“Concept of Integrated Approach to Air Pollution and its potential applicability on a wide scale”

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Overview

Introduction

Historical hints

Concept of Integrated Approach – Application to Air Pollution

Examples of application (Asia, Europe, Italy)

Extension of applicability of the Integrated Approach

Conclusions
Introduction 1

Economic development without environmental controls – leads to external disbenefits on human health and environment – threatens sustainable development

Air pollution is a prime example where negative impacts on human environment are felt rather immediately

With ongoing economic development industrialized countries have taken effective counter-measures to control pollution
Developing countries seem to take responsive action - earlier projections of air pollution indicate trend reversals at much lower levels of per capita income – and at much lower levels of per-capita pollution.
Per-capita NO$_x$ emissions 1940-2030
Critical concern:

How to manage sustainable development/clean air without compromising economic development:

An integrated approach can indicate action that achieves maximum environmental benefits at least costs.
Historical hints (1)

A successful example of international cooperation, aimed at the protection of the environment and the human health, is given by the Convention on Long Range Transboundary Air Pollution (CLRTAP), in the region of the United Nations Economic Commission for Europe (UN-ECE)

CLRTAP was signed in 1979, (the 25th anniversary celebrated in December 2004). It has been the first legally binding treaty for the protection of the environment. Nowadays, ratified by 51 parties.
Historical hints (2)

The starting point was the acidification effects detected, in the sixties, in the Scandinavian rivers and lakes, due to the transboundary nature of some air pollutants, like sulphur oxides, recognized by extensive international research.

In the seventies, the acidification became an issue in Canada, as several studies demonstrated the link between sources in USA and Eastern Canada and the acid deposition in the sensitive Canadian Shield. Hence, the extension of the geographical scope to North America.
Historical hints (3)

Against the background of the cold war, CLRTAP succeeded in building trust between political blocks, increasing awareness and finally defining legally binding protocols, to take common actions.

The driving forces have changed over time, from politics to public concern, environmental damage and, more recently, health concern.
Historical hints (4)

Along years, with the improvement of the scientific knowledge and awareness, other effects related to air pollution were taken into account. Damage to forest, crops, materials and human health became increasingly evident, due to other pollutants (e.g. Nitrogen oxides and ozone)

At the same time it became clear the causes of those effects were correlated among them, and had to be addressed simultaneously. The “Integrated Approach” concept was born.
Historical hints (5)

The Protocols of the CLRTAP

Among the 8 Protocols established within CLRTAP, the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, entered into force on 17 May 2005, is the first example of legally binding instrument based upon a multi-pollutant, multi-effect approach applied to the Air Pollution.

The Gothenburg Protocol implies actions to be taken by the ratifying Parties for a simultaneous reductions of emissions for the $\text{SO}_2$, $\text{NO}_x$, $\text{NH}_3$, and VOC pollutants.
Concept of Integrated Approach (1)

The solution of complex problems, like combating the effects of Air Pollution, implies the investigation of all the concerned aspects, looking at links, sinergies and trade-offs, pursuing the most effective actions to simultaneously address the causes behind.

In addressing the Air Pollution, science research issues, technology developments, impact on the environment and human health, macro-economic aspects, social implications, etc. are simultaneously tackled.
Concept of Integrated Approach (2)

Integrated Assessment Approach applied to Air Pollution

Simplified flow chart

- Economic Development
- Anthropogenic activities

- Emissions
- Atmospheric dispersion
- Depositions & concentrations

- Costs of implementation
- Control technologies

- GDP/capita costs
- Health/Env Effects
- Social aspects

Concept of Integrated Approach (3)

The application of the previous schema allows:

Multi-scenario analysis (e.g. business as usual, etc)

Target settings (emission, impact, costs, etc)

Cost-benefit analysis

Identifying specific mitigation measures for all atmospheric pollutants across all economic sectors that achieve the environmental targets at least costs
Concept of Integrated Approach (4)

Introduction and evaluation of economic instruments (emission trading)

Evaluation of the level of social equity in policy development

Evaluation of relative contributions from different geographical areas (even at hemispherical level)
Concept of Integrated Approach (5)

Assumed the general applicability of such methodology, the Integrated Approach has been applied to Air Pollution, encoding the principles in proper modelling tools.

Ad hoc Integrated Assessment Model (IAM) have been developed and successfully applied, in the development of environment policies, in the frame of CLRTAP, in Asia, in the European Union.

More recently, even at national level IAM Projects have started, like in Italy and the Netherlands. Other EU Countries are considering similar projects (e.g. Sweden, Ireland)
Application of integrated assessment models to Air Pollution
The RAINS model
Regional Air pollution Information and Simulation

- Energy/agricultural projections
- Emission control options
- Emissions
- Costs
- Atmospheric dispersion
- Health and environmental impacts
- Driving forces
The multi-pollutant/multi-effect approach of the RAINS model

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<th>Quantification of impacts</th>
<th>Costs of emission controls</th>
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Quantification of physical and chemical interactions in the atmosphere:

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Policy analysis with the RAINS cost-effectiveness approach

Energy/agricultural projections  
Emission control options  
Emissions  
Atmospheric dispersion  
Health and environmental impacts  
Costs  
Driving forces  

OPTIMIZATION

Environmental targets
Cost-effectiveness analysis
with the RAINS optimization model

Minimize total emission control costs

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Optimization
Examples of implementations for Europe and Asia
RAINS policy applications for Europe

- UN ECE Convention on Long-range Transboundary Air Pollution:
  - Second Sulphur Protocol 1994
  - Gothenburg Multi-pollutant Protocol 1999

