EXPAH - ACTION 7.1: Report on evaluation of policy and mitigation scenarios (revision)

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Riferimento
ARIANET R2013.14

Revision 1: March 2014

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1 Executive Summary

EXPAH measurement campaigns and model simulation results allowed to define Rome air pollution conditions with respect to PAHs concentrations, showing that the yearly average limit for B[a]P was respected everywhere, while high PAHs concentrations were recorded during cold months. The analysis of measured PAH congeners and of their space and time variation suggests that Rome city is exposed to a multiplicity of sources, with a relevant contribution of non industrial combustion during wintertime. The existing emission inventories ascribe the major contribution to PAHs emission to domestic heating activities and, in particular, to biomass combustion. These results carried to focus the identification of possible future emission reduction scenarios on measures having possible impact on winter emissions. The first step of this process is the evaluation of the concentrations variation that can be expected for the forthcoming years due to people behaviors/consumptions, to the results of ongoing technological improvements and of already established air quality and climate related policies at European, national and local levels. The reference (Current Legislation) scenario for year 2020 has been identified using GAINS-Italy project results. A general reduction of 2020 emissions with respect to 2009 reference values was observed for all pollutants but PAHs. CO and NOx show respectively a 26% and 20% reduction for Rome municipality mainly due to the decrease of road traffic contribution. SO_2 and NMVOC are reduced of about 24% and 11% respectively. PM10 and PM2.5 decrease of 8% and 4%, while PAHs emissions show an increase of 38%. The limited reduction of PM emissions is mainly due to the growth of non-industrial combustion that compensates other sectors (e.g. transports) relevant emission reduction. The growth of PAHs emission is largely influenced by domestic heating and mainly due to the relevant increase of wood combustion contribution. The previously mentioned results, concerning the relevant impact of domestic heating on PM and PAHs emissions, induced the development of an Additional Measures Scenario based on the reduction of domestic heating emissions forcing variations in fuel usage and considering the possible introduction of district heating. On the basis of present knowledge about domestic heating emissions, these measures have the potential impact to reduce PAHs emissions up to more than 90% with respect to 2009 reference value. To fulfill the main objective to estimate future air concentration and population exposure trends and evaluate the impact of possible mitigation measures, the following two emission scenarios are finally defined for model simulations: a) 2020 Current Legislation; b) 2020 Additional Measures (Current legislation plus substitution of biomass with natural gas for house heating within Rome municipality).

2 Introduction

One of the main objectives of the EXPAH project is to develop a prototype method to assess the population exposure to PAHs concentrations and to support the evaluation and monitoring of forthcoming environmental policies at local and national levels. The first step has been the reconstruction of PAHs concentration fields during the year long period covered by EXPAH outdoor and indoor measuring campaign. The modelled concentration fields, corrected on the basis of the available measured values, represent an estimation of present air pollution conditions (Silibello et al., 2013). PAHs concentrations showed a strong seasonal variation over Rome metropolitan area, with short term mean values about one order of magnitude smaller during the summer, with respect to winter values. Estimated B[a]P annual average values respect everywhere the target value of 1 ng/m^3 stated by the European Directive 2004/107/EC (EC, 2004) and Italian D. Lgs. 155, 2010 (DL, 2010) while exceedances of this reference value have been recorded during winter measurement periods. The reduction of winter PAHs concentration should therefore be the main objective to reduce possible health impact of these harmful substances. The second step is the evaluation of the concentrations variation that can be expected for the forthcoming years due to people behaviors/consumptions, to the results of ongoing technological improvements and of already established air quality and climate related policies at European, national and local levels. The estimation of expected future concentrations is the main reference to evaluate the impact on air quality, population exposure and public health of possible additional mitigation strategies. The starting point to evaluate air pollution trends is the identification of emission scenarios describing the effect of ongoing policies together with possible alternative policies for PAHs and/or additional mitigation scenarios. Additional measures emission scenarios should generally correspond to concrete and feasible mitigation actions that have to be defined keeping into account their economic and social costs, together with possible technical implementation difficulties. Nevertheless, a proper definition of mitigation actions is not always possible due to the lack of knowledge concerning specific human activities and emission sectors (e.g. biomass burning). In this condition it is anyway very useful to estimate the air quality impact of emission reduction concerning the emission sectors of major relevance for specific pollutants.

A first evaluation of future trends is obtained from the comparison of current legislation emission scenario with the reference emission inventory that has been used to define present air pollution conditions (Radice et al., 2012). Reference emissions for the city of Rome are resumed in Table 1.

