AIR POLLUTION & EMISSION REDUCTIONS OVER THE PO-VALLEY: TOWARDS AN INTEGRATED ASSESSMENT ANALYSIS

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ABSTRACT

Exceedances of PM10 and O3 limits are frequently observed in the Po Valley, respectively in winter and summertime. In order to investigate what can be done to achieve the air quality limits in this area a range of both technological and political options for reducing emissions and, consequently concentration, must be analysed and compared.
Starting from a regional emission inventory, the regional integrated assessment aims at examining annual average pollutant concentrations, estimated on the basis of a range of emission projection scenarios, in order to define cost-effective and optimized strategies to achieve air quality standards and reduce the population exposure.

Keywords: *Emission inventory, emission scenario, air quality modelling, integrated assessment.*

1. INTRODUCTION

The Po valley has been identified as one of the main areas in Europe where pollution episodes will persist in 2020, according to the different scenarios carried out in the frame of the Clean Air for Europe (CAFE) [10]. Both the geographical characteristics of the Po valley, surrounded by a mountain range which leads to poor ventilation, and the high density of emissions cause high pollution levels, especially during the winter season and not only in the urban areas. The particularly high background levels of pollutant concentration are almost uniform across the Po valley [12], underlining the importance of applying pollution reduction strategies all over the Po valley.

With this aim, a collaborative research project to identify the best pollution reduction strategies started between the JRC and the Lombardy region, in cooperation with the other Po valley regions.

In the frame of this collaborative research project, several tasks have been planned for the implementation of a shared and improved emission inventory for the Po valley regions. Main improvement will be 1) the refined vehicle fleet inventory consistent across the regions of the Po-Valley, 2) the implementation of a new transport model across the whole Po Valley (including freight transport and heavy duty vehicles) and 3) the collection of new information from survey on wood combustion practices. On the basis of the common emission inventory, different scenarios will then be developed including Current legislation scenario (CLE), Maximum Technically Feasible Reduction (MTFR) together with a set of less ambitious scenarios.

All these data will be used as input for the POMI air quality modeling exercise (PO valley Model Intercomparison), which aims at exploring the changes in air quality predicted by an ensemble of different atmospheric chemistry transport models (CTM) in response to changes of emissions in the Po valley and more specifically in the Lombardy Region.

Another basic work package of this project focuses on integrated assessment (IA) techniques for the analysis of possible regional policy options to reduce emissions, both in terms of air quality improvement of and cost effectiveness..

Iimplementation of this IA methodology and the realization of an open IT tool for performing a cost-effective integrated assessment at the regional scale is one of the main objectives of the collaborative agreement between the JRC and the Lombardy Region which will be described in this work.

2. METHODOLOGY DESCRIPTION

The collaborative inter-regional research project will assess a number of possible regional policy options aimed at a cost-effective improvement of air quality in the Po Valley.

The fundamental steps of the full project are the following:

1. emission inventory implementation and improvements;
2. air quality modelling;
3. integrated assessment.

Each of this part will be explained hereafter.

2.1. Emission inventory

The first step of the project is the implementation of a common emission inventory for the whole Po Valley modelling domain referred to the year 2005. The inventory will result from the union of two different databases: the regional emission inventory INEMAR 2005 [1] and the national emission inventory of 2005 disaggregated at provincial scale by APAT [3] and further disaggregated ad municipal scale by the JRC. INEMAR is a regional high-quality emission inventory with information at municipal level. Although developed at first in Lombardy, it has recently been adopted by several other regions of the Po Valley. However due to the recent implementation of INEMAR in these other regions, only emission data for some SNAP97 sectors are available homogeneously for all regions in this first stage of the project. For the remaining sectors the municipal disaggregation of the APAT provincial database will be used.

The modelling exercise will need emission data spatially resolved on regular grids with a resolution of 6x6 km over the whole Po-Valley domain and 3x3 km over a nested grid covering the Lombardy region. The gridding of the municipal emissions will be done according to a 3x3 km grid covering the full Po-valley domain. The specific rules for the spatial disaggregation of the common emission inventory will focus on:

- identification and isolation of the main point and linear sources to be subtracted from the total municipal emissions;
- selection or definition of the relevant proxy variables correlated to municipal emission activities;
- spatial allocation and gridding of emissions according with the geographic distribution of socio-economic proxies and land-use data.

In addition the JRC is currently working to improve the emission information related to the transport sector and wood combustion activities, which seem to be the main contributors to the high observed PM concentrations all over the Po Valley [4].
With regard to on-road mobile sources two topics are already developed: elaboration of a new detailed vehicle fleet inventory (2005) at Municipal level for the Po valley area and the technical definition of a new transport model extended to the whole Po Valley that, once implemented, will be able to take into account also freight transport and heavy duty vehicles.

