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Forsund, F.R.

IIASA Interim Report
June 2000

Forsund, F.R. (2000) An Economic Interpretation of the Compensation Mechanism in the RAINS Model. IIASA Interim Report. IR-00-036 Copyright © 2000 by the author(s). http://pure.iiasa.ac.at/6209/

International Institute for Applied Systems Analysis
Schlossplatz 1 • A-2361 Laxenburg • Austria
Telephone: (+43 2236) 807 342 • Fax: (+43 2236) 71313
E-mail: publications@iiasa.ac.at • Internet: www.iiasa.ac.at

Interim Report **IR-00-36**

An Economic Interpretation of the Compensation Mechanism in the RAINS Model

Finn R. Førsund

Approved by

Markus Amann
Leader, Transboundary Air Pollution Project

June 23, 2000

Contents

Abstract

In 1999 the optimization mode of the Regional Air Pollution Information and Simulation (RAINS) model was used to support international environmental negotiations on the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone of the UN/ECE Convention on Long-range Transboundary Air Pollution and on the Directive for National Emission Ceilings of the Commission of the European Union. The optimization determines the cost-minimal set of emission reductions that bring acid deposition below user-specified constraints.

In the original formulation of the optimization problem in the RAINS model, such deposition constraints were specified for each of the 750 grid cells in Europe, for which acid deposition is calculated, and emissions had to be reduced in such a way that all constraints are fully met. During the course of the negotiations it was recognized that, using such a formulation, deposition targets for individual grid cells might impose undue emission control burdens, which might not always be fully supported by verified scientific data. As a consequence, a 'compensation' mechanism was developed, which introduces a certain spatial flexibility to the achievement of the deposition targets while maintaining the overall level of environmental achievements.

This paper provides an economic interpretation of the compensation mechanism.

Acknowledgments

This paper was written while visiting IIASA, Laxenburg for two weeks in June 2000. Helpful comments from Markus Amann and Wolfgang Schöpp are gratefully acknowledged. Financial support was received from the Norwegian Research Council.

About the Author

Finn Førsund is professor at the Department of Economics University of Oslo, Norway, and Member of the Frisch Centre in Oslo.

AN ECONOMIC INTERPRETATION OF THE COMPENSATION MECHANISM IN THE RAINS MODEL

1. Background

Within the tradition of partial equilibrium models of environmental economics there are two basic approaches to connect environmental variables with the activities of firms (see, e.g., Baumol and Oates, 1975). Both approaches link activities of economic agents (most commonly firms) to the generation of residuals that may be polluting. The difference is how the environment is linked to emissions. In the *damage function approach* the adverse environmental effects of polluting residuals are evaluated and monetised through a function termed the damage function. Optimal pollution policies are then based on minimising the sum of control costs of residuals generation and environmental damages. The *environmental standards approach* links generation of polluting residuals to standards of exposure to pollution at various receptor sites. Optimal pollution policies are then based on either maximising the benefits from being able to pollute, or minimising control costs of pollution, subject to the environmental standards as constraints.

The model that was most successfully applied for the recent international environmental negotiations on transboundary emission controls in Europe follows the environmental standards approach. The **R**egional **A**cidification **IN**formation and **S**imulation (RAINS) model developed at the **I**nternational **I**nstitute for **A**pplied **S**ystems **A**nalysis (IIASA) basically integrates an atmospheric transportation model (the EMEP model, see Eliassen and Saltbones (1983) for the start and Tarrason et al. (1998) for the latest update) linking the emissions from countries as sources of pollution to the deposition of pollutants at receptors. This analysis is combined with data on purification costs for the emission sources at a country level. At the receptor side, the

EMEP model distinguishes the spatial pattern of deposition over Europe using a regular grid mash with a 150*150 km resolution. The model can be used for scenario analyses and to derive cost effective European wide reductions of emissions. In this latter 'optimization mode', environmental objectives are linked to acid deposition by formulating standards in terms of depositions for each grid cell. The RAINS model was extensively used for the background analyses supporting the negotiations on the Second Sulphur Protocol signed in Oslo in 1994. After this the model was continuously improved and extended. The latest element to be included was the formation of ground-level ozone (see Amann *et al.,* 1998), and such a version of the model was used for background analyses for the Göteborg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone signed in December 1999.

An innovative feature of the RAINS optimisation version was the introduction of *Critical Loads* (CL) as environmental standards. Critical loads reflect, for a given ecosystem, the maximum amount of acid deposition at which no significant environmental damage is expected in the long run according to present knowledge, i.e., where ecosystems should function normally as to reproduction and biomass stability (see Nilsson, 1986).