Table 1: Reference emissions (t/year) produced by the city of Rome (2009)

	CO	NH3	NMVOC	NOX	PM2.5	PM10	SO2	PAH
Energy Production	624.8	3.7	32.7	1519.9	52.7	57.7	2747.3	0.002
Comb.in Residential	17314.5	0.0	1572.6	2992.2	688.6	723.8	900.6	1.736
Comb. In Industry	50.0	0.0	4.6	136.7	28.1	29.5	189.0	0.000
Prod.Process	23.3	2.8	1344.6	47.5	31.6	75.6	43.4	0.000
Extraction Fossil Fuel	0.0	0.0	1428.7	0.0	0.0	0.0	0.0	
Solvent Use	0.0	0.0	11711.0	0.0	0.0	0.0	0.0	
Road Transport	44846.0	341.5	5724.6	22501.4	978.0	1325	119.3	0.061
Other Transport	5855.0	0.0	1980.0	12320.0	351.0	351.0	864.0	0.010
Waste Treatment	511.0	524.0	788.0	50.8	20.1	23.5	248.3	0.000
Agriculture	9.5	722.0	2.2	0.3	7.7	15.4	0.0	
Nature	12.0	0.0	1726.0	0.0	2.0	4.0	0.0	0.000
TOTAL	69246.1	1594.0	26314.8	39568.8	2159.9	2605.9	5111.9	1.808

The different emission sectors contribution to the present PAHs emission inventory and the tendency identified for the forthcoming years are the main input for the definition of effective additional mitigation measures.

The following sections contain a detailed description of the different elaboration steps that were carried out to produce future emission scenarios.

3 GAINS model

Starting from Geneva Convention on long range transboundary air pollution distance (Convention on long-range Transboundary Air Pollution, CLRTAP), entered into force in 1983 and subsequently extended by eight specific protocols, emission scenarios have assumed increasing importance in the policy-making community to contrast air pollution. In particular, the Gothenburg Protocol of 1999 to combat acidification, eutrophication and tropospheric ozone has assumed a central role, establishing national emission ceilings for sulphur oxides, nitrogen oxides, ammonia, volatile organic compounds and non-methane hydrocarbons to be achieved by 2010.

The Italian Legislative Decree No. 155 of 2010 (DL, 2010), implementation in Italy (together with Legislative Decree No. 171 of 2004) of the European Commission Directive 2001/81/EC on national emission ceilings, states that “ISPRA develops the national energy and productive activities scenario and downscales it at Regional level, and, on the basis of this scenario, ENEA develops, following the methodology defined at Community level for these purposes, the national emission scenario”. In this context, ENEA and ISPRA have jointly developed the new reference emission scenario, named *2012 baseline* and covered by this report, using the GAINS-Italy modelling tool.

This model, which is part of the national integrated assessment model for air pollution (MINNI, http://www.minni.org/) developed by ENEA, on behalf of MATTM (Ministero dell’Ambiente e della Tutela del Territorio e del Mare, *Ministry for the Environment, Land and Sea*), in collaboration with IIASA (International Institute for Applied Systems Analysis) and ARIANET s.r.l., reflects on a national scale the model structure of GAINS-Europe (GAINS, 2009) and updates the RAINS model (Regional Air Pollution Information System, Amann et al., 2004), that had been developed about twenty years ago to meet the growing needs of quantification and international regulation of emissions of polluting substances affecting the ecosystems on a continental scale.

The model GAINS (GAINS, 2009) processes possible scenarios by reducing emissions of SO_2, NOx, NH_3, NMVOC, PM and greenhouse gas (Klaasen et al., 2005; Höglund-Isaksson and Mechler, 2005; Tohka, 2005, Winiwarter, 2005) to consider the interactions between atmospheric pollution and climate change; the model estimates, at the national and international scale, the effects of acidification and eutrophication, tropospheric ozone damage to vegetation and human health, as well as the impact on human health of the population exposure to PM2.5 concentrations.

By combining information on economic and energy development, emission control potentials and costs, atmospheric dispersion and environmental sensitivities towards air pollution (Schöpp et al., 1999), the model produces a reference emission scenario (also called baseline or, more correctly, Current Legislation or CLE, i.e. based on the implementation of abatement measures expected by current legislation), that requires first of all the quantification of anthropogenic activities, their expected time variation, and the definition of a control strategy. The control strategy represents the set of measures which are expected to be introduced within the reference time horizon on the basis of the application of national and Community legislation in force and it is expressed in terms of percentage of application by sector, fuel and technology.

To reduce pollutant emissions three groups of approaches can be distinguished:

1. **technical measures**, developed to capture emissions at their sources before they enter the atmosphere; the so-called “end-of-pipe” measures don’t need any kind of change in energy system or in agricultural activities;
2. **behavioral changes**, linked to spontaneous changes in life style or to a command and control approach, like traffic restriction (Amman et al., 2006), or to economic incentives (e.g., pollution taxes, emission trading systems, etc.), that aren’t internalized in the GAINS model but are represented by alternative exogenous scenarios of the driving forces;
3. **structural measures**, that allow to provide the same level of energy to the consumer using less polluting activities (e.g.: the switch from oil to natural gas)

By quantifying pathways of future modification of technical systems, it is possible to analyze consequences of these pathways (costs, environmental impacts) and of the environmental changes caused by modified exogenous parameters.