Regarding the first topic, the classification of the registered municipal vehicle fleet into region-specific fuel/emission categories is considered as an essential improvement to develop a high quality regional emission on-road mobile sources inventory. Indeed local information about traffic and its average composition is a necessary input to perform a more accurate representation of the spatial distribution of mobile sources emissions at the regional scale. With this aim, an effort has been done to collect, analyze and properly format all the "registration distribution" of vehicles referred to each single municipality for all the regions of the Po Valley.[8].
The new transport model covering the whole Po valley, will constitute an innovative and crucial element for the regional emission inventory. Indeed, regions do not all have a traffic flow model based on an analytical evaluation of the transport demand on their territory. Furthermore, a unique study leading to the implementation of a traffic model calibrated on the whole Po Valley will avoid heterogeneity problems due to separate modelling exercises in the single regions. A transport model extended to the full Po Valley road network will also allow specific analysis and estimations of inter-regional traffic flows and the realization of traffic emission scenarios due to common (technical and non technical) measures for emission reduction. Specific evaluation will done to establish the portion of heavy duty vehicles that are supposed to travel across the regional boundaries contributing to trans-regional flows and to the generation of road emissions due to in-out transit instead than regional transport activity.

The importance of domestic wood combustion emissions on the Italian territory has been recently underlined by two studies at the regional and national scales (respectively for Lombardy and Italy) [2] [6]. Both studies identify an increase of residential wood consumption, with the consequent increase of particulate matter emissions. Moreover one of the largest uncertainties in the assessment of emission sources contributions to national and regional inventories arises from the wood combustion emissions estimate. Even if the EMEP/CORINAIR emissions inventory Guidebook (chapter 2) [5] proposes a methodology, the estimation of this activity contribution to total emissions is not straightforward due to uncertainties associated both to emission factors and activity data. Due to the importance of residential wood consumption as a source of particulate matter emission and the uncertainty of its estimate, a study has been planned to establish with more accuracy the activity data for residential wood combustion. In particular, more information has been requested on the usage of residential wood combustion, on the types of technologies used and on the householder motivations to prefer wood rather than other heating systems. Additionally, an activity estimation of some less-known sources, like barbecues, home wood ovens and backyard burning practice, has been required. At the moment, the questionnaire is ready to be administered to the sample population.

The 2005 emission database will be used as base case and to define an initial set of "exploratory" scenarios for the year 2012. These scenarios will be obtained by changing the main emission sectors, sub-sectors or activities of the base-case scenario and be the input for a number of AQ simulations aimed at evaluating the sensitivity of AQ models to specific sector

emission reductions and to identify the areas where further research would be more pertinent and cost-effective.

The final emission inventory (to be prepared in a final stage of the project) will be based on a more coherent methodology which will make use of the INEMAR emission and projection estimates consistently over all regions. In this frame, the advantages of having a common tool for the preparation of Regional Emission Inventories are important.

2.2. Air Quality Modelling

The POMI (PO valley Model Intercomparison) exercise is a model intercomparison which aims to investigate the changes in air quality predicted by different atmospheric chemistry transport models (CTM) in response to changes in emissions in the Po valley and more specifically in the Lombardy Region (Figure 2). POMI will focus on ambient levels of ozone, PM and NO_2 [11] [12]. As defined by the EU-Directives, the assessment of health impact as well as of impacts on vegetation requires information about the long-term exposure to a set of air pollutants, the methodology of POMI will be based on long-term simulations with hourly time resolution. POMI will build upon the experience gained in past model intercomparison exercises and will in particular address the following issues:

- Assess the level of accuracy of current state-of-the-art CTM in reproducing air quality levels in the Po valley and the main associated indicators characterizing the base case (comparison with available measurements) In particular, it will investigate the model variability associated to the modelling of those indicators?
- Assess the expected model response to emission reduction scenarios and associated model variability An estimate of this variability needs to be assessed to increase our confidence in the robustness of the model responses, especially when those are used in the policy context.
- Assess the level of refinement in terms of emission inventory (spatial allocation of sources, activity sectors, temporal disagregation, etc.) needed to correctly reproduce the main air quality indicators and obtain meaningful answers in terms of emission reduction scenarios?

POMI will make use of the “ensemble modelling” [7] approach for a more robust estimate: 5 European modelling groups currently participate to the intercomparison exercise (CHIMERE, EMEP, CAMx, RCG and AURORA) but participation is open to other groups that would like to compare their modelling chains in the frame of POMI.

