Chapter 2

RAINS and MERLIN: two approaches to explore optimized emission control strategies

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Earlier this year, on May 4th 2001, the European Commission adopted the official Communication announcing and describing the new Clean Air For Europe (CAFE) program. CAFE has the general aim of developing long-term strategic and integrated policy to protect against the effects of air pollution on human health and the environment. Although the major priorities identified for the next phase of EU's air quality policy relate to particulate matter and ozone, CAFE also aims to address problems of acidification, eutrophication and material damage.

Both the UN/ECE Convention on Long Range Transboundary Air Pollution (CLRTAP) and CAFE have recognized the need to create and maintain strong structural links to ensure cooperation and coordination between the technical analysis work carried out under the two programs. Structural links have been established (ECE/EB.AIR/71) and the technical work to support the development of future policy work has already been initiated. The time frame of the CAFE program coincides with the envisaged revision of the Gothenburg Protocol by 2004. Therefore, the next few years offer a unique possibility for scientific cooperation to improve the underlying knowledge used in policy development. Among others, two projects have been identified as potentially significant contributors to the scientific work under this process. These are:

1. The further development of the RAINS model, as presently underway under the IIASA-DNMI contract contribution to CAFE
2. The MERLIN project

Both projects address the further development of integrated assessment frameworks to support the air quality policies in Europe but propose different approaches. This chapter shortly describes the main similarities and differences between the projects and explores how they can be best conducted in a complementary manner.

The IIASA-DNMI contribution to CAFE focuses (i) on the derivation of source-receptor relationships from the Eulerian EMEP/MSC-W model that can be used in integrated assessment models and (ii) on the inclusions of the most relevant aspects of urban scale pollution into the RAINS model framework.

The MERLIN project aims at an integrated assessment framework, which will include the assessment of costs and benefits as well as the macro-economic impacts of emission controls. Thereby MERLIN will also investigate the advantages of introducing a cost-benefit approach into integrated assessment.

The participants of both projects are aware of the need to coordinate their efforts and to avoid duplication of work. The fact that the EMEP/MSC-W modeling team is involved in both projects facilitates the exchange of information and coordination between the projects and their links to the CLRTAP work. It is shown here how both projects can benefit from each other and how their added contributions can best support the strategy discussion on the development European air quality policies.

2.1 Two different integrated assessment approaches

Integrated assessment aims to support the development of emission control strategies to reduce the impact of air pollution. Integrated assessment studies include emission models, atmospheric transport models, effects indicators and assess the involved costs. Integrated assessment models combine this information in a common framework and include an optimization feature to find optimal solutions for given environmental problems. There are various concepts to drive an optimization in an integrated assessment framework, for instance:

a cost-effectiveness concept	will provide an analysis on how to reach a defined environmental policy target at minimum costs.
a cost-benefit approach	will balance the costs of reducing emissions with the monetary benefits of reduced air pollution impacts.
Uncertainty concepts	will search for emission reduction measures which provide the minimum uncertainty while attaining the environmental targets.

The choice of the most appropriate optimization principle is political. The 2nd Sulphur Protocol, the EU National Emission Ceilings Directive and the Gothenburg Protocol used the effect-based cost-effectiveness approach, which aimed for the least-cost measures for attaining politically decided environmental targets. Although there is much room for improvement in the cost-effectiveness approach, the revision of the present air quality policies in Europe could also consider alternative concepts. It is probably too difficult at present to introduce an uncertainty based approach because the determination of uncertainties in integrated assessment is still preliminary. However, the scientific development on cost-benefit approach allows a discussion on the possibility of using this type of optimization. A cost-benefit approach as envisaged in the MERLIN project would balance abatement costs against monetary environmental benefits and would thereby replace the policy choice of the desired environmental ambition level with a model-determined optimal balance between costs and monetary benefits.

Table 2.1 lists the main similarities and differences between the RAINS extensions under the IIASA-DNMI contract and the MERLIN project. The scope of the projects is very similar, both dealing with the analysis of measures affecting different air pollutants and different effects. We have identified three significant differences between the projects.

