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Institute for Environment and Sustainability
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Krakow Project

From toxic emissions to health effects:

An integrated emissions, air quality and health impacts case study in Krakow, PO

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1 Background

Emissions**,** their fate in the environment, the resulting human exposure and associated health impacts are not well understood for all classes of air pollutants, even though certain knowledge has been gathered for regulated pollutants like CO, SO_2 and NO_x. Other pollutants such as particulate matter (PM) and associated pollutants like dioxins and polycyclic aromatic hydrocarbons (PAHs) are of particular concern.

In **EU New Member States** and in **Candidate Countries** specific national circumstances may result in different source emissions profile[1]. Thus, sources of medium importance in the EU, like domestic heating with solid fuels, might be of high relevance in some EU New Member States [2]. For instance, Poland alone consumes more coal in the residential sector that the whole EU-15. Moreover the rapidly changing transport sector in these countries, having older vehicle fleet than in EU-15, poses additional environmental pressures to be tackled.

In line with European Environment and Health and the Urban Environment thematic strategies, the problems of toxic emissions, the resulting air quality and their impacts on human health need to be addressed with **an integrated approach**. In order to offer the policy makers an adequate support to develop appropriate emission reduction strategies, the Joint Research Centre of the European Commission coordinates with relevant scientific partners the assessment of emission sources, the resulting pollutant levels in the air, the human exposure and their eventual health impacts.

In a stepwise approach **a methodology** is being developed in a confined and well-characterised area. In a second step, this methodology will be applied to other regions. The city of **Krakow** and its surroundings comprise a confined area with typical emission sources suitable for a case study. Coal in this region is still widely utilized in residential heating appliances. The first measurements indicate a high load of ambient air particulate matter (PM) with high concentration of dioxins and polycyclic aromatic hydrocarbons

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[1] Paradiz B., Dilara P.: Dioxin Emissions in the Candidate Countries: Sources, Emission Inventories, Reduction Policies and Measures, Ispra, 2003, EUR 20779 EN.

[2] Olendrzynski K., Fudala J., Hlawiczka S., Cenowski S., Kachniarz M., Kargulewicz I., Debski B. Skoskiewicz J.; Emission Inventory of SO_2, NO_2, NH_3, CO, PM, HMs, NMVOCs and POPs in Poland; UN ECE – EMEP/Poland – Report, IOS, Warszawa, 2002

(PAHs). Even in the surrounding mountain settlement, where no industry exists, high levels of PM and associated PAHs, dioxins, as well as SO_2 have been measured. This highlights the possible importance of solid fuels used for residential heating as a relevant contributor to the local air pollution and human exposure and poses open questions for specific adverse health effects.

In the meeting organized in Warsaw and Krakow from 24-27 May 2004, the polish authorities confirmed their strong support and commitment to the project implementation as a clear example of JRC activity in support to the EU policy making process and to EU Member States.

2 Objectives of the project

The objective of the project is to develop a methodology in order to support the decision making process at local, state and EU level to design appropriate air quality and emission reduction strategies. One of the main goals of the project is the integration of new EU member states by capacity building through broad participation of experts, institutions and authorities.

The objectives of the project are:

- Study of emissions and its sources, air concentration levels and related health impacts of particulate matter (PM) and associated pollutants (dioxins, polycyclic aromatic hydrocarbons (PAHs)).
- Development and test of modelling tools to identify the contribution of the various sources to ambient levels, human exposure and health impacts (compilation of detailed emission inventories, dispersion modelling, source apportionment).
- Evaluation of the ambient air and health impacts improvement for synthetic scenarios of emission reductions focused on residential and transport sector.
- Science based support to the decision-making process integrating environment and health competences in EU Member States and Candidate Countries.

