road transport
070103 Passenger cars: urban driving
070203 Light duty vehicles: urban driving
070303 Heavy duty vehicles and buses: urban driving
070400 Mopeds and motorcycles < 50 cm^3
070503 Motorcycles > 50 cm^3 : urban driving

Other mobile sources and machinery
080105 Household and gardening (080900 in SNAP94)

Waste treatment and disposal
090800 Latrines (091007 in SNAP94)

Nature
111000 Humans (not present in SNAP94).

Partial urban activities

The list of SNAP90/94 classification activities or sub-sector divided by sector that case by case could refer totally or partially to the urban area (again referring to the area sources) is as follows:

Production processes
040605 Bread
040606 Wine
040607 Beer
040608 Spirits
040611 Road paving with asphalt
040613 Glass

Extraction and distribution of fossil fuels
050503 Gasoline distribution - service stations
050603 Gas distribution networks - distribution networks

Solvent use
060102 Paint application - other industrial application (car repairing, boat building) (060102 and 060106 in SNAP94)
060201 Metal degreasing
060202 Dry cleaning
060403 Printing industry
060405 Application of glues and adhesives
060406 Protection of wood
060409 Vehicles dewaxing

Road transport
070101 Passenger cars: highway driving
070201 Light duty vehicles: highway driving
070301 Heavy duty vehicles and buses: highway driving
070501 Motorcycles > 50 cm^3 : highway driving
070600 Gasoline evaporation from vehicles (quasi totally urban)
only in SNAP94:
070700 Automobile tyre and brake wear

Other mobile sources and machinery
080200 Railways
080300 Inland waterways
080401 Marine activities: harbours (081000 in SNAP94)
080500 Airports (LTO cycles)

Waste treatment and disposal
090100 Waste water treatment (091002 in SNAP94)
090201 Incineration domestic/municipal waste
090205 Incineration of sludges from water treatment
090300 Sludge spreading (091003 in SNAP94)
090400 Land filling (091004 in SNAP94)
090600 Biogas production (091006 in SNAP94)
only in SNAP94:
090900 Cremation

Proposal for an inventory
The following inventory structure (Table 2) can be used to compile an inventory of European urban emissions, to satisfy the needs of the main users:

Table 2: Top-down European urban emission inventory structure

City	*area*	*population*	*pollutant*	*emission per SNAP sector*										
				1	2	3	4	5	6	7	8	9	10	11

where EUROSTAT database supplied the information about city, area and population, and EEA can now supply CORINAIR90 database at NUTS3 territorial level useful to estimate urban emissions for the 8 main pollutants (and by the end of 1996 CORINAIR94 database).

EUROSTAT was also able to supply information available to calculate urban emission estimates:

- location (longitude and latitude) of cities;
- area and population of NUTS3 regions;
- when available, indicators used in CORINAIR90 for emission estimates and other proxy variables both for NUTS3 and selected cities.

The availability of the following specific required data should be examined (for example at EUROSTAT):

- the size of the cities to select for the inventory will be probably more than 250,000 inhabitants;
- area size in km^2 of the cities could be estimated using above mentioned WHO formula;
- population should refer to the same year as the CORINAIR inventory (1990/1994);
- indicators and proxy variables data both at NUTS3 and city level should be referred to 1990/1994;
- because for the largest cities a higher spatial resolution is needed down to the order of 10×10 km^2, indicator and proxy variables data at urban district level are useful.

The following data are specifically required from the CORINAIR90/94 database:

- 11 sector split. This disaggregation of data satisfy the modellers´ temporal resolution requirements; they need time resolved emission patterns, which might be modelled according to the EMEP or LOTOS models;
- NUTS3 territorial emissions data (referred to the selected cities) by 8 main pollutant and referring to 1990 (or more for 1994);
- location (latitude and longitude) and emissions of the large point sources included in the NUTS3 areas considered;
- SNAP urban, partial urban and not urban activities classification;
- list of indicators or proxy variables for each urban activity to determine the share of urban emissions to attribute to the selected cities (both at NUTS3 and city level data may be provided by EUROSTAT);
- list of indicators or proxy variables for each partial urban activity used to determine the amount of emissions to attribute to the selected cities (both at NUTS3 and city level data may be provided by EUROSTAT);
- for road transport emissions to consider the specificity of various urban contexts (driving patterns, climatic conditions and orographic structure), it should be useful to define and quantify correction coefficients that account for the specifications.

In the following a proposed list of proxy variables for each urban and partial urban activity (with CORINAIR90 code), that can be used in the case that data on indicators of CORINAIR90 are not available for the selected cities, is given:

SECTOR/SUBSECT./ACTIVITY	INDICATOR	PROXY VARIABLES
Public power		
010200 District heating plants	Fuel consumption	Population, Gj amount
Commercial/residential combustion plants		
020002 Comm/resid combustion plants	Fuel consumption	Population, Gj amount
Production processes		
040605 Bread	Produced Quantity	Population, Industry prod.index
040606 Wine	Produced Quantity	Population, Industry prod.index
040607 Beer	Produced Quantity	Population, Industry prod.index
040608 Spirits	Produced Quantity	Population, Industry prod.index
040611 Road paving with asphalt	Coated surface	Km road, Area
040613 Glass	Produced Quantity	Population, Industry prod.index
Extraction/distribution of fossil fuels		
050503 Gasoline distr.-service stations	Sold Quantity	Mileage, Car registr., Population
050603 Gas-distribution networks	Supplied gas Quantity	Population
Solvent use		
060102 Paint-other industrial application	Paint consumption	Car registration, Population
060103 Paint-construction and buildings	Paint consumption	Popul, Area, Industry prod.index
060104 Paint application - domestic use	Population	Population
060201 Metal degreasing	Solvent consumption	Population, Industry prod.index
060202 Dry cleaning	Population	Population, Industry prod.index
060403 Printing industry	Ink consumption	Population, Industry prod.index
060405 Applic. of glues and adhesives	Applied Quantity	Population, Industry prod.index
060406 Prevention of wood	Solvent consumption	Population, Industry prod.index
060408 Domestic solvent use	Population	Population
060409 Vehicles dewaxing	Car registration	Population, Industry prod.index
Road transport		
070101 Passenger cars: highway driving	Mileage	Km highway roads in urban area
070103 Passenger cars: urban driving	Mileage	Car registration, Population
070201 LD vehicles: highway driving	Mileage	Km highway roads in urban area
070203 LD vehicles: urban driving	Mileage	Car registration, Population
070301 HD vehicles and buses: highway	Mileage	Km highway roads in urban area
070303 HD vehicles and buses: urban	Mileage	Car registration, Population
070400 Mopeds / motorcycles < 50 cm^3	Mileage	Car registration, Population
070501 Motorcycles > 50 cm^3 : highway	Mileage	Km highway roads in urban area
070503 Motorcycles > 50 cm^3 : urban	Mileage	Car registration, Population
070600 Gasoline evaporation	Mileage	COPERT value*(Popul., No.car)
Other mobile sources and machinery		
080105 Household / gardening	Fuel consumption	Population
080200 Railways	Fuel consumption	Km railways in urban area, railway passenger traffic
080300 Inland waterways	Fuel consumption	Km waterways in urban area, Ship passenger/goods traffic
080401 Marine activities: harbours	Fuel consumption	Ship passenger/goods traffic
080500 Airports (LTO cycles)	Fuel consumption	Air passenger traffic, No. flights

Waste treatment and disposal			
090100	Waste water treatment	Population	Population, Area
090201	Incin. domestic/municipal waste	Incinerated Quantity	Population, Area
090205	Incineration sludges	Incinerated Quantity	Population, Area
090300	Sludge spreading	Spread Quantity	Population, Area
090400	Land filling	Land filled Quantity	Population, Area
090600	Biogas production	Burnt Quantity	Population, Area
090800	Latrines	Population	Population, Area
Nature			
111000	Humans	Population	Population, Area

Software requirements

It is possible to consider the following activities in which software use is needed:

1. allocation of large point sources inside or outside cities, having coordinates of LPS and coordinates and radius of the cities;
2. allocation of distributed emissions to each considered city starting from emissions, indicators and proxy variables (typically population/area) at NUTS3 level and indicators and proxy variables at city level;
3. to produce a database available for general users containing the data of the inventory structured as shown above in Table 2;
4. to produce thematic maps showing the emissions in urban areas (total and by sector).

Point 1 and 2 can be performed by means of a standard spreadsheet software like Excel. For point 3 a database management system (like Access) can be considered. Point 4 needs a GIS system which can be easy to use like MAPINFO or sophisticated like ARCINFO, according to the quality and complexity of the representation.

Verification of the results

The urban inventory to be produced by ETC/AE needs a validation procedure involving the member states. To this aim the resulting database should be sent for comments to the national focal points and/or CORINAIR experts.

A further validation of the ETC/AE top-down urban inventories can be performed comparing the emissions estimated by top-down approach with the results of the bottom-up urban emission inventories collected in the context of the catalogue activity and other EEA projects (for example the Air Quality Monograph).

8. DISCUSSION AND CONCLUSION

Top-down and bottom-up urban inventories are complementary tools:

- top-down urban inventories as deduced from the CORINAIR inventory (1990/1994) give a complete but not detailed picture of the urban situation at European level;
- bottom-up urban inventories are usually more detailed and reliable if compared with the "top-down" corresponding inventories, but presently give an incomplete and not harmonised picture of the European situation.

The long-term target must be to have a complete picture of urban emissions through harmonised bottom-up urban inventories throughout Europe.

In the transient period, a cautious use of CORINAIR data may give a complete picture at European level: shortcomings of the approach, however, must not be disregarded.

At the same time the European catalogue of bottom-up urban inventories gives the state of the art of the situation in Europe, allows a consistency check of the top-down approach and constitutes the first step toward the harmonisation of bottom-up European urban emission inventories.

8.1 Future development

As for consistency and comparability, urban inventories should be harmonised with national and European inventories and hence the CORINAIR general methodology and nomenclatures should be used in urban inventories. To enable this, the joint EMEP/CORINAIR "Atmospheric Emission Inventory Guidebook" and other material produced by the ETC/AE will be made widely available and should be used as far as possible. However, ETC/AE activities may well be expanded in the field of urban emission inventories. In order to reach this aim, the following actions could be undertaken:

- define the state of the art of urban emission inventories through collection and analysis of the most relevant inventories that are being compiled across Europe;
- recognise possible users and analyse their requirements; this activity needs close contacts with the ETC/AQ as the main reference in this field;
- provide an assessment study, based on the available documentation, concerning the consistency and the comparability of the collected information, and how it responds to the user's requirements;
- define general characteristics of existing models for the detailed estimation of traffic emissions in urban areas in connection with air quality modelling activities (providing more detail than COPERT);
- provide guidelines for the production of local inventories ensuring their compatibility with each other and with national ones;
- identify criteria for verification of local inventories;

- define indicators in order to standardise the presentation and facilitate the comparison of regional/local inventory data.

Further discussion with national experts and guidance from the EEA is needed to determine methodological details to be considered in the development of the activities of the Air Emissions Topic Centre in this field.

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