4 Future emissions inventory projections

Assuming a full implementation of emission control legislation, significant changes of emissions are expected for year 2020 in the Lazio region. GAINS-Italy computes emissions scenarios, at 5 year intervals, for SO_2, NOx, NH_3, VOCs and PM, on the basis of a list of applicable abatement technologies, which the user includes in the so called Control Strategy, according to the implementation of measures due to the Current Legislation (CLE Strategy) or alternative Reduction Strategies. In this way Gains-Italy is able to provide an official set of emission data useful to create the "base" of future emission scenarios to which it is possible to add regional and local strategies regarding energy.

For pollutants not explicitly considered by GAINS it has been chosen to adopt other pollutants emission trends as a reference, in particular PAHs have been projected using PM trends for each single sector considered.

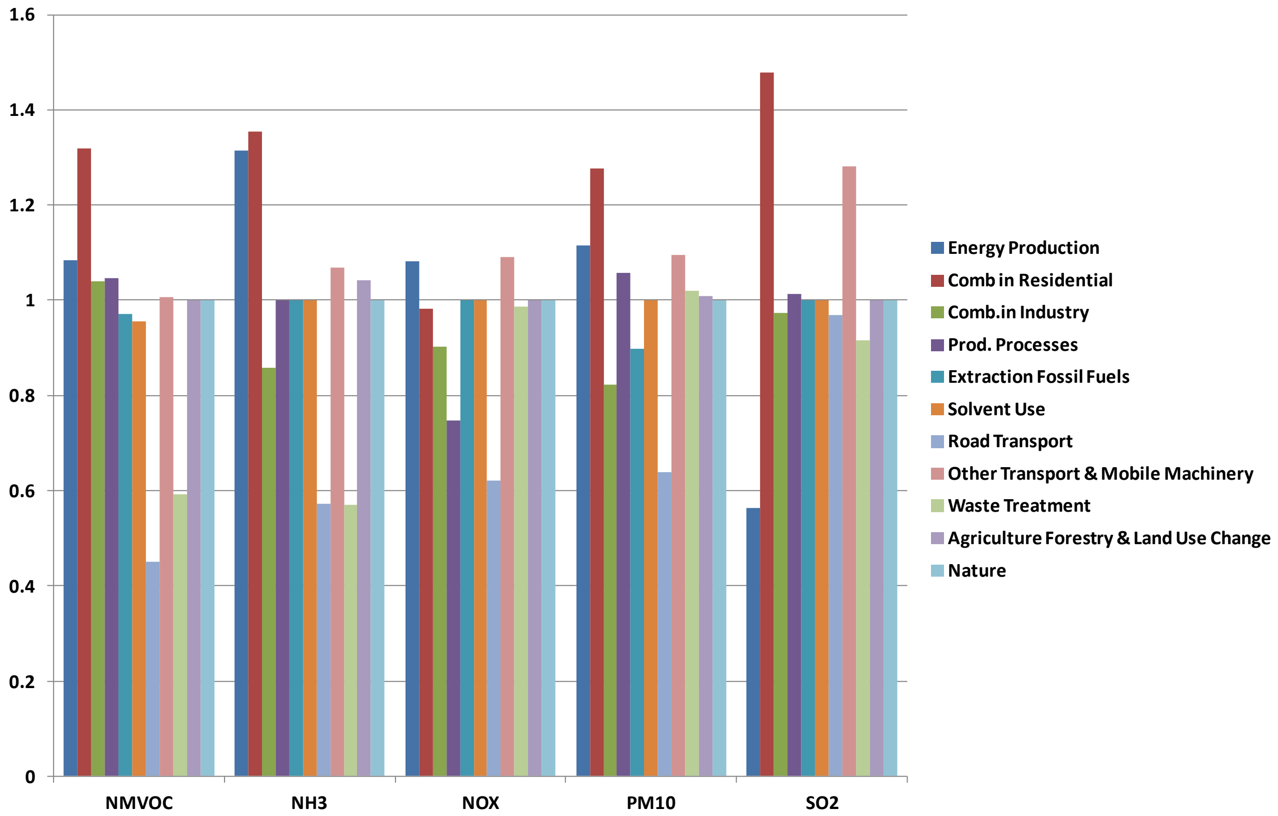

Figure 1. GAINS Coefficients used to update Lazio 2009 inventory to 2020

Pollutant trends can be very different depending on the chemical specie and on the group of activities considered (Figure 1). NOx emissions, for example, increase of 8% for activities related to energy production and decrease of about 40% for road transport. Non industrial combustion shows a decrease of 2% of NOx emissions but, at the same time, an increase of more than 25% of particulate.