- European Union
  - Acidification Strategy 1997
  - National Emission Ceilings 1999
  - Clean Air For Europe 2005
  - Revision of National Emission Ceilings 2007
Economic drivers 2000-2020
assumed for the CAFE baseline scenario, EU-25
Loss in statistical life expectancy in year 2000 attributable to fine particles [months]

Loss in average statistical life expectancy due to identified anthropogenic PM2.5
Calculations for 1997 meteorology
Environmental impacts of air pollution
RAINS estimates for 2000

PM, Eutrophication, Ozone, Acid, forests, Acid, lakes, Acid, semi-nat. ecos.
Scope for further improvement in 2020:
Loss in life expectancy attributable to PM2.5 [months]

2000
203 mio YOLLs

2020
Current legislation
136 mio YOLLs

2020
Maximum technically feasible reductions
96 mio YOLLs
Costs for reducing health impacts from fine PM
Analysis for the EU Clean Air For Europe (CAFE) programme

(Change between current legislation baseline and maximum measures)
Cost savings from the RAINS approach
Estimates presented by European industry associations

"Equal technology" approach

RAINS cost-effectiveness approach

Health improvement
(Change between current legislation baseline and maximum measures)
Costs and benefits of the policy scenarios for 2020
(Source: Holland et al., 2005)
Environmental improvements of the EU Thematic Strategy in 2020
Impact indicator in 2000 = 100%
Costs for achieving the environmental targets of the EU Thematic Strategy, by sector
Conclusions

- The RAINS integrated assessment model emerged as a central analytical tool for European Clean Air policy.

- Cost-effectiveness approach is shared by stakeholders

- Key elements for success:
  - Methodology based on peer-reviewed solid science
  - Accepted by stakeholders, extensive consultations on input data
  - Interactive policy analysis
  - Policy frameworks to bring different stakeholders on one table. The model helps to separate technical and policy issues:
    - Agreements on the facts
    - Debate about different political objectives
National RAINS implementations

- RAINS-Asia
- China
  - National Acid Rain policy plan 2004
  - Multi-pollutant/multi-effect clean air policy 2007
- Netherlands
- Italy
MINNI – The Italian Integrated model.
A tool for scientific support to policies in the field of air pollution.
MINNI
National Integrated Model

Transfer matrix

Atmospheric Modelling System

RAINS Italy

Scenario


Resolution 20 km

Resolution 4 km
Percentage abatement of annual average PM2.5 concentration following 50% abatement of Nox emissions Lombardy (sx) e Lazio (dx)

Other “Side benefits”

Setting up an up-do-date Atmospheric Modelling Systems provides the national policy makers with a tool suitable to test options in addition to the typical RAINS scenarios.

This is a further opportunity for “spot” applications of the modelling system to develop policy strategies involving a limited number/kind of sources and/or a limited area.
“Side benefits” - Examples
“Side benefits” - Examples

• Evaluation of future power plants in Po Valley
“Side benefits” - Examples

Application of PM filter to off-road vehicles

PM10 Composition – 1999 - Italy

Primary

Secondary
“Side benefits” - Examples

Ground level NO2 - MINNI

Ground level NO2 – Piedmont CTM
Future developments of AMS

Extension to other meteorological years to better assess uncertainties.

Continuous improvement of physical chemical description

Evolution to a national air quality forecast system. (TBE).
Extension of the integrated approach
The GAINS model: The RAINS multi-pollutant/multi-effect framework extended to GHGs

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Costs for air pollution and GHG mitigation in 2020
EU-25, GAINS estimates

- National energy and agricultural projections (+2% CO₂)
- With 20€ carbon price (-8% CO₂)
- With 90€ carbon price (-20% CO₂)

Costs for current legislation on air pollution
Additional costs for TSAP
Additional costs for the CO₂ reduction
Per-capita NO\textsubscript{x} emissions
1940-2030
GAINS-Asia
Greenhouse gas – Air pollution Interactions and Synergies

• An FP6 project to explore socio-economic aspects of atmospheric pollution in Asia:
  – How to minimize economic burden of pollution control?
  – How to maximize synergies between air pollution and GHG mitigation?
  – Implemented for India and China

• Project team:
  – International Institute for Applied Systems Analysis (IIASA)
  – The Energy and Resources Institute (TERI), Delhi
  – The Energy Research Institute (ERI), Beijing
  – Joint Research Centre (JRC), Ispra

• 2006-2007
An initial GAINS analysis for Andra Pradesh, India: Population, GDP and coal use for power generation in Andra Pradesh (projection provided by TERI)
Emissions from power generation in Andra Pradesh 2020 relative to 2000, provisional GAINS-Asia results,
Costs of electricity generation
Andra Pradesh, 2020

- Conv. coal with current AP standards
- Coal + advanced air pollution control
- With IGCC for new plants after 2015

Uncertainty range quoted by IPCC
Conclusions

• A focus on co-benefits of air pollution control strategies on GHG mitigation
  – Especially relevant for developing countries where air pollution is high on the political agenda
  – Need for air pollution control can make GHG mitigation economically more viable

• Crucial role for clean coal technologies with multiple benefits in the power sector

• Further analyses for other options (e.g., energy efficiency) necessary.
  – Some options exhibit clear trade-offs (bio-fuels, diesel, etc.)
Conclusions

The Economic Development implies environmental controls, to be sustainable.

The Integrated Approach provides measures to achieve environment/health targets at least costs, taking into account of social aspects, too.

The Integrated Approach to Air Pollution, can be applied to other geographical areas and extended to additional pollutants and also to consider other perspectives.
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