EMISSION INVENTORY OF THE CITY OF MILAN:

FIRST STEPS TOWARDS THE BOTTOM-UP APPROACH

Silvia Moroni and Simone Casadei - *AMA, Mobility and Environment Agency, Milan (Italy)* - silvia.moroni@ama-mi.it; simone.casadei@ama-mi.it

INTRODUCTION

Emission inventory is an important instrument to address air quality policies at national and regional scale but also large urban areas need to know the contribute of different pollutant emissions sources in order to plan local scale and microscale interventions. In fact, to plan strategies for air quality improving, to carry out quantitative evaluations of traffic and energy policies or to give reasonable data input to the mathematical dispersion and chemical models (one of the decision support instruments) a detailed emission inventory is fundamental. The city of Milan is located in the centre of the Po Valley (North of Italy) - **Figure 1** - and represents the Lombardy Region capital city and economic centre (**Figure 2**). The population of the city is approximately 1.3 million inhabitants with a density population of 7'500 inhabitants/km^2, but the population of the town including the neighbouring municipalities is approximately 2.5 million inhabitants. Besides, nowadays the people prefer to live outside Milan even if they work in the town, so the number of residents in Milan is more and more decreasing but at the same time the number of journeys between the town and its surroundings is gradually increasing, leading problems of traffic congestion. Finally, the most part of tertiary and commercial activities are in Milan city, while numerous industrial activities take place mainly in the neighbouring municipalities. The orographical and meteorological conditions are favourable to pollutant accumulation in the low troposphere: flat area surrounded by high mountains, low winds with frequent high pressure and stagnating meteorological conditions, elevated solar radiation during summer, cold temperature during winter sometimes with fog. These conditions, together with the concentration of the human activities in the urban area, lead to a great number of exceedances of air quality EU Limit Values for PM10 and NO_2 specially in winter season and O_3 in summer.

Figure 1. Milan area orographical map

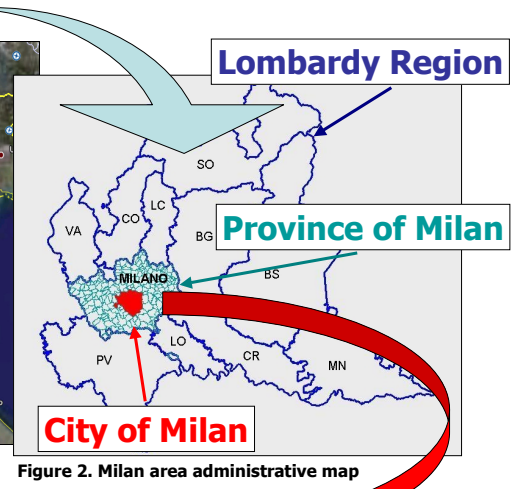

Figure 2. Milan area administrative map

FIRST DETAILED STUDY ON THE CITY OF MILAN: the Bottom-Up Approach

In order to obtain the best evaluation of the emission sources contribute in the urban area AMA - the local Mobility and Environment Agency of Milan - in cooperation with Galileo Ambiente s.n.c. has realized, for the Local Administration, the first detailed studies on its emission inventory focusing on the most important sources. This first study has regarded the following SNAP activities of the EMEP/Corinair Methodology:

- **Combustion in energy and transformation industries (Group 1)**
- **Non-industrial combustion plants (Group 2)**
- **Road Transport (Group 7)**
- **Waste treatment and disposal (Group 9).**

The reference year is 2005 and the considered pollutants are showed in **Table 1** together with the per cent contribution to total emissions of the Groups 1-2-7-9, obtained by the previous emission inventory taken as reference for the City of Milan (Province of Milan, 2000).

METHODOLOGY

Group 1 and Group 9 emission estimates are based on a specific source emission survey realized by sending questionnaires to the managers of various plants located within the Municipality, referring to the 2005 year. Detailed information have been gained on the source activity data (such as fuel consumptions and temporal disaggregation profiles) on pollutant abatement techniques and on specific emission factors (directly stack-measured for some pollutants). The plants, treated as point sources, are district heating plants natural gas fuelled (Group 1), solid waste incineration plants and waste water treatment plants (Group 9).

The Group 2 emission values have been obtained by fuel consumption estimates calculated by AMA using the most detailed available data for the Municipality, distinguishing < 3,5 kW from > 3,5 kW plants, characterized by different technologies and temporal profiles. These emissions are considered as an areal source at a district level.