To define trends, the model follows a bottom-up technological approach: starting from single emission sector or subsector, the aggregate result is obtained from the sum of individual products or services. This approach ensures a better accuracy and a greater detail compared to a top-down approach, where sectorial variables are derived from general macro variables such as gross national product. GAINS includes over 70 different demand for energy services, which cover the four main sectors: agriculture, industry, transport and civil.

Each sector is in turn divided into homogenous sub-sectors in terms of energy and service, and, for industry, the main produced material. The industrial sector, in particular, was divided into subsectors steel, non-ferrous metals, bricks, ceramics, glass, cement, paper, chemical, mechanical, textiles and food. For each demand, two or more alternative technologies are considered. Each technology is characterized by its data on energy efficiency, carbon performance and costs, investment and operation. For example, in the civil sector, the heating demand has been described in terms of expressed heated surface (m^2) and subdivided between new and existing buildings, multifamily or independent. The user can specify different isolation levels and the use of central heating, district heating or independent heating system in addition to boilers with different efficiencies (D'Elia, Peschi, 2013).

For the transport sector, GAINS has been extended to allow a separate treatment of cars, light-duty trucks, buses and heavy-duty trucks. These categories were previously lumped into light-duty

and heavy-duty vehicles and data were collected not only for fuel consumption but also for mileage (kilometers per vehicle) and vehicle number for each vehicle category.
The emission characteristics of control technologies were modified to reflect the COPERT-IV emission factors (Samaras, 2006). COPERT-IV reflects recent measurements of emissions in real operating conditions, instead of data measured in test cycles. Real-life emission factors turned out to be higher than factors measured during test cycle for light-duty and heavy-duty diesel vehicles.
In addition, data concerning Euro-5 and Euro-6 passenger cars and light-duty vehicles have been revised taking into account the current proposals prepared by the European Commission (CEC, 2005b, CEC, 2006). From this brief description of the future emissions projection process, it is easy to understand that to reduce a specific pollutant (and its effects on environment and human health) it is necessary to act on the correct driving forces. Assessing the future impact of possible measures, policy makers will be more conscious about the acceptability (or not) of the consequences of present decisions.
The total pollutant emissions projected to year 2020 in CLE scenario, according to GAINS methodology, are shown in Figure 2 for Rome municipality.