The background analyses for the Oslo Protocol soon revealed that it was not feasible, or too costly, to use CL as strict environmental standards. More relaxed targets for deposition load to receptors had to be formulated. The principles for formulating such target loads became crucial as to fairness in a multinational setting of consensus decisions (see Tuinstra *et al.,* (1999) for a record of the discussion). Finally, the principle of closing the gap between the critical loads and some benchmark deposition levels was chosen; the *gap closure* principle, which aims for an equal relative reduction of excess deposition for all grid cells (see, e.g., Tuinstra *et al.,* (1999), or the exposition in Førsund, 1999b).

Using this gap closure concept, it was quickly recognized that optimised cost-effective solutions may depend on the constraints of very few, in the extreme case on only one, receptor sites (grid cells). Such a situation places a very high demand on the quality of the data behind the formulation of the environmental constraint (the deposition target). If the quantification of the deposition target for such a single receptor site is based on uncertain information, minor changes in these environmental data might produce very different solutions to the optimisation problem, i.e., might have significant impacts on the least-cost allocation of purification measures. A related problem may be a possible infeasibility of the solution due to a few, may be only one, constraints[1]. In the case of the cost for achieving a few, or only one, deposition target becoming extremely high, it may also be relevant to question the meaning of specifying hard targets for interim solutions.

In order to aim for more robust optimisation results, the basic optimisation problem has therefore been reformulated by introducing a *compensation mechanism* (introduced in the *Fourth Interim Report to the European Commission, DG-XI*, February 1998, and developed further in the fifth and sixth interim reports, see Amann *et al.*, 1998). This compensation mechanism *softened* the spatial inflexibility of the environmental objectives for receptors that was essentially driving the basic model solution.

The purpose of this note is to provide an economic interpretation of the compensation mechanism and to illustrate the effects on optimisation results. We will use the *pedagogical* version of the RAINS model, as presented in Førsund (1999b), focussing just on a single pollutant (e.g., SO_2). However, we believe that the basic principles will be exposed within such a simplified framework. Generalisations can be done more or less straightforwardly without changes in the

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[1] A feasible solution with a very dominating constraint (for Germany) triggered the development of the compensation mechanism (personal communication from Markus Amann).

basic interpretations of the compensation mechanism (for the complete mathematical exposition of the RAINS optimising model see Makowski *et al.*, 1998).

2. The Basic RAINS Model

The optimization approach of the RAINS model reflects the overall environmental policy objectives by specifying constraints on the maximum deposition at each grid cell. A cost effective cooperative solution is then obtained by finding a pattern of emissions that minimise total emission control costs, measured in a common currency (Euro) for the countries involved, that meet the specified constraints on deposition. Thereby, spatial environmental standards (targets) are formulated as constraints of the optimisation problem:

$$\mathrm{Min}_{e_i} \sum_{i=1}^{N} c_i\left(e_i^o - e_i , e_i^o \right)$$

subject to

$$e_i^{\min}(e_i^o) \le e_i \le e_i^o , i = 1,..,N \qquad (1)$$

$$\sum_{i=1}^{N} a_{ij} e_i + b_j \le d_j^* , j = 1,..,R$$

where $c_i(.)$ is the control, or *purification*[2], cost function for country i, e_i^o is the initial emission from country i, e_i the optimal emission, a_{ij} the atmospheric transportation coefficient from country (source) i $(i=1,..,N)$ to receptor j $(j=1,..,R)$ (i.e., the EMEP squares with a 150x150 km resolution in the RAINS model), and b_j the background deposition. The variables d_j^* reflect the environmental objectives specified as deposition targets. They were originally termed *target loads* in the negotiation process (see Tuinstra *et al.,* 1999).

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[2] Purification costs are used instead of the expression control costs or abatement cost to remind the reader that abatement in the form of reducing the production of goods generating emissions, or structural changes as changes in fuel mix, e.g. substitution of natural gas for coal, are not considered.