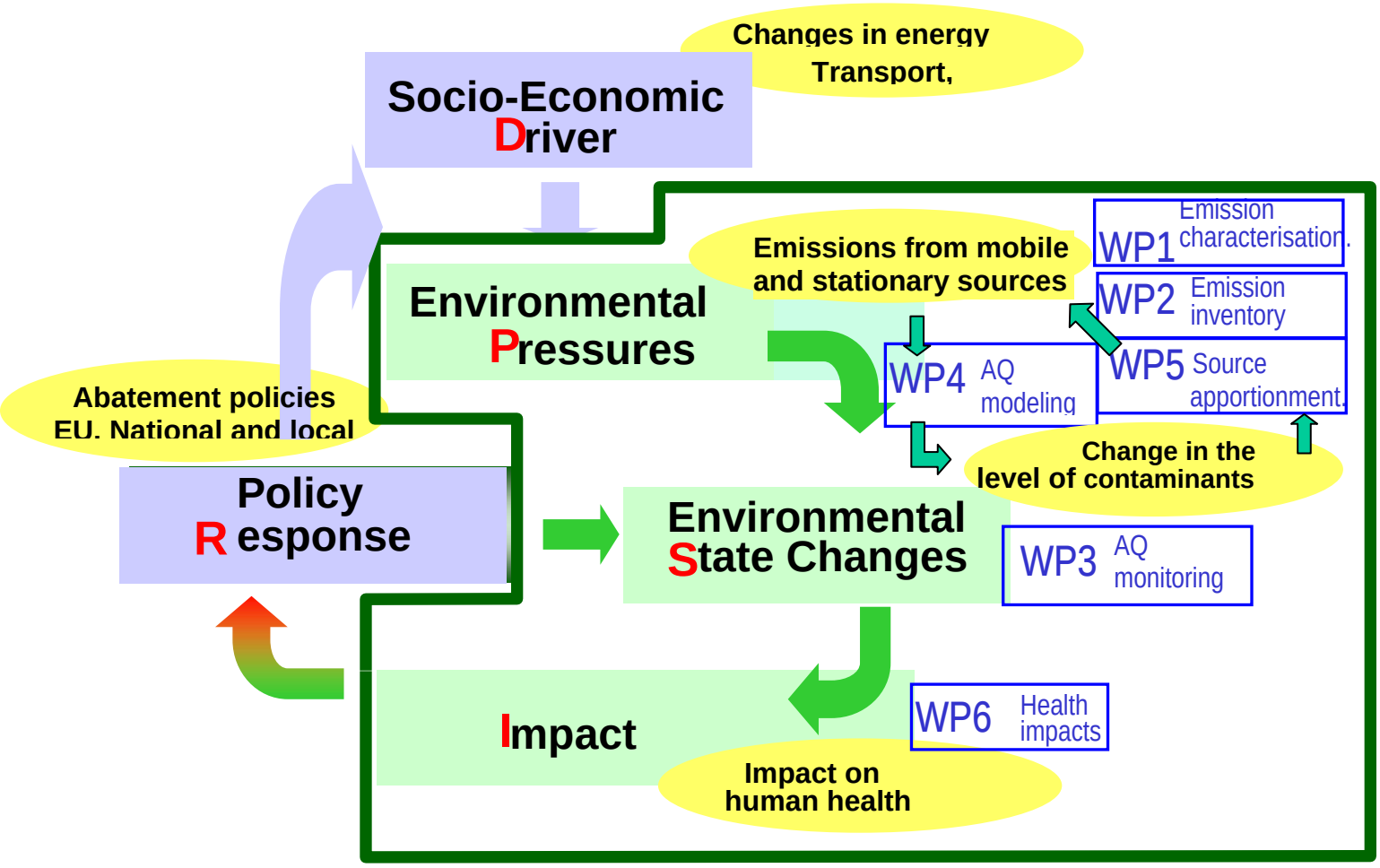
3 Relevance to Policy – Stakeholders

The project is part of the JRC Enlargement and Integration action plan. The issues to be addressed in this research cover a wide range of policy issues, the European Environment and Health and Urban Environment thematic Strategies, and the CAFÉ programme.