The Group 7 emissions are evaluated by AMA using COPERT 4 Programme to calculate exhaust and evaporative emissions from Road Transport and EMEP/Corinair methodology for PM emissions from road abrasion. Detailed data on vehicle fleet composition, traffic counts, kinematic conditions and fuel composition are used in order to obtain the best available estimate on this important emission source.

The EMEP/Corinair Emission Inventory Guidebook (EEA, 2006) is taken as the reference for emission estimates methodology. Emission factors given by EMEP/Corinair Guidebook are integrated by emission factors deduced by stack-measurements or specific studies on local plants (national/regional/provincial level).

RESULTS

In **Table 1** are showed the results of the emission estimate conducted on the basis of this detailed study, that is the first attempt to compile the Milan urban emission inventory with a Bottom-Up approach. These results can be compared to those of other emission inventories available for the Municipality of Milan, obtained with Top-Down approach (listed in Figure 4 e Figure 5) in order to calibrate them and to start a reconciliation procedure on activity and emission data between Top-Down approach and Bottom-Up approach.

Table 1. Municipality of Milan, Year 2005. Total emissions by Groups 1, 2, 7, 9 calculated with Bottom-Up approach (Mobility and Environment Agency - AMA, 2007)

POLLUTANTS	CO	NO_x	SO_2	NMVOC	CH_4	COV	TSP	PM10	PM2.5
GROUP DESCRIPTION	ton/year	ton/year	ton/year	ton/year	ton/year	ton/year	ton/year	ton/year	ton/year
Group 1 - Combustion in energy and transformation industries	23	75	0	4	4	9	1	1	1
Group 2 - Non-industrial combustion plants	3,109	2,233	1,582	677	306	983	188	181	175
Group 7 - Road Transport	31,860	7,945	30	6,979	371	7,350	727	612	503
Group 9 - Waste treatment and disposal	24	401	7	9	709	717	0	0	0
TOTAL EMISSIONS (Groups 1-2-7-9)	35,015	10,654	1,618	7,669	1,389	9,058	917	795	679

Relative contribute to total emissions by previous Emission Inventory taken as reference (Province of Milan, 2000)	CO	NO_x	SO_2	NMVOC	CH_4	COV	TSP	PM10	PM2.5
	95%	92%	98%	42%	5%	28%	n.a.	98%	n.a.

POLLUTANTS	CO_2	N_2O	NH_3	GHG [CO_2 eq.]	Acidifying Substances	O_3 precursors
EMISSION GROUP	kton/year	ton/year	ton/year	kton/year	kton/year	ton/year
Group 1 - Combustion in energy and transformation industries	98	5	0	100	2	99
Group 2 - Non-industrial combustion plants	3,058	324	3	3,165	98	3,747
Group 7 - Road Transport	1,751	63	252	1,778	188	20,182
Group 9 - Waste treatment and disposal	664	48	13	693	10	510
TOTAL EMISSIONS (Groups 1-2-7-9)	5,571	440	268	5,736	298	24,538

Relative contribute to total emissions by previous Emission Inventory taken as reference (Province of Milan, 2000)	CO_2	N_2O	NH_3	GHG [CO_2 eq.]	Acidifying Substances	O_3 precursors
	77%	85%	60%	74%	91%	66%

CURRENT BEST EMISSION INVENTORY ESTIMATES FOR THE MUNICIPALITY OF MILAN

Year 2005

To obtain the per cent contribute by all the 11 Groups of EMEP/Corinair methodology on the Municipality of Milan for the year 2005 (**Figure 3**) - in order to gain an instrument to address local air quality interventions - AMA has combined the results of its detailed study on 1, 2, 7, 9 Groups with those of the most recent emission inventory available for the urban area: the Lombardy Region emission inventory 'INEMAR 2005' in public review (ARPA Lombardia, 2007). INEMAR 2005 pr data have been used with some calibrations in order to obtain a more reliable result. Road transport is the main source for CO (88%), NO_x (73%), TSP (71%), PM10 (69%), PM2.5 (66%), NH_3 (60%), Acidifying Substances (60%), O_3 precursors (51%), while second source is residential heating (Group 2) with contributions mainly relevant for these pollutants: SO_2 (97%), N_2O (69%), CO_2 (53%), GHG (51%), Acidifying Substances (32%), PM2.5 (23%), PM10 (21%) and NO_x (21%).