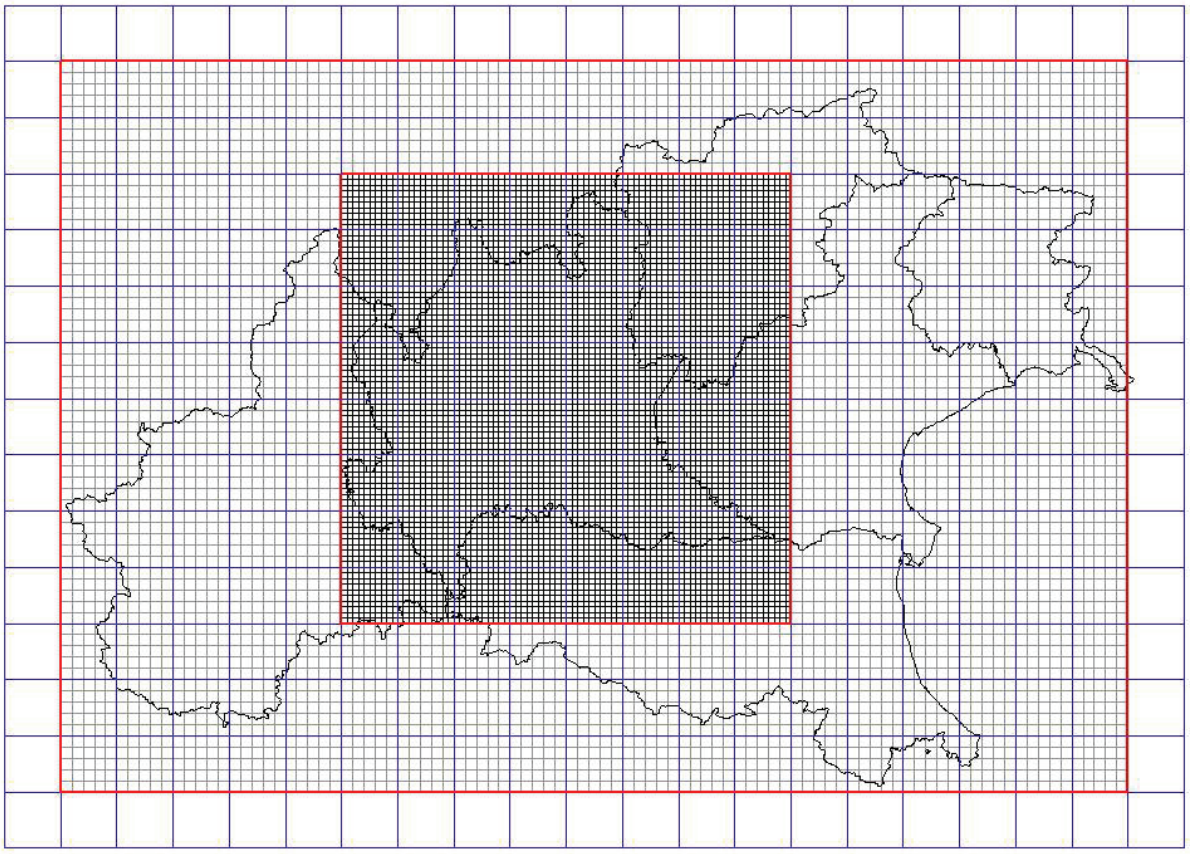

Figure 1: **POMI** modelling domains: PO-Valley (6 km resol., 95 x 65 cells) and Lombardy Region (3 km resol., 80 x 80 cells).

2.3. Emission Scenarios and integrated assessment

The scope of this project culminates in this last point. Basically, which are the policy options that have the best chances to bring the desired effect to air quality, while at the same time taking into account all costs?

The task will combine data on pollutant sources, their respective contributions to atmospheric concentrations and human exposure as well as their socio-economic impacts, together with information on potential technological and other abatement measures that may be used to reduce air pollution taking into account their economic costs, in order to identify cost-effective strategies for improving air quality at regional level.

Different emission scenarios will be developed including the baseline current legislation (CLE), the maximum technically feasible reduction (MTFR) and a set of less ambitious scenarios. This set of specific scenarios will be prepared focusing on the emission abatement in the industry (stringent implementation of the IPPC directive), on transport (including non-technical measures), on agriculture and on energy conservation. Those emission scenarios might be optimized according to the results obtained in the frame of the air quality modeling exercise to indicate and assess possible strategies to comply with the air quality limits.

