The economic design of a potential tradable permit system for SO2 emissions in the European Union

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The economic design of a potential tradable permit system for SO_2 emissions in the European Union[1]

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INTRODUCTION

Acid air pollution has been considered an important international policy issue since the early 70s. In Europe, several initiatives have been taken to abate acid emissions, by focusing first on SO_2. Following the 1979 Geneva Convention on Long Range Transboundary Air Pollution (LRTAP), that was developed in the framework of the UNECE, the European Commission implemented a policy of abatement of sulphur emissions to air from power generation and industrial sources, with the Directive on Large Combustion Plants (LCPD). Two LRTAP protocols have been successively agreed upon : Helsinki (1985) leading to the so-called 30% abatement club, and Oslo (1994), that defined new, differentiated, national targets for SO_2 abatement on the top of emission standards for sources and agreed specifications of the best available technologies to be used by operators. The agreed long run objective[3], not addressed by agreed abatements targets and timetables, is to reduce SO_2 emissions in a way that acid deposits will be below the 5-percentile critical loads identified for each unit zone in Europe[4]. Up to now, regulatory requirements agreed upon within the Protocol are not providing the

1.- This article is based on a study done in 1996 by the authors for the DGII. See Cros and Godard (1996).

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3.- Article 2 of the Oslo Protocol states that Parties should take any possible measures not entailing excessive costs to limit their acid deposits in the long run under the sulphur critical loads. The European Community has endorsed the same long run objective "*of no exceedance ever of critical loads and levels*" in its 5th Environmental programme adopted in 1993.

4.- In the context of this article, each time a territorial dimension is implied, 'Europe' or 'European' should be understood as the whole European territory concerned by the Oslo Protocol, i.e. including non EU parts. 'EU' then refers to the territory of the present member countries of the European Union.

means to reach this long term objective. Introducing new policy instruments or significantly tightening existing ones will be necessary to reduce the gap.

The aim of this article is to provide a broad outline of, and to make suggestions about, the possible use of SO_2-related allowance trading as a policy instrument to be adopted by the European Union (EU), in order to implement a cost-efficient move towards the long term goal of respecting acid critical loads everywhere in the EU. The expected transition will be sufficiently long to make it profitable to pay for the initial organisational investment required for the development of trading schemes.

Our main goal is to envisage trading solutions which fit the essential features of the present institutional context of the European acidification game, that combines EU and international (UNECE) features[5]. More specifically, we take the LRTAP Protocol of Oslo as granted, regarding its main rationale.[6] This framework allows some margin in using economic instruments, but poses constraints that rules for emissions trading should meet. Namely we interpret this Protocol as providing two main constraints:

- national emissions caps for stationary sources have been agreed on according to a timetable specifying targets for several years (2000, 2005, 2010);
- deposition caps for each unit zone of a European territorial grid should be respected according to a 60% abatement target -as a first step- in the gap between current deposits and the 5-percentile critical loads.

The second constraint is not formulated as such in the Protocol, but results from the way differentiated national targets have been arrived at, and from the expected rules which will be imposed on joint implementation. It introduces a major departure from what has been the main experiment in SO_2 trading, i.e. the Acid Rain Program developed in the USA since the 1990 Amendments of the Clean Air Act: a national market for SO_2 allowances has been set up, on the top of local regulations aiming at local environmental protection, for the whole territory, from Boston to Los Angeles; provided that local regulations are met, SO_2 trading can be achieved without any specific constraint of location (Godard, 1994 ; Rico, 1995).

Although no existing policy and measures can guarantee the respect of both constraints, the challenge our proposals try to take up is to design trading schemes which fits

5.- As is well known, switching from national to international contexts involves not only changing territorial scales, but the very nature of the co-ordination problem (Godard, 1992; OECD, 1992a). In a national context, a State administration is supposed to have the capacity to enforce a new law on every citizen, even those who feel themselves to be net losers from the change of law. In an international context, a new rule has to be accepted by each Party and there is a severe problem of potential free-riding. In the context of the EU, the situation is intermediate, depending on the nature of the issue and the type of voting procedure (unanimity or majority).