One substantial difference is the fact that the MERLIN project aims at including macro-economic effects and cost-benefit assessment in the optimization. The RAINS concept does not plan to internalize economic benefit assessment in the optimization, but instead acknowledges the role of negotiators in deciding the politically most appropriate environmental ambition level. This means that MERLIN will include an economic evaluation of the benefit of reducing the environmental impact of the air pollutants in the search for optimal emission controls. In this respect, the comparison of the results

	IIASA-DNMI contract	MERLIN project
Funding Body	**DG Environment**	**DG Research**
Time frame	**2001-2003**	**2001-2003**
Partners	**International Institute for Applied System Analysis (IIASA, coordinator)** **Norwegian Meteorological Institute** **Joint Research Center- Environmental Institute**	**University of Stuttgart (IER, coordinator)** **University College London** **Norwegian Meteorological Institute** **Institute for Ecology in Industrial Areas** **Ecofys B.V.** **Aristotle University of Thessaloniki**
Pollutants	**SO2, NOx, NH3, VOC, CO, PM**	**SO2, NOx, NH3, VOC, CO, PM** **CO2, CH4, N2O, HM**
Effects	**Health, acidification, eutrophication, crops and forests**	**Health, acidification, eutrophication, crops and forests** **material damage**
Years	**2000-2020**	**2000-2020**
Emissions	**IIASA- EMEP/CORINAIR**	**EMEP/CORINAIR**
Atmospheric transport	**Regional model : EMEP/MSC-W** **Urban model: JRC-EI (TAPOM)** **Inter-comparison study**	**Regional model: EMEP/MSC-W (extended to HM for MERLIN)** **Urban model: AUT (OFIS and EZM)**
Transfer matrices	**country -to-grid**	**sector-to -grid**
Optimization	**RAINS**	**OMEGA-2**
Cost effectiveness	**YES, country cost curves**	**YES, individual sectors**
Macro economic effects	**NO**	**YES**
Benefit assessment	**NO**	**YES, ECOSENSE**

Table 2.1: Main similarities and differences between the IIASA-DNMI contract and the MERLIN project for integrated assessment modeling in Europe.

from these two projects can broaden the scientific basis for a political discussion about the role of optimization concepts in European air quality policy.

Another substantial difference is the approach chosen for determination of cost-effectiveness. Based on country- and technology-specific sectoral analysis, the present setup of the IIASA-RAINS model considers cost-curves and thereby decision variables of the optimization problem on a country-by-country basis. The MERLIN-OMEGA-2 system uses representations of sectoral abatement measures as building blocks to set up efficient reduction strategies. Both approaches are valid and complement each other. The actual improvement for integrated assessment models that will be achieved by the MERLIN project is to have the possibility of choosing between an optimization addressing national measures and an optimization of Europe-wide sectoral measures.

The third substantial difference concerns the inclusion of urban air quality in integrated assessment. MERLIN proposes to assess the impacts of regional air quality control strategies in urban areas by coupling two different types of urban models with a regional scale model in an iterative way. The IIASA-DNMI contribution explores instead which information about urban air quality needs to be included into a Europe-wide cost-effectiveness analysis. Through a Europe-wide model inter-comparison organized by the Joint Research Center (JRC) at Ispra, the responses of urban air quality towards changes in regional and urban emissions will be explored and the findings will be introduced into the RAINS integrated assessment framework. It is envisaged that the urban modeling team in MERLIN will participate in the city model inter-comparison coordinated by JRC and benefit from the discussion on urban integrated assessment carried out under the IIASA-DNMI contract.

Other differences, like the inclusion of greenhouse gases and heavy metals in the pollutant analysis or the inclusion of material damage in the analysis of effects, are not substantial in nature, as both modeling systems are in principle prepared to deal with these.

In summary, the two projects complement each other in their cost-effectiveness analysis. MERLIN provides a different approach with cost-benefit assessment and the two projects can benefit from each other in the development of requirements for urban integrated assessment. Their envisaged added contributions, together with the work on emission scenarios and integrated assessment carried out by the European Environment Agency (EEA) and the work by modeling groups and stake-holders at national level, should provide a solid basis for the revision of European air quality strategies.

2.2 The IIASA-DNMI contract

The IIASA-DNMI contract provided bt the European Commission under LOT10 “Preparatory actions in the public health and environmental policy sector” focuses on cost-effective strategies for reducing health impacts caused by fine particulate matter. This includes an analysis of the interactions of particles with other pollutants such as ozone and sulphur dioxide. It also involves the assessment of interactions between regional and urban air pollution. Progress reports and information on this project can be found at *http://www.iiasa.ac.at/~rains/index.html*.

Cost-effectiveness in RAINS

The project aims at extending the analytical capabilities of the RAINS model by carrying out a systematic study of non-linearities in the air concentrations of primary and secondary components of Particulate Matter due to changes in primary emissions of particles and precursor gases. Regional air concentration fields are calculated with the EMEP/MSC-W model developed at DNMI.

Different emissions scenarios are used as a basis to derive source-receptor relationships and are calculated on a country-by-country basis for the RAINS model. Non-linear responses in air concentrations due to emission changes are mainly due to the complexity (non-linearity) of atmospheric photo-chemistry and to a lesser degree to the numerical treatment of atmospheric transport and dispersion. The systematic analysis of these non-linear responses serves to identify critical interactions on the impacts and in relation to atmospheric processes and thus contributes to improve the reliability of the transport models used in integrated assessment. The data sample will also IIASA to develop a reduced-form statistical model that is required by the RAINS model for the simulation of atmospheric transport.