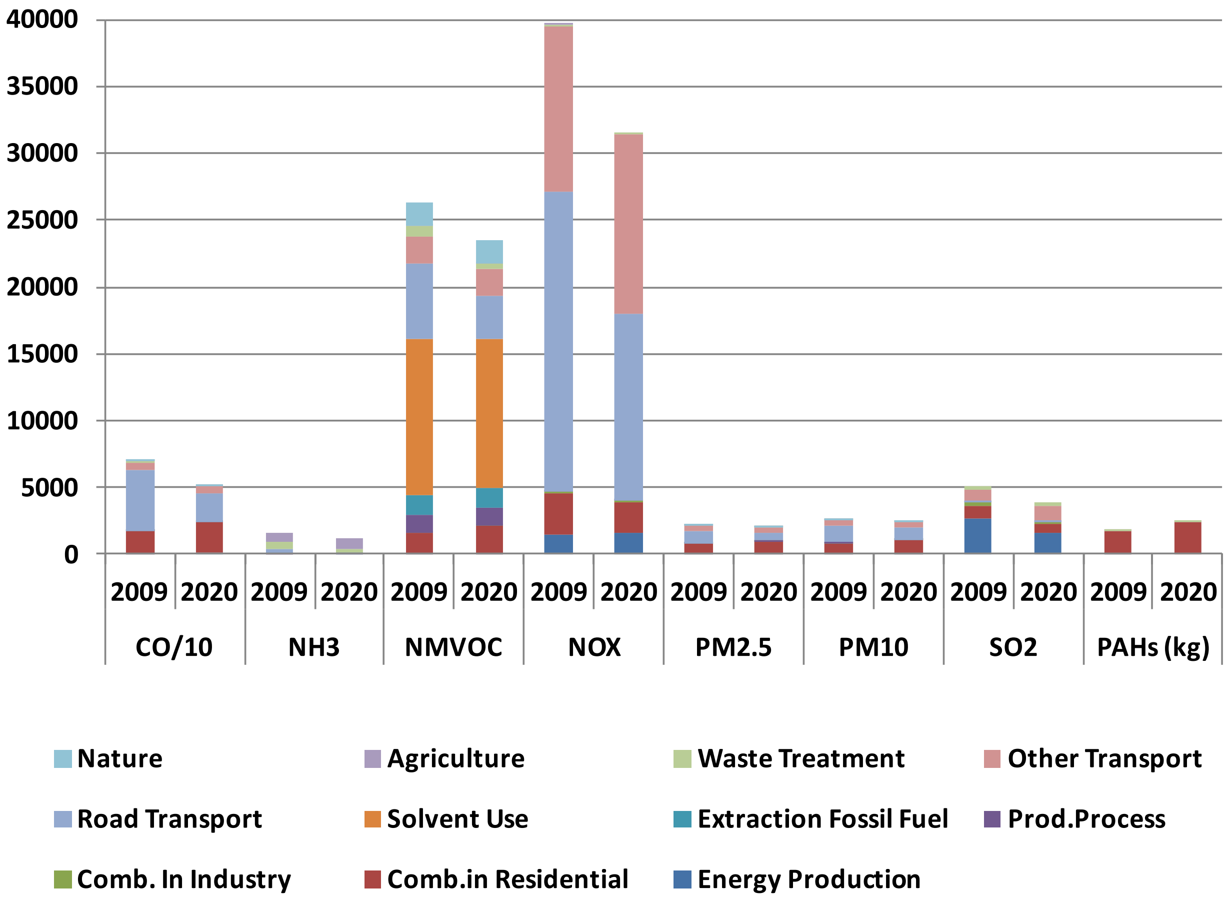

Figure 2. Comparison of 2020 emission projection (t/year) with 2009 reference year for the municipality of Rome

It can be observed that an overall decrease of emissions is expected for 2020 for all pollutants but PM. Detailed PM10 trend is shown in Figure 3. It's possible to stress that the limited decrease is due to the increase of emissions from residential heating that compensates reduction from other sectors, in particular road transport. Even if according to GAINS projections, 2020 mileage will be higher for all kind of vehicles, (with the exception of the category of "Motorcycles, mopeds and cars with 2-stroke engines" that represents a small contribution to all traffic PM emissions), PM emissions produced by road transport will be reduced more than 30%, thanks to better technologies used.

On the other side, the improvement in the abatement technologies estimated by GAINS for heating sectors is not strong enough to contrast the increase in the use of wood and other fuels with important emission factors.

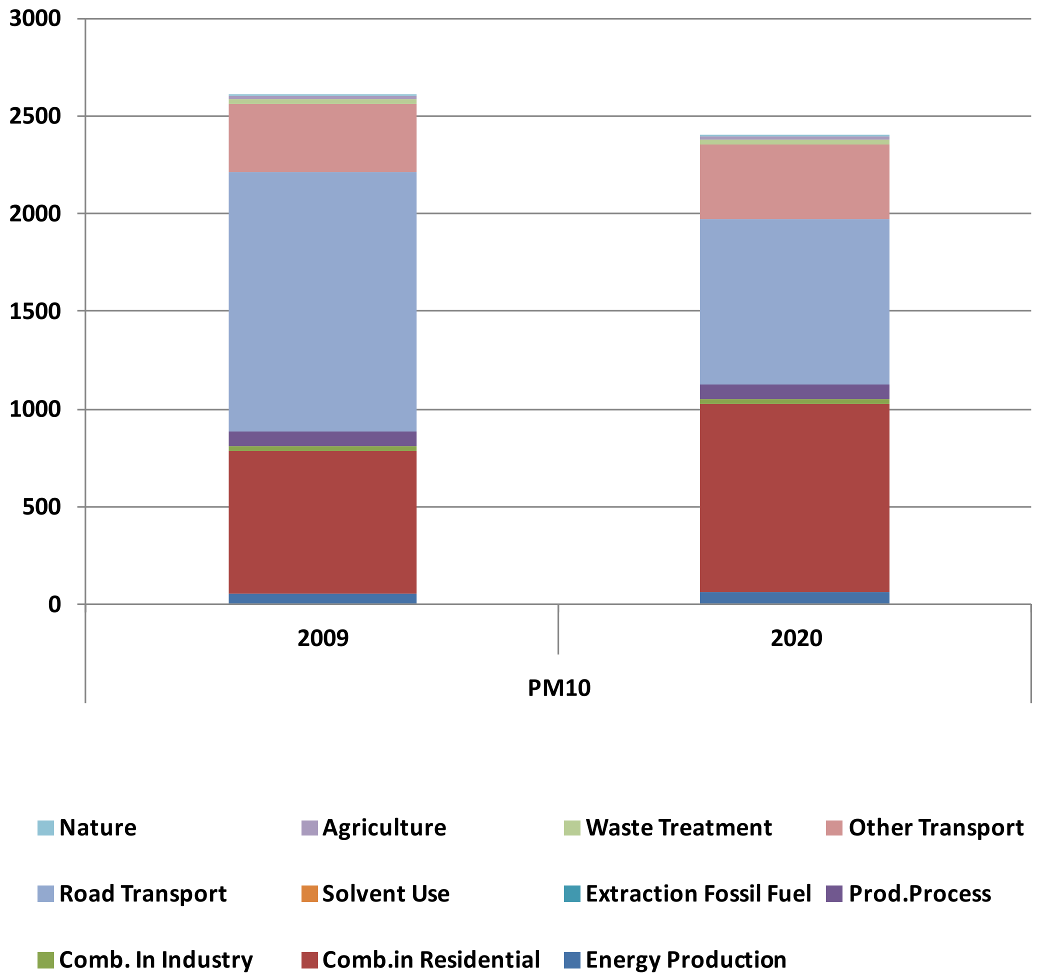

Figure 3. Comparison of 2020 PM10 emission projection (t/year) with 2009 reference year for the municipality of Rome

As explained before PAHs are not estimated in GAINS and for this reason PM trends are used to projects these emissions; the most important contributor to PAHs total emissions is for sure domestic heating, and, in particular, the fraction produced by wood combustion, the increase of which causes the total increase of this pollutant.