6.- By March 1997, only four countries had formally ratified this Protocol: Denmark, Netherlands, Norway and Sweden. This number is insufficient to give it any binding legal value. The assumption supporting the article is that this Protocol will eventually be enforced.

them. It is not our purpose in this article to propose detailed rules regarding any practical question that would be raised if such an instruments were considered for practical implementation. Neither is it to establish a systematic comparison of tradable permits with other economic instruments, such as incentive taxation, or with Command and Control (CAC) approaches[7], or to elaborate an integrated framework using allowance trading for all types of atmospheric pollutants (NOx, PM, ..). We intend to simply give a sense of why it might be a good idea to develop SO_2 trading schemes for organising the EU action against acid deposits, and what could be the broad design of such trading schemes. Accordingly it provides some insights on how to shape an economic instrument so as to make it compatible with basic institutional features of existing regulatory regimes.

Such proposals are conceived for an implementation limited to the power generation sector, although an extension to all large combustion plants, including SO_2 emissions of refineries, would be profitable so as to enlarge the market and set a more comprehensive action framework.

This paper contains two main parts. The first develops the issues of the European acid policy, and sets out the general background of the related regulatory regime. It also gives an overview of the theoretical and actual features of emissions trading mechanisms. It then considers the potential attractiveness of SO_2 trading in the EU. This background throws light on the more specific analyses and proposals described in the second part of the paper, which is devoted to a presentation of possible frameworks for SO_2 trading in the power generation sector in the EU. In section 2.1., we look at some key design variables. In section 2.2., we present three alternative ways of designing a trading scheme. In section 2.3., we consider specific issues related to zoning and scaling.

1. GENERAL BACKGROUND

1.1. Issues in European acid policy

Airborne acid deposition has been considered a major environmental problem in Europe for a significant period of time. A key achievement of the UN Conference on the Human Environment held in Stockholm in June 1972 was to focus the attention of European governments on this issue. Since then, successive policy responses have been given.

Major recent steps have been: the LRTAP 1985 Protocol of Helsinki on SO_2, which led to the so-called 30% Club, i.e. countries committing themselves to achieving at least a

7.- This has been achieved in the context of OECD (see for example 1993, 1994) or, more recently, the IPCC process (Working Group III's 1995 report).

30% cut in SO_2 emissions by 1993 relative to 1980 levels; the EU 1988 Large Combustion Plants Directive (LCPD) (88/609/EEC) introducing SO_2 and NO_x emission standards for new plants (after July 1, 1987) and global country caps on emissions from existing sources, with three stages (1993, 1998 and 2003); and the LRTAP 1994 Protocol of Oslo defining new and differentiated targets for emission abatement on a per country basis. For the first time at this level, major progress has been planned for emissions from both new and existing plants, with most European countries[8] required to make overall reductions in emissions of 40%-80% relative to 1980 levels, with a mean value of 62% for the EU. Table 1 gives targets for a selection of countries.

Table 1 : national emission targets for SO_2 set by the Oslo Protocol

Countries	**Actual emissions** kt SO_2 per year		**Sulphur emission caps**			**Abatement percentage** (reference year 1980)		
	1980	1990	2000	2005	2010	2000	2005	2010
Austria	397	90	78	-	-	80	-	-
Belgium	828	443	248	232	215	70	72	74
Denmark	451	180	90	-	-	80	-	-
France	3348	1202	868	770	737	74	77	78
Germany	7494	5803	1300	990	-	83	87	-
Greece	400	510	595	580	570	0	3	4
Italy	3800	-	1330	1042	-	65	73	-
Netherlands	466	207	106	-	-	77	-	-
Spain	3319	2316	2143	-	-	35	-	-
Sweden	507	130	100	-	-	80	-	-
United Kingdom	4898	3780	2449	1470	980	50	70	80

The Oslo Protocol reveals tension between the nature of the commitments taken by governments and the type of thinking developed during the preparatory work. The commitments are formulated in terms of national ceilings, although preliminary work was focused on catching decentralised connections between localised sources and localised deposits, according to a grid of 150 km X 150 km cells, irrespective of national boundaries. This was achieved with the help of the EMEP model. Consequently, experts were working to obtain the maximum practical acknowledgement that emissions generate different impacts,

8.- Within the EU, exceptions are Spain, Greece, Ireland and Portugal.

depending on their location.[9] Moreover, the EMEP assessment of pollutant transport shows that one receptor zone can often receive deposits from various sources located in different places. There is at present a risk that a country will satisfy its national target by decreasing emissions from plants which are not the most damaging. A concentration of the abatement effort on a few plants located in the same region may also occur. The result would be an unequal impact on various receptors - some will see their situation improved, while others may see little change from the present level of deposits. So, the protocol does not include regulatory measures that could guarantee the achievement of its long term objective. This is a new challenge, whatever policy instrument is used. For example, to secure this objective with emissions standards, they would have to become absolutely stringent for every existing source. This could be dramatically costly.

An alternative to CAC would be the introduction of national markets for SO_2 emissions allowances in the power generation sector according to the bubble concept, i.e. national zones within which exchanges of emission allowances are accepted without constraint. This would not change anything in the legal situation established by the Oslo Protocol, regarding the obligations that have to be fulfilled relating to physical environmental performance. To the extent that national ceilings have been accepted by the Protocol, there is no reason why the location of the abatement efforts within countries should create a legal problem, provided that other rules included in the Protocol are met. This bubble approach may improve the cost-effectiveness of the measures that have been decided centrally. Generally though the bubble concept is applied to situations where the regulator wants to develop cost-effective means to reduce emissions without worrying about the location of emissions. This is not really the case as regards acid deposits in Europe. By itself, setting-up national bubbles in the electricity sector could not guarantee the achievement of a cost-effective abatement plan meeting the goal of a 60% -and further- reduction of the gap between current deposition and the 5-percentile critical load. So, at best, national schemes of trading emissions allowances would be partial mechanisms. This realisation should not lead to such schemes being dismissed out of hand. Rather, it may mean that something else is required to supplement the instrument.

One article of the Oslo Protocol is of interest in this respect. Article 2, paragraph 8 acknowledges the future potential of joint implementation. It says: "*the Parties to this Protocol may, at a session of the Executive Body, in accordance with rules and conditions which the Executive Body shall elaborate and adopt, decide whether two or more Parties may jointly implement the obligations set out in annex II.*" This scope for joint implementation seems to open the door to the possibility of some international exchange of targets. So, under

9.- It may matter a great deal whether they are located in the North or in the South of a given country, particularly if it is a large country, such as Germany.

conditions that still have to be specified[10], the EU countries could envisage a pooling of efforts by adopting a single emissions quota for the EU.

This idea of an EU joint implementation faces two types of obstacle:

- Firstly, there is a risk that a strictly regulated joint implementation scheme will raise obstacles to the flexibility already existing at the national level. For instance, a conflict may emerge between the development of national trading schemes as a way to implement national ceilings, and an EU joint implementation, since new constraints related to critical loads then have to be incorporated into the rules. Another conflict may arise between the rules and requirements imposed to joint implementation and the flexibility needed for the development of EU-wide trading schemes. In both respects, too cautious an approach to joint implementation may create additional constraints which make the exercise unfeasible or cause it to lose its economic attractiveness.
- Secondly, a full development of joint implementation may call into question the rationale of the political negotiation which resulted in the distribution of national targets set in the Protocol. The national ceilings represent political commitments which often involve difficult considerations and tricky compromises. If proposed regulations for joint implementation introduce new allocation rules (for instance a merging of all national targets of EU countries into one overall EU target, redistributed among countries according to some new rule) they can meet severe political opposition or require an entirely new negotiation.

A way between these two types of obstacles has to be found. Up to now, the proposals formulated by the Working Group established in the context of the LRTAP envisage mainly bilateral agreements between decentralised sources. They also focus on the protection of the interests of third parties and the proof required to show that a specific joint action will achieve progress towards reducing the critical loads gap. The acceptance of a joint implementation agreement between two or more parties would require the consensus of all parties. Such