The main stakeholders of the project are DG-JRC, DG ENV, EU Member States and Candidate Countries.

4 Activities overview

The project consists of six interrelated work-packages that cover the pressure, state and impact of the DPSIR model:



WP1: Emission characterisation (WP Leader: B. Paradiz)

Emission characterization will be focused mainly on toxic pollutants difficult to measure like dioxins and PAH in order to derive representative emission factors for the most relevant area sources. Dioxin and PAHs emissions from residential heating appliances will be measured in the JRC small sources facility with fuels of polish origin. PAHs emissions from transport will be to the great extend derived from the measurements performed in JRC VELA facility. Dominant industrial and residential sources will be

measured as an input to the source apportionment workpackage (WP5) (fingerprints). These emission measurements could contribute to more accurate emission inventory (WP2), reflecting local circumstances.

WP2: Emission inventory and synthetic emission scenarios (WP Leader: J.Niedzialek)

Emission inventory were updated and improved in order to identify most important sources of pollution, to serve as an input to the air quality modelling (WP4) and source apportionment (WP5). Focus was on PM and associated emissions (dioxins, PAHs) complemented with emission of other pollutants like SO_2, NO_x, NMVOC and CO. Appropriate spatial resolution was provided in the area of Malopolska Voivodship to enable air quality modelling (WP4). All relevant sectors were covered. Local circumstances were taken into account and Polish project partners were to a great extent involved in its compilation, due to their knowledge of input data.

To investigate the effects of emission reductions on air quality (WP4) and human health (WP6) synthetic emission scenarios for transport and household heating emissions were developed on the basis of the emission inventory.

WP3: Outdoor and indoor air quality levels and human exposure measurement campaign: (WP Leader: A. Borowiak)

An air quality monitoring campaign complemented the data from existing ambient air monitoring network in Krakow to have additional data on spatial distribution of PM levels. The JRC mobile Air Quality Laboratories (ERLAP, SPASS and the aerosols lab) with its advanced instrumentation capable of detailed characterisation of PM (and aerosols) was deployed. Collected PM was used for additional elemental and chemical analysis to provide input for source apportionment (WP5). During the same period on several locations indoor and outdoor PM levels were measured to investigate links of indoor levels with outdoor pollution and indoor activities. Human exposure to PM were preliminary assessed by personal samplers. The outdoor campaign intended to get representative information on air pollution in the winter period lasted 3 weeks during in January / February 2005 (with a week interruption in the middle due to adverse weather conditions).

WP4: Air Quality Modelling (WP Leader: K. Cuvelier)

Air quality modelling was used to provide a deterministic link between emissions and resulting pollutant levels in the atmosphere. The Integrated Modelling System for Air Quality (JRC-IMSAQ) together with other five modelling groups from Poland were applied to assess impacts of various local emission sources as well as regional atmospheric transport of the pollution to air quality. Air quality modelling was used to complement the PM outdoor monitoring data in particular for the assessment of the links between air pollution and health effects . The comparison of the results of the modelled and measured pollutant levels (WP3 and existing monitoring network) as well as the source apportionment results (WP 5) have benn useful for the identification of emissions inventory gaps (WP2). Finally air quality modelling was used to provide an assessment of improvement of the air quality for different (synthetic) emission reduction scenarios.

WP5: Source apportionment: (WP Leader: B. Larsen)

Source apportionment complements air quality modelling (WP4) by providing fundamental information on importance of various emission sources by an alternative, independent approach. Several PM monitoring sites were equipped to enable detailed chemical and elemental characterisation of PM. These data was used in Chemical Mass Modelling to identify and quantify contribution of the various sources to the PM outdoor levels. In addition to the outdoor levels an attempt was made to apply source apportionment also to indoor air pollution levels. The dataset was distributed to a number of experts in receptor modelling using different models (UNMIX PMF, PCA, Factor Analysis) for comparison of source apportionment methods.