5 Non Industrial Combustion: 2020 scenarios

Due to its great importance for PM and PAHs emissions, non industrial combustion sector has to be considered with special attention. In Table 2 domestic heating emissions for 2009 are subdivided by fuel employed. It is possible to see that the biggest contribution to PAHs, PM10, CO and NMVOC emissions is linked to biomass combustion. The contribution of different fuels to energy demand of domestic heating from 2000 to 2020 is reported in Figure 4, the biomass utilization shows the most important increase.

Table 2: Emissions (t/year) produced by non industrial combustion in the city of Rome (2009)

	CO	NMVOC	NH3	NOX	PM25	PM10	SO2	PAHs
Non Industrial Combustion (city of Rome)	17315	1573	0	2992	689	724	901	1.736
biomass	**15847**	**1268**	**0**	**169**	**629**	**658**	**0**	**1.733**
waste	1	84	0	7	0	0	0	0.000
medium distillate	180	27	0	451	32	32	839	0.000
natural gas	911	182	0	1823	7	7	0	0.000
LPG	14	3	0	71	3	3	0	0.000
others	361	9	0	472	17	23	61	0.003

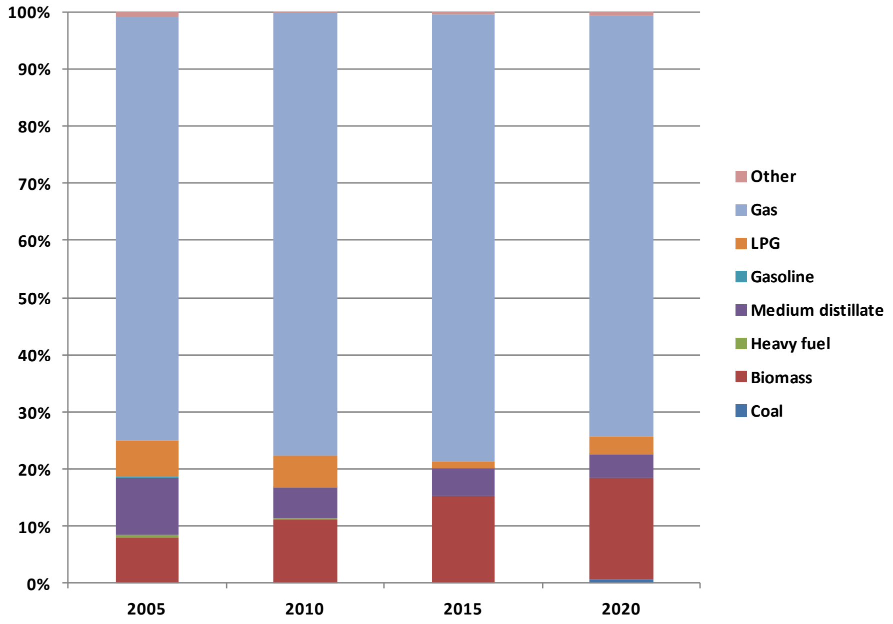

Figure 4. Different fuel contribution, at national level, in domestic sector (source: GAINS, Scenario Baseline 2012 new)

Considering the two mentioned features together (emission contribution and consumption trends) it is easy to understand the relevance of future decisions about this particular fuel on pollutants concentration.

Applying GAINS trends to domestic heating sector, we obtain 2020 emissions shown in Table 3, with biomass representing by far the biggest contributor to PM, NMVOCs and PAHs emissions.

Table 3: Emissions (t/year) produced by non industrial combustion in the city of Rome (2020) in current legislation scenario

	CO	NH3	NMVOC	NOX	PM2.5	PM10	SO2	PAH
Non Industrial Combustion (city of Rome)	**24075**	**0**	**2095**	**2188**	**913**	**959**	**671**	**2.393**
biomass	22781	0	1822	293	864	905	0	2.390
waste	1	0	84	7	0	0	0	0.000
medium distillate	128	0	19	317	24	24	609	0.000
natural gas	791	0	158	1523	6	6	0	0.000
LPG	14	0	3	36	1	1	0	0.000
others	361	0	9	12	17	23	61	0.003

If current legislation trends are applied, PAHs and PM10 emissions from house heating will increase of 38% and 32%, although better technologies will be applied. Even if emission control strategies will be more and more efficient, the strong increase of biomass used as fuel for non industrial combustion will produce a large quantity of PM10, NMVOC and PAHs causing an increase of the emissions.