The inclusion of urban air quality

In collaboration with the Joint Research Center (JRC) at Ispra, the project proposes an European wide city modeling inter-comparison. The goal is to determine the influence of regional and urban scale emission reductions on urban concentrations of ozone and particulate matter for selected cities in Europe. This requires a systematic analysis of the interactions between chemistry and transport at different scales and an interpretation of the non-linear responses to emission changes.

The main focus of the model inter-comparison will be on the response of urban air quality to reduced emissions as predicted by the different participating urban and regional transport models. In this way, the range of model responses to emission changes can be identified and the uncertainties in atmospheric transport modeling can be determined. JRC is presently working on the selection of the temporal and spatial coverage of the inter-comparison to allow a discussion on the European representativeness of the results.

It is desirable that the urban modeling team in MERLIN participates in this city model inter-comparison coordinated by JRC. The statistical capability of the OFIS model to provide long-term simulations and the possibilities of the Eulerian mesoscale approach from the European Zooming Model (EZM) will be useful in the discussion of the European representativeness of the results. At the same time, it is expected that the participants from MERLIN will benefit from the underlying discussion on urban integrated assessment carried out under this IIASA-DNMI contract.

2.3 MERLIN Project

The MERLIN project (Multi-pollutant, Multi-Effect Assessment of European Air Pollution Control Strategies: an Integrated Approach) aims at the development and application of methodologies and tools for integrated assessment in Europe. These methodologies will be implemented both for cost-effectiveness and for cost-benefit assessment, thus allowing for comparison of these two approaches. More information on the MERLIN can be found in the project web site at *http://www.ier.uni-stuttgart.de/merlin*

Cost-effectiveness in MERLIN

Cost-effectiveness is determined in MERLIN with the help of the optimization model OMEGA-2. There are a series of differences between OMEGA-2 and the RAINS optimization module. The most important difference is the way how abatement measures are evaluated and taken into account in the optimization process. While RAINS uses country- and technology- specific abatement cost curves, MERLIN considers the costs of individual sector measures and combination of measures across European countries for an iterative optimisation approach. Both models foresee technical and non-technical measures, and both.

OMEGA-2 and RAINS use long-term source-receptor relationships calculated with the EMEP/ MSC-W chemical transports models. However these source-receptor relationships are not the same for both cases but require a separate evaluation of the model responses to emission changes. The resulting two sets of source-receptor relationships complement each other and allow a cross-examination of the present understanding of the non-linear responses from chemical and physical processes to emission changes. They provide also a relevant input to the evaluation of the differences between regional and urban scale responses to emission changes. As stated before, MERLIN can benefit from the discussion on urban scale integrated assessment envisaged under the IIASA-DNMI contract and can contribute with the analysis of European cities carried out by the OFIS and EZN (European Zooming Model) models from the University of Thessaloniki.

In MERLIN, measures to reduce greenhouse gases are explicitly analyzed. With the IIASA/RAINS model, the analysis of synergies with greenhouse gas emission reduction is regularly conducted in conjunction with the National Technical University of Athens and under the auspices of the European Environmental Agency. As many measures reduce greenhouse gases as well as other pollutants, it is interesting to note that both modeling approaches have developed methodologies to include the study of synergies with climate change.

The inclusion of material damage and heavy metals analysis complete the study proposed in the MERLIN project. These inclusions require additional effort on the evaluation of indicators for material damage and on the upgrading of the EMEP/MSC-W chemical transport model to derive the atmospheric dispersion of lead, cadmium and mercury. Such advances in the methodological tools can be easily incorporated by other integrated assessment models and in this way MERLIN can contribute to the further development of the RAINS model.

Cost-benefit assessment in MERLIN

The basic difference between the two approaches is the fact that MERLIN includes a cost-benefit assessment and an monetary evaluation of the effects of the abatement measures. The analysis in MERLIN aims to balance the costs of reducing emissions with the monetary benefits of reducing their impacts. The monetary values of the avoided damage by air pollution control in the different countries are determined in MERLIN by using a complex tool called ECOSENSE developed by IER (University of Stuttgart) in the frame of the ExternE project series supported by DG Research. A further special feature of the project is the inclusion of macro economic effects. By coupling OMEGA-2 to a partial equilibrium model, some statements on the impacts of abatement strategies on unemployment and on economic growth in the different countries can be made. Furthermore, the impacts of pollution control strategies on income distribution can be investigated. In this way, MERLIN will bring the possibility to consider an alternative approach to the well established cost-effectiveness policy and broaden the scientific basis for the strategy discussions for the revision of air quality policies by 2004.