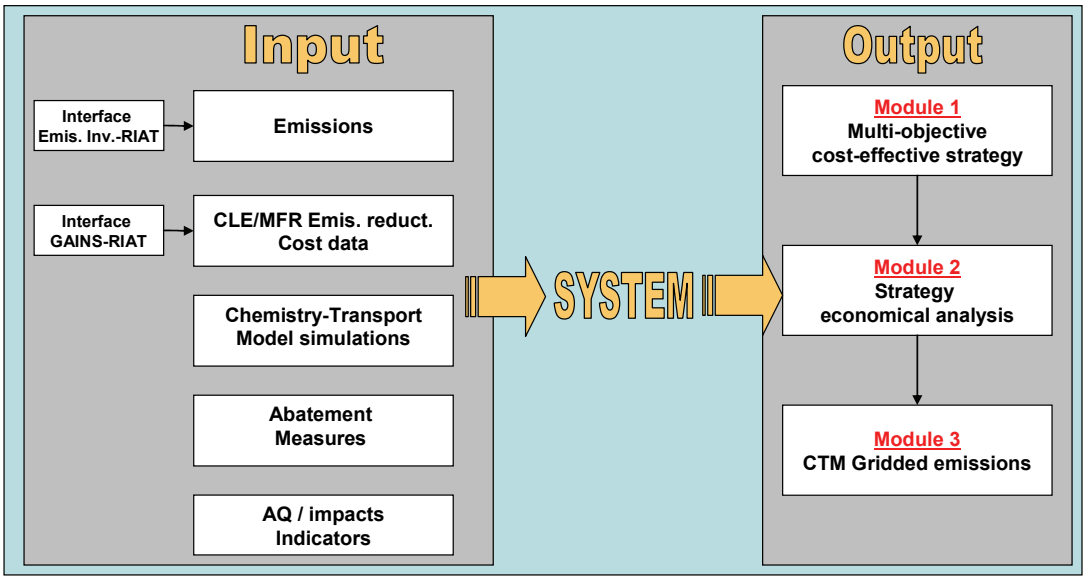

Figure 2: The regional integrated assessment tool system.

The reference tool in Europe for the assessment of abatement costs related with policy options is currently the GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) model. The new GAINS model incorporates the latest version of the RAINS-Europe model (Regional Air Pollution Information and Simulation) as it has been prepared for the 2007 revision of the NEC directive. GAINS incorporates the estimate of emissions, mitigation potentials and costs for the six greenhouse gases included in the Kyoto protocol additionally to the conventional air pollutants already considered by RAINS [9]. The integrated assessment methodology performed by the GAINS/RAINS model has been developed by the International Institute for Applied System Analysis (IIASA) for the UN Convention on Long Range Transboundary Air Pollution (UN-ECE CLRTAP9 and used by the EU Commission to develop policies on Air Pollution (CAFÉ).

The RAINS model has been down-scaled and adapted to Italy (RAINS-IT model), by ENEA in cooperation with IIASA, in the frame of the development of the national Integrated Assessment Modeling system (MINNI Project) and is currently used to support Italian regions in evaluating the efficacy of regional policies.

Yearly average deposition/concentration maps related to emission scenarios and projections performed with RAINS-IT are based on the source-receptor relationships (or ATM – Atmospheric Transfer Matrixes) estimated in the frame of the MINNI project, defined on a 20x20 km modelling grid, with the meteorology of 1999, using the base case emission inventory defined at national scale and encoded with a different classification system. All these technical aspects of the RAINS-IT system are appropriate for the evaluation of scenarios and emission projections at national scale, but they are, to some extent, not entirely suitable and convenient for the specific and more spatially accurate evaluation requested at the regional level. In fact, the spatial distribution of emission sources in the RAINS-IT system is under the constraint of the source-receptor relationships and, as a consequence, sources location can not be smoothly changed with the purpose of introducing region-specific details. Analogous constraint make difficult to change the driving forces at the basis of the evolution of specific activities or the market penetration of a specific abatement technology. Furthermore, the RAINS-IT software tool is owned by ENEA and it is not released to the public, implying some limitations for the Regional authorities in the autonomous use of the software and its input datasets.

The objective of the JRC, in the frame of the integrated assessment work package, is to develop a methodology and realize an application that will combine the information publicly available through the GAINS web-portal with more specific and accurate regional information to perform a regional cost-effective and multi-objective integrated assessment analysis. An application with these characteristics shall enable the Po Valley regions to use more specific and detailed input data referred to their scale of interest, reducing therefore the technical constraints imposed by the information at national-scale used in the RAINS-Italy modelling system. This regional Integrated Assessment tool for the air pollution will specifically be projected to support policy maker in designing emission scenarios and selecting the most effective abatement strategies, taking into account available regional economic information.

3. EXPECTED RESULTS OF THE PROJECT

The main objective of this project is the evaluation of a range of emission scenarios and their effect on pollution levels in Lombardy in support to policies focusing on the optimization of emission abatement measures.

The main results will be:

- Improvement of the emission inventory working on the weakest aspects that have been identified, like wood combustion activity data, and the lack of an integrated transport model for a better determination of road mobile sources activity data across the whole Po Valley.
- Development of emission scenario
- Assessment of the uncertainty associated to AQ modelling at different scales.
- Application of Sensitivity analysis techniques to updated emissions, meteorology or boundary conditions.
- Realization of an application that combines data on pollutant sources (emission inventories), their respective contribution to atmospheric concentrations (S/R relationships) and human exposure, together with information on potential technological and other measures that may be used to reduce concentrations taking into acount their costs.

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