In order to reduce future concentrations additional measures need to be planned with main focus on residential heating contribution. Two different approaches can be conceived:

- reduction of emissions coming from all fuels, that can be reached by improving building energy efficiency and/or substituting domestic boilers with district heating;
- substitution of the total amount of biomass used for residential heating with natural gas.

The first approach possible impact is resumed in Table 4 for different fractional reduction objectives. This measure would have relevant impact on CO and PM emissions, while PAHs emissions would be nearly completely removed, but it’s important to remind that emissions coming from plants that would produce district heating should have to be considered.

Table 4: Percent emissions reduction produced by fractional reduction of non-industrial combustion in the city of Rome (2020) reachable improving building efficiency and implementing district heating.

reduction (%) Non Industrial Combustion	emission reduction in the city of Rome							
	CO	NMVOC	NH3	NOx	PM2.5	PM10	SO2	PAHs
20%	-9%	-2%	0%	-2%	-9%	-9%	-5%	-19%
50%	-23%	-5%	0%	-5%	-24%	-22%	-12%	-47%
100%	-46%	-10%	0%	-9%	-47%	-44%	-25%	-95%

The second approach, substituting biomass with natural gas, would cause the reduction of emissions resumed in Table 5, that has to be compared with Table 2 and 3 to identify the impact of the additional measure. Applying this measure, CO emissions from residential heating would be reduced of about 93%, PM10 of 95% with respect to 2009 reference emission scenario, while PAHs emissions would be substantially removed.

This latest measure seems quite preferable due to its large potential environmental impact obtainable through an action that would target a limited population fraction and that can be implemented through administrative actions.

Table 5: Emissions (t/year) produced by non-industrial combustion in the city of Rome (2020), with complete substitution of biomass with natural gas

	CO	NH3	NMVOC	NOX	PM2.5	PM10	SO2	PAH
Non Industrial Combustion (city of Rome)	**1135**	**0**	**221**	**2268**	**33**	**33**	**609**	**0**
biomass	0	0	0	0	0	0	0	0
waste	1	0	84	7	0	0	0	0
medium distillate	128	0	19	317	24	24	609	0
natural gas	994	0	199	1914	8	8	0	0
LPG	14	0	3	36	1	1	0	0
others	0	0	0	0	0	0	0	0

The ban of biomass fuel, with possible incentives to support fuel change, would give good results because of the different values of heating power that characterize each substance. The heating value (or calorific value) of a fuel is the quantity of heat released during the combustion of a specified amount of it, and it is measured in units of energy per unit of the substance (i.e. kJ/kg, kJ/mol or kcal/kg). If we compare wood with natural gas, the former is more inefficient than the latter, as its heating value is roughly a half, that means that to produce the same amount of heat we would need a larger quantity of wood. This aspect, combined with (much) higher PM and PAHs emission factors of wood, in comparison with the natural gas ones, makes biomass use not advisable for air quality, especially inside or nearby urban areas.

The emissions characterizing 2020 Current Legislation and Additional Measures scenarios for Rome Municipality are resumed and compared for all considered pollutants in Table 6, while Table 7 describes percent variations of the two scenarios with respect to 2009 reference emission inventory (Table 1).

Table 6: Emissions (t/year) produced by the city of Rome (2020), according to the CLE scenario (named "orig") and the one originated by the complete substitution of biomass with natural gas (named "mod")

	CO		NH3		NMVOC		NOX		PM2.5		PM10		SO2		PAHs	
	orig	**mod**	**orig**	**mod**	**orig**	**mod**	**orig**	**mod**	**orig**	**mod**	**orig**	**mod**	**orig**	**mod**	**orig**	**mod**
Energy Production	677	677	5	5	33	33	1660	1660	59	59	64	64	1546	1546	0.00	0.00
Comb.in Residential	24075	1136	0	0	2095	304	2188	2275	913	33	959	33	671	610	2.39	0.00
Comb. In Industry	52	52	0	0	5	5	123	123	23	23	24	24	184	184	0.00	0.00
Prod.Process	24	24	3	3	1406	1406	35	35	33	33	80	80	44	44	0.00	0.00
Extraction Fossil Fuel	0	0	0	0	1389	1389	0	0	0	0	0	0	0	0	0.00	0.00
Solvent Use	0	0	0	0	11184	11184	0	0	0	0	0	0	0	0	0.00	0.00
Road Transport	20176	20176	3282	3282	154	154	13993	13993	625	625	846	846	116	116	0.04	0.04
Other Transport	5896	5896	0	0	1995	1995	13427	13427	384	384	384	384	1108	1108	0.01	0.01
Waste Treatment	302	302	298	298	405	405	36	36	21	21	24	24	226	226	0.06	0.06
Agriculture	9	9	753	753	2	2	0	0	8	8	16	16	0	0	0.00	0.00
Nature	12	12	0	0	1726	1726	0	0	2	2	2	2	0	0	0.00	0.00
				0												
TOTAL	51223	28284	4341	4341	20394	18603	31462	31549	2068	1188	2399	1473	3895	3834	2.50	0.11

Table 7: Comparison between percent emissions reduction produced by the city of Rome (2020), according to the CLE scenario (named "orig") and the one originated by the complete substitution of biomass with natural gas (named "mod"), towards 2009 emissions

	CO		NH3		NMVOC		NOX		PM2.5		PM10		SO2		PAHs	
	orig	mod	orig	mod	orig	mod	orig	mod	orig	mod	orig	mod	orig	mod	orig	mod
Energy Production	8%	8%	35%	35%	1%	1%	9%	9%	12%	12%	11%	11%	-44%	-44%	12%	12%
Comb.in Residential	39%	-93%			33%	-81%	-27%	-24%	33%	-95%	32%	-95%	-26%	-32%	38%	-100%
Comb. In Industry	4%	4%			10%	10%	-10%	-10%	-18%	-18%	-19%	-19%	-3%	-3%	-18%	-18%
Prod.Process	3%	3%	7%	7%	5%	5%	-26%	-26%	4%	4%	6%	6%	1%	1%	6%	6%
Extraction Fossil Fuel					-3%	-3%										
Solvent Use					-4%	-4%										
Road Transport	-55%	-55%	-55%	-55%	-43%	-43%	-38%	-38%	-36%	-36%	-36%	-36%	-3%	-3%	-36%	-36%
Other Transport	1%	1%			1%	1%	9%	9%	9%	9%	9%	9%	28%	28%	9%	9%
Waste Treatment	-41%	-41%	-43%	-43%	-49%	-49%	-29%	-29%	4%	4%	2%	2%	-9%	-9%	2%	2%
Agriculture	-5%	-5%	4%	4%	-8%	-8%			4%	4%	0%	0%				
Nature																
TOTAL	-26%	-59%	-24%	-24%	-11%	-17%	-20%	-20%	-4%	-45%	-8%	-43%	-24%	-25%	38%	-94%

6 Conclusions

After reconstructing PAHs concentration fields during a year long period, it was possible to evaluate the air pollution situation over Rome metropolitan area.

Thanks to GAINS-Italy modeling tool, emission variations expected for the forthcoming years were evaluated taking into account: already established air quality policies, people behavioral and trends of consumptions. Applying GAINS trends to Rome pollutant emissions to estimate 2020 Current Legislation Scenario, CO and NOx result to be 26% and 20% lower than in 2009, thanks first of all to the strong reduction of road traffic contribution. SO_2 is expected to decrease of 24% mainly due to the decrease of energy production emissions. NMVOC and PM10 emissions will reduce of 11% and 8% respectively, while for PM2.5 a slight reduction of 4% is expected. For PM the overall result is due to the compensation of the relevant reduction of emissions from transport and industrial sectors and of the increase of residential combustion contribution. On the other hand, PAHs emissions, largely influenced by domestic heating, will be 38% higher due to the relevant increase of wood combustion contribution.

Other mitigation measures were added to the mentioned reference scenario in order to evaluate a further possible limitation of the impact of PM and PAHs on human health.

The previously mentioned results, concerning the relevant impact of domestic heating on PM and PAHs emissions, induced the development of an Additional Measures Scenario considering the reduction of domestic heating emissions based on the variation in fuel usage that is obtained forcing the substitution of biomass with natural gas. On the basis of present knowledge about domestic heating emissions, this measure has the potential impact to reduce PAHs emissions up to more than 90%. Table 8 resumes the characteristics of the two emission scenarios that will be simulated by the air quality model FARM to evaluate 2020 expectable concentrations and compare them with present values.

Table 8: Emission scenarios to be simulated to evaluate expectable 2020 concentrations variation due to current legislation implementation, technology and behaviors changes and to the possible introduction of additional mitigation measures.

Scenario	Main features	Variation with respect to 2009 reference emissions in Rome Municipality
Current Legislation (CLE)	2020 GAINS-Italy CLE reference scenario	CO: -26%, NO_X: -20%, SO_2: -24%, NMVOC: -11%, PM10: -8%, PM2.5: -4%, PAHs: +38%
Additional Measures (AM)	2020 GAINS-Italy CLE + substitution of biomass with natural gas for non-industrial combustion	CO: -59%, NO_X: -20%, SO2: -25%, NMVOC -17%, PM10: -43%, PM2.5: -45%, PAHs: -94%.

Future refinements of the presented approach could benefit of a better evaluation of specific sectors emissions (domestic heating, first of all) and of their space localization. These possible improvements will be a key factor to build and address more effective mitigation actions.

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