The Lagrangian for the cost minimisation problem (1) may be written as

$$\begin{aligned} L = & -\sum_{i=1}^{N} c_i\left(e_i^o - e_i \, , e_i^o \right) \\ & -\sum_{j=1}^{R} \lambda_j\left(\sum_{i=1}^{N} a_{ij} e_i + b_j - d_j^* \right) \\ & -\sum_{i=1}^{N} \mu_i\left(e_i - e_i^o \right) \\ & -\sum_{i=1}^{N} \gamma_i\left(- e_i + e^{\min}\left(e_i^o \right) \right) \end{aligned} \qquad (2)$$

The necessary first order conditions are

$$c_i' - \sum_{j=1}^{R} \lambda_j a_{ij} - \mu_i + \gamma_i \leq 0 \, , i = 1,.., N \qquad (3)$$

The first term are the marginal purification costs of country *i,* and the second term is the total marginal evaluation of deposition resulting from emissions of the country *i*. The shadow prices on the environmental standards are only positive if the corresponding constraint is binding. If we have typical upstream-downstream configurations it is to be expected that many constraints (deposition targets) will be over fulfilled (i.e., they will not be binding and not influence the optimal solution).

The shadow prices on the upper and lower constraints on emissions from a country cannot both be positive at the same time. If we are at the upper boundary μ_i will be positive and γ_i zero, and vice versa at the lower boundary. For an interior solution both are zero. We then have the standard textbook condition: It is necessary for an optimal emission level that marginal purification cost equals the total marginal shadow value of unit depositions. Note that marginal purification costs differ between countries due to the country-specific atmospheric dispersion coefficients.

The shadow prices on deposition constraints (for the environmental standard) can be interpreted as the change in the objective function of a marginal change in the (deposition) constraint (evaluated at the optimal solution). Relaxing a binding constraint will in general improve the optimal value of the objective function; in our case it will decrease total purification costs. Tightening the environmental standard, i.e., lowering the deposition target d_j*, will impose a positive cost on the participating countries.

Shadow prices and cost benefit analyses

In discussions of the usefulness of the model results it has been pointed out that since shadow prices are either positive or zero, this leads to two classes of receptors: the set of receptors generating economic control costs, and the receptors that seem to be without economic value. However, it should be remembered that in the economics jargon evaluation of environmental constraints by shadow prices is a mathematical property of an optimal solution, and should not be confused with a cost benefit analysis of using resources on emission control. Shadow evaluation is helping us understand the nature of the solution. They show which constraints are driving the solution and are central determining the spatial distribution of depositions. It should be born in mind that reduction of deposition loads in receptors with zero shadow prices on the deposition constraints have certainly economic value as long as depositions are above critical loads.

The RAINS model is a partial equilibrium model solving the control cost effectiveness problem of achieving given environmental target at lowest costs. If one wants to make a cost benefit analysis of control costs, independent evaluations of states of the environment are necessary. A general equilibrium modelling framework should then be employed in principle. Now, in an economy-wide context, cost–benefit analysis corresponds to asking what are the optimal emission levels. The point of stressing a general equilibrium framework is that money used on abatement has an *opportunity cost* in terms of forgone consumption possibilities.

A partial equilibrium model most suitable in our context can be formulated following the damage function approach mentioned in the introduction. Let $A_i(e_i)$ be the abatement cost of controlling emissions in country *i*. In the more general framework we have in mind these costs encompass more than purification costs captured by the cost functions $c_i(.)$ above, and include structural changes and fuel mix substitution. The upper and lower constraints on emissions are then no longer relevant. The function $A_i(e_i)$ is decreasing in emissions. Let $D_j(.)$ be the monetised damage function depending on the total deposition, $\sum_{i=1}^{N} a_{ij} + b_j$ at receptor *j*. According to the definition of critical loads $D_j = 0$ for $\sum_{i=1}^{N} a_{ij} + b_j \# CL_j$, the function is increasing in deposition[3]. A social optimum corresponding to setting up conditions for a cost – benefit analysis, is then found by solving

$$Minimise \ \{\sum_{i=1}^{N} A_i(e_i) + \sum_{j=1}^{R} D_j(\sum_{i=1}^{N} a_{ij} + b_j)\} \qquad (4)$$

The necessary first order conditions are

$$A_i'(e_i) + \sum_{j=1}^{R} D_j' a_{ij} = 0 \ \Rightarrow \ -A_i'(e_i) = \sum_{j=1}^{R} D_j' a_{ij} \ , \ i = 1,..,N \qquad (5)$$

Note that the marginal abatement costs of country *i* should equal total marginal damage costs caused by country *i*'s emissions. Notice that the condition (5) implies that the marginal abatement costs differ between countries. If the rule (5) is applied one can say that abatement costs have been applied according to a cost – benefit criteria. A marginal rule can be applied because it is assumed that other resources in the complete economy outside our partial equilibrium model are also allocated according to opportunity costs.