WP6: Health Effects (WP Leader: N Stilianakis)

A pilot epidemiological study based on indoor and outdoor PM measurements (WP3), including health effects monitoring was performed. The aim of the study was to identify potential health hazards associated to PM. The cross sectional epidemiological study using a larger population sample (around 600 citizens) by employing health status questionnaires and effect monitoring measurements. The collected data was evaluated and interpreted in connection with the air quality data modelled by NILU with regard to their health impact and health risk analysis.

5 Project contributions

The project is funded by the JRC enlargement and integration program. A substantial contribution is given by the JRC Institutional work- program.

During the first phase of the project, additional contributions from the main stakeholders were defined, namely Polish authorities, and research institutions.

Within this project, JRC actively fostered collaboration with research institutions from New Member States and Candidate Countries organizing as well various workshops with the objective of transferring the know how developed with the project. The involvement of Polish research organizations and Polish local and national environment authorities and the collaboration of other major research centers have made possible the success of the project.

The list of Project partners is as follows:

- Chief Inspectorate for Environmental Protection,
- Voivodship Inspectorate for Environmental Protection in Krakow,
- Malopolska Governor Office,
- Krakow Municipal Office,
- NILU & NILU Polska
- Jagiellonian University,
- University of Helsinki
- Polish- Italian Foundation S. Raphael,
- Central Mining Institute,
- US-EPA
- National Environmental Research Institute (NERI, Denmark)
- Warsaw Polytechnic
- AGH University of Science and Technology
- Technical University of Lodz
- Institute of Meteorology and water Management (Krakow Branch)
- EC-Joint Research Centre:
    - Institute for Environment and Sustainability
        - Units: Transport and Air Quality (*Project Leadership*), Climate Change, Rural-Water- & Ecosystem
    - Institute for Prospective and Technological Studies - Sustainability in Industry, Energy and Transport Unit
    - Institute for Reference Materials and Measurements – Isotope Measurements Unit

6 Dissemination of results

A very important part of the project is the capacity building and dissemination of the developed methodology. This is being achieved by broad participation of experts from New Member states and Candidate Countries. A series of dedicated training workshop are being organised in Poland and in other EU Member states in order to achieve this goal.

National experts and other JRC visiting scientific staff from New Member States and Candidate Countries (Poland, Czech Republic, Estonia, Slovenia, Bulgaria,…) have

contributed significantly to the implementation of the project and to the dissemination of its scientific output.

7 Project duration

The project was started in 2004 that was devoted to the definition and preparatory phase, the experimental phase was mainly carried out in 2005 and the final results are presented in the workshop of May 2006. The very intensive research work carried our during this period will results in an important scientific output in the form of scientific publications and conference presentations that will take place during the coming years.

8 Follow-up activities

The project results will provide appropriate basis for the design and implementation of emission reduction strategies by the respective authorities. From a scientific aspect modelling tools could be improved and topics to be addressed could be widened by for instance inclusion economic aspects (This has been initiated within the current project by JRC-IPTS). In line with the capacity building objective of the project, it is envisaged that as far as the concrete implementation of the project the Polish partners will take over the leadership of the project.

The follow-up activities will be discussed during the project workshop that will be held in Krakow on 15-16 of May. Possible scientific topics are:

- Definition of guidelines for the identification of the origin of PM in Europe, including the development of a database for Source Apportionment Fingerprints.
- Additional emission measurements and improved emission inventory focused on discrepancies found between emission inventory, dispersion modelling and source apportionment.
- Refined, optimised emission reduction scenarios and their influence on air quality. Air quality modelling during longer periods.
- Additionally cost of the implementation of emission reduction measures could be assessed and compared with decrease in external costs due to air pollution. The relationship between toxic and greenhouse gases emissions reduction could also be investigated.
- The methodology developed and applied in this study will be extended to other geographical areas and to longer time scales. (e.g. Regione Lombardia, Italy)

The expertise accumulated within the JRC in the field of sustainable transport is planed to be deployed also to perform some case studies mainly is support of new Member states and Candidate countries in this field.