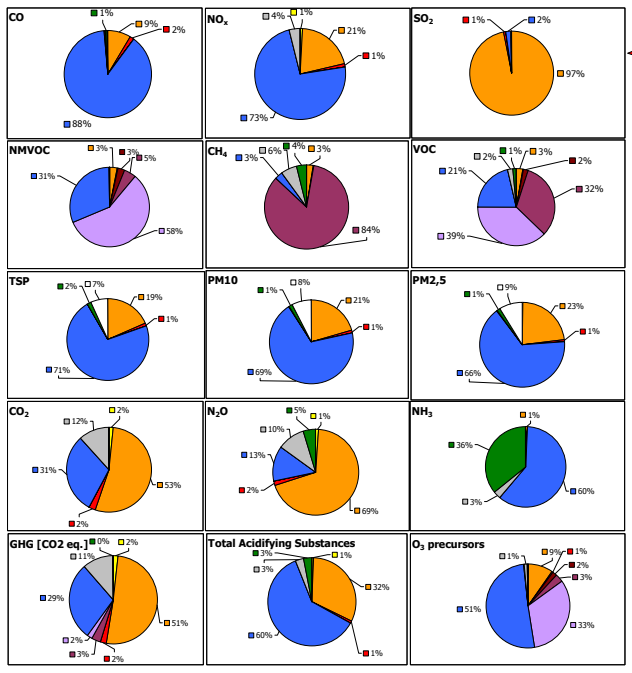

Figure 3. Municipality of Milan, year 2005: Emission Inventory for the main pollutants (Mobility and Environment Agency-AMA elaboration on the base on AMA, 2007 and ARPA Lombardia, 2007 data)

EMISSIONS UNCERTAINTY

Using INEMAR 2005 pr dataset, some calibrations have seemed to be necessary for the activities that the Top-Down approach has attributed to the Municipality of Milan by mean of proxy variables, but that don't appear to be realistically located in the urban area in such extent: industrial processes and agricultural ones (AMA, 2007). For these Groups of emissions (in particular 3, 6, 8 Groups) AMA will conduct future studies in order to reduce weakest aspects and uncertainties. For the activities of Group 2 connected with 'Wood and similar' fuel, AMA estimates take into account the value provided by INEMAR 2005 pr, that refers to a specific and recent study at municipal level for the Province of Milan area. In **Figure 4**, where the different Group contribution to total emissions from available inventories for the area of Municipality of Milan in different years is showed, it is possible to observe the variability of the estimates given by different references and the uncertainty connected most with mentioned Groups. A large variability is also existing for total emission levels given by different data sources with differences between pollutants (**Figure 5**).

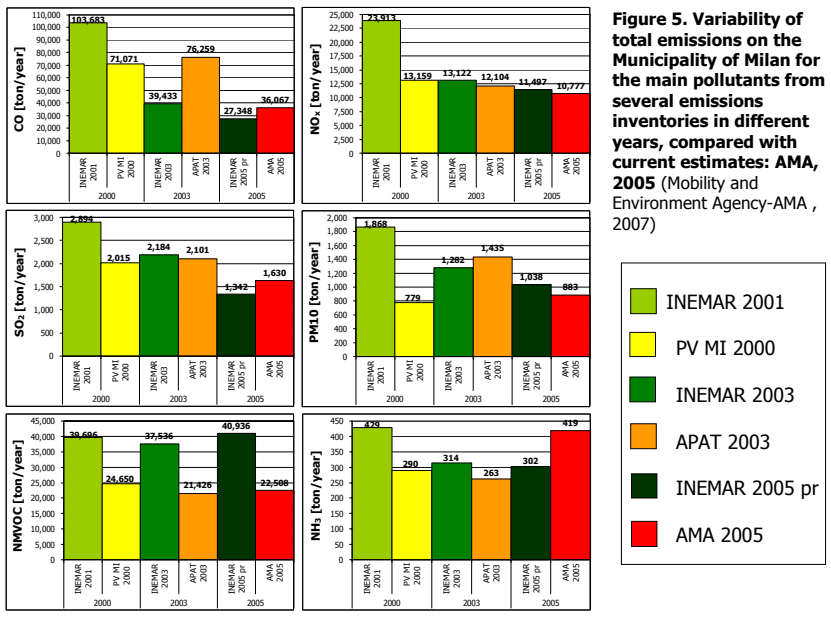

Figure 5. Variability of total emissions on the Municipality of Milan for the main pollutants from several emissions inventories in different years, compared with current estimates: AMA, 2005 (Mobility and Environment Agency-AMA , 2007)