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3 As mentioned above, critical loads is a dynamic concept. The introduction of a static damage function is therefore problematic, but we will here just follow standard procedures in environmental economics.

Using the term cost benefit analysis in the setting above with conditions of marginal costs being equal to some measure of marginal benefits may be unfamiliar. The most common applications of cost-benefit analyses are concerned with *project evaluations*. The key assumption is then that the size of the project is small relative to the activities of the total economy. This means that e.g. equilibrium prices of goods are not influenced by the project. The project acceptance criteria is that benefits are greater or equal to costs (i.e., the present value, applying proper discounting, is non-negative). Notice, then, that by *assumption* the benefits generated by the project has to be spent on the project itself. The project is not competing with other activities in the economy under the condition of uniform opportunity costs of resources. If these assumptions are relevant for resources used on emissions reductions, i.e., if emission reductions are viewed as an isolated project allocated a certain amount of funds, then the total criterion applies[4].

Now, if we compare the marginal conditions (3) of the RAINS type optimisation model following the environmental standards approach with the conditions (5) within the damage function approach we see that marginal damages and shadow prices on the deposition constraints appear in a symmetric way. For ease of comparison we will assume that marginal purification costs in (3) corresponds to marginal abatement costs in (5), and that the constraints on emission in (1) are not binding. By such a comparison we see that we should not use a single shadow price, λ_j, as a basis for cost-benefit analysis. It may be tempting to pick out a single λ_j with a high value, and then say that the marginal improvement in receptor j is not worth this cost. But remember that the shadow price λ_j shows the total (summing over all countries) marginal costs for a marginal tightening of the deposition constraint of receptor j, and do not show the evaluation of the environmental improvement taking place in a number of other receptors in order to be able to fulfil the deposition constraint in receptor j with equality. Focussing on improvement in receptor j is therefore too limited.

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[4] For an elementary exposition of this marginal cost rule of cost-benefit analysis, and the project evaluation rule of total costs equal to total benefits, see Førsund (1999a)

As an example let us assume that we have only one binding receptor constraint, receptor j, in the optimal solution to problem (1). We then have from (3):

$c_i' = \lambda_j a_{ij}$.

It may be tempting to compare this value with an (informal?) estimate of marginal benefits of reducing the deposition in this receptor. But from the damage function model we have from (5):

$$-A_i' \ (= c_i') = \sum_{j=1}^{R} D_j' a_{ij} \ .$$

As long as critical loads are not reached, *all* the marginal damages are positive. It is the weighted sum of these that are relevant for evaluating abatement effort in country i, and not only the term D_j'. For the two models to give the same solution for emissions from country i we have:

$$\lambda_j a_{ij} = \sum_{j=1}^{R} D_j' a_{ij} \, .$$

It may very well happen that $\lambda_j >> D_j'$. Marginal benefits in receptor j should therefore not be compared with the shadow price λ_j.

In the general case, the shadow prices λ_j help us understand a solution to a cost minimisation problem. We need independent estimates of marginal environmental damages to be able to perform cost benefit analysis.

3. The Compensation Mechanism

The compensation mechanism takes as a point of departure the total accumulated excess deposition within the country, i.e., the sum of deposition exceeding the critical loads, accumulated over all ecosystems in a grid cell. As mentioned above a technical reason for introducing the mechanism was to avoid too heavy dependence on the quality of the data for just a few variables. A rationale for the specific design of the mechanism may be that countries are more concerned with total (harmful) excess deposition within their whole territory than about excess deposition of individual ecosystems. In such a case it is only important for a country that the target load is not violated on *average*[5], of course taking into consideration that deposition below the critical loads do not reflect actual environmental benefits and should therefore not be used to compensate for harmful excess deposition.

Let us allocate receptors uniquely to each country and for simplicity assume that no receptors are shared (this assumption can easily be generalised). The set L_k is the set of receptors within country k, and the sum of receptors within each country is equal to R. Let us further introduce I as the set of N countries, and M as the set of R receptors. The cost efficient allocation of emissions is then found by solving the following problem:

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[5] Note the similarities with mechanisms for emission trading between countries elaborated at UNECE Task-force level (see Klaassen et al. (1994).Trade between countries implies that some deposition levels may be increased, but various balancing constraints may be added (Førsund and Nævdal (1998)). However, whereas the idea emission trading was met with hostility the compensation mechanism has been introduced in RAINS without much discussion or attention.

$$\text{Min}_{e_i} \sum_{i=1}^{N} c_i(e_i^o - e_i, e_i^o)$$

subject to

$$e_i^{\min}(e_i^o) \leq e_i \leq e_i^o \text{ , } i=1,..,N \tag{6}$$

$$\sum_{j\in L_k} [(\sum_{i=1}^{N} a_{ij} e_i + b_j - d_j^{*}) + \text{Min}\,[0, CL_j - (\sum_{i=1}^{N} a_{ij} e_i + b_j)]] \leq 0 \text{ , } k \in I \text{ , } L_k \subset M$$

The *M* receptor deposition constraints in the basic model (1) is replaced by *N* country balance constraints (in the recent implementation of RAINS *M* is of the order of above 700, and *N* is about 38).

The Lagrangian for the cost effective allocation model with compensation mechanism is

$$\begin{aligned} L = & -\sum_{i=1}^{N} c_i(e_i^o - e_i \text{ , } e_i^o) \\ & - \sum_{k\in I} \phi_k \, [\sum_{j\in L_k} [(\sum_{i=1}^{N} a_{ij} e_i + b_j - d_j^{*}) + \text{Min}\,[0, CL_j - (\sum_{i=1}^{N} a_{ij} e_i + b_j)]]] \\ & - \sum_{i=1}^{N} \mu_i (e_i - e_i^o) \\ & - \sum_{i=1}^{N} \gamma_i (- e_i + e^{\min}(e_i^o)) \end{aligned} \tag{7}$$

The necessary first order conditions are

$$c_i' - \sum_{k\in I} \phi_k \sum_{j\in L_k} a_{ij} - \mu_i + \gamma_i \leq 0 \text{ , } i = 1,.., N \tag{8}$$

The shadow prices of the cost function constraints, μ_i and γ_i, have the same interpretation as for the basic model. The discussion of these shadow prices is therefore not repeated.

Assuming an interior solution (i.e., both μ_i and γ_i are zero), we see that marginal purification costs should be equal to an expression involving sums of unit transport coefficients and country shadow prices, φ_k . The total *shadow marginal evaluation* of deposition originating from emissions from a source *i* is now the sum of the evaluations, each expressed by the product of the shadow price, φ_k, for each country and the sum of the emitting country's unit atmospheric dispersion coefficients to the receiving country *k*. The sum of the dispersion coefficients must be less than one in the normal case that country *k* only contains a subset of all the receptors reached by emissions from country i. Note that the evaluation of deposition to each of a country's receptors is the same. For receptors in countries where critical loads are not exceeded, the contribution of source country *i* to the deposition at such as 'protected' receptor site is given a zero shadow evaluation. This means that deposition cancel out in the country balance constraints when the second term in the constraints in (7) is different from zero. (This situation, however, is not shown explicitly in Equation (8).)

We must have at least one country balance being binding for environmental considerations to influence the solution to problem (6). Shadow prices on country balances are only positive if the constraints are binding. For such countries the target load only holds on average (in the sense defined above), and we must have that one or more of the deposition targets (receptor target loads) in the country are violated compared with the basic model, assuming the same target loads. The country balance will in general not be binding if no deposition targets are exceeded. But notice that one or more deposition targets may be exceeded without the country balance constraint being binding.

Notice that marginal costs are still country-specific as in the basic model. It is in general the country-specific atmospheric dispersion coefficients a_{ij} that give rise to country-specific marginal costs. One cannot say in general that the differences in marginal costs are smaller now than in the basic model. However, avoiding extreme shadow prices will lead to smaller differences in marginal purification costs.

With the compensation mechanism there are no longer shadow prices on the *hard* constraints on deposition targets for individual grid cells, but shadow prices on the *soft* country balances instead. Shadow prices of country constraints can be interpreted as the impact on total purification costs of all countries if the constraint is relaxed marginally, i.e., for a marginal increase within the room for violation. As we have set up the Lagrangian function, the impact on costs is negative when the violation constraint is relaxed. Using the envelope theorem we have that the marginal impact of increasing a target load for a receptor within a binding country constraint is evaluated at the shadow price of the country balance. A relaxation of a deposition target decreases total purification costs with the amount expressed by the country balance shadow price. These shadow evaluations of target loads for a country's receptors are equal. Thereby the concept of a *hot spot* is replaced by a *hot country*.

In contrast to the basic model where each deposition target has a unique shadow price (but zero if the constraint is not binding), as seen from (2) and (3), the target loads of receptors within a country now have the same shadow price. To illustrate the difference between the two models let us assume that a country with some binding and some non-binding receptor constraints in the basic model (1) now has a binding country balance in model (6). The shadow prices that consist in the basic model of zeros and different positive numbers will now, with the compensation mechanism, in a way be *aggregated* to a common positive value for all target loads. It seems reasonable to assume that this average shadow price is lower than the positive prices in the basic model, but this may not be the case in general. If only one country had binding grid square constraints in the basic model, and only one and the same country a binding country balance, and if all target loads are the same, then this will be true.

The question may be asked whether the solution to the problem with the compensation mechanism results in *higher* overall emissions than the basic model without compensation. There is no unique answer to this question, and the question is not really interesting within our framework with an emphasis on the spatial distribution of deposition. We can state that, since the objective functions of the two problems (1) and (6) are the same, for identical deposition targets in general the total optimised purification costs must be *less* with the compensation mechanism due to the lower number of constraints.

A generalised compensation mechanism

In order to avoid undue problems with hot-spot receptors, the violations of or surpluses over targets may be weighted, and also absolute limitations to maximum deposition (higher than target depositions) introduced. The deposition constraint for each receptor for the basic problem (1) can be replaced by two types of constraints. One type of constraint implements the compensation mechanism, allowing violations at one or more receptors to be compensated by surpluses experienced at other receptors within the same country. The other constraints would require deposition at each receptor to stay below a given absolute level. The average target load used as a constraint may also be generalised to a number different from zero[6]. The more elaborate problem then becomes (see Makowski *et al.*, (1998) for the complete RAINS formulation):

$$\text{Min}_{e_i} \sum_{i=1}^{N} c_i(e_i^o - e_i, e_i^o)$$

subject to

$$e_i^{\min}(e_i^o) \le e_i \le e_i^o, i=1,..,N \qquad (9)$$

$$\sum_{i=1}^{N} a_{ij} e_i + b_j \le d_j^{\max}, j \in M$$

where w_{kj} is the weight assigned receptor j in country k, B_k the balance of country k (a positive (negative) number increasing (decreasing) the scope for violations), and d_j^{max} the maximum deposition allowed at receptor j. If all of these maximum values are set equal to the original deposition targets we are back to the basic model (or the solution may be infeasible due to a

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[6] In the discussion of emission trading between countries at UNECE Task-force level country balances opening up for the average target load being violated by a fraction were introduced, see Førsund and Nævdal (1998).

combination of weights and balance level). It will be a coincidence if a country balance is binding at the same time as the *hard* constraints are biting.

4. Conclusions

Provided that the long term goal of critical loads could not be achieved in the near future, closing the gap between some benchmark loads on the environment with the same relative factor for all receptors irrespective of country was accepted as fair by the countries negotiating the Oslo Protocol. However, in order to avoid data for a very few exogenous variables among the tens of thousands of variables to unduly determine the solution, a compensation mechanism was introduced as an option in the RAINS optimisation model when negotiating the Göteborg Protocol. This compensation mechanism relaxes the spatial rigidity of the environmental constraints within each country. Overshooting a target load at one receptor can be compensated by depositing less than the deposition target constraint (but compensation is only allowed as long as depositions are above critical loads) in other receptors within the same country. As an analogy one can say that the compensation mechanism allows a country *emission trading* between its own receptors (see, e.g., Klaassen *et al.* (1994) and Førsund and Nævdal (1998) for emission trading building on RAINS).

Comparing the basic model without the compensation mechanism and the revised version with the compensation mechanism we conclude that in general total purification costs are lower with the compensation mechanism, given the same target loads. This is the *reward* for relaxing a strict spatial compliance with the environmental standards, and may be seen as one way of tackling undue reliance on a few model variables in view of the existing uncertainties. But on the negative side it must be noted that the spatial distribution of deposition is also changed for countries with non-binding country balances. Seen from the perspective of emitting countries all receptors of a receiving country with a binding country balance constraint have the same shadow evaluation, irrespective of the differences in target loads reflecting different environmental sensitivities to deposition. The key question is how the “hard” constraints are interpreted concerning fairness of interim solutions. Is the spatial rigidity really wanted? If yes, then the compensation mechanism should only be used if the nature of an 'uncompensated' solution raises concerns about the robustness. The compensation mechanism is an available *option* in the RAINS optimisation model. Using the compensation mechanism as a general standard implies a change in the interpretation of the fairness principle of gap closure, from strictly applied to each receptor, to a more relaxed interpretation focussing on each country’s deposition balance relative to its deposition targets.

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