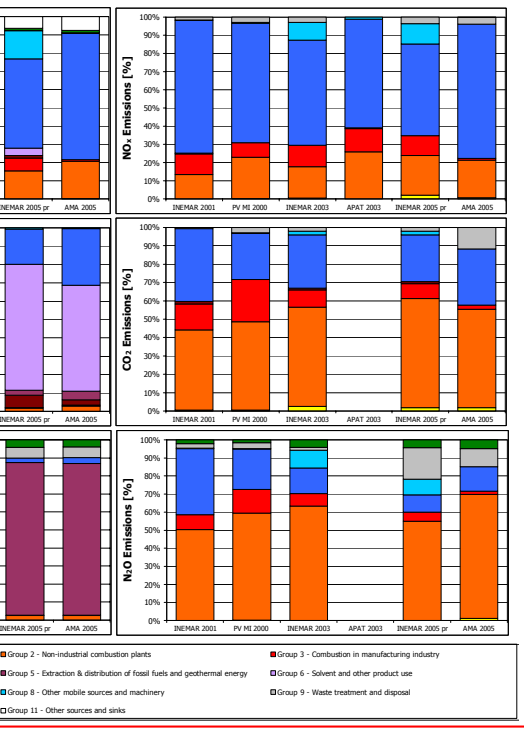

Figure 4. Different Groups contribution to total emissions from available emission inventories for the area of the Municipality of Milan (Mobility and Environment Agency - AMA, 2007)

CONCLUSIONS

AMA, the Mobility and Environment Agency established by the Municipality of Milan to support the mobility and environmental planning and programming activities, has realized the first emission inventory for the Municipality of Milan, referred to year 2005, conducting detailed studies focusing on the most important sources in the urban area.

The results, obtained in compliance with the EMEP/Corinair Methodology, have been integrated with the most recent data available for the area by the Lombardy Region emission inventory that adopts Top-Down Approach to obtain emissions spatial disaggregation (ARPA Lombardia, 2007).

The detailed studies conducted by AMA constitute the first step towards the Bottom-Up approach for realizing the urban emission inventory of the City. The results of AMA's studies have been compared to those of other emission inventories available for the Municipality of Milan (national and regional emission inventories adopting Top-Down approach) finding some important differences.

The authors think it would be useful a constructive dialogue between the Authorities that realize emission inventories at national/regional scale and local agencies that conduct detailed studies on urban areas in order to start a reconciliation procedure, on activity and emission data, between Top-Down approach and Bottom-Up approach. A similar process could lead to a validation of emission inventory on large scale. This kind of cooperation will conduct to obtain more and more reliable emission estimates and will allow an important resources and human energy saving.

ACKNOWLEDGEMENTS

The authors would like to thank Marco Bedogni, Alberto Colombo, Marta Papetti (Mobility and Environment Agency - AMA), Cristina Lavecchia and her staff (Galileo Ambiente s.n.c.) for the technical-scientific support and Stefano Caserini and his staff (Lombardy Region Agency for Environmental Protection - ARPA Lombardia) for making available the INEMAR 2005 public review data for this paper. This work was funded by the Municipality of Milan within institutional activities of Mobility and Environment Agency.

REFERENCES

✓AMA - Mobility and Environment Agency (2007), *Emission inventory of the Municipality of Milan - Year 2005. Final Report* Doc. n. 70190007_00 (in italian)
✓ARPA Lombardia (2007) - *INEMAR 2005 Public review*. October 2007, http://www.arpalombardia.it/inemar/inemarhome.htm
✓ARPA Lombardia and Lombardy Region (2007) - *INEMAR 2003, Lombardy Region emission inventory. Emissions in Lombardy Region in the year 2003. Final data*, April 2007 (in italian)
✓ Bultrini M., Colaiezzi M., Faticanti M., Pantaleoni M., Taurino E., Serafini C., Leopardi A., Cirillo M.C. (2006) *Atmospheric emissions in 24 big italian cities. APAT 2003 data.* 3th Urban Environmental Quality Report, APAT, 2006 (in italian)
✓EEA, EMEP/CORINAIR *Atmospheric Emission Inventory Guidebook*, Third Edition, European Environment Agency, Copenhagen, 2006.
✓Province of Milan (2002) - *Provincial Atmospheric Emission Inventory - Year 2000*, http://www.provincia.milano.it/ambiente/aria/qualita_inventario_anno2000.shtml

Milano

Comune di Milano

AGENZIA MILANESE MOBILITÀ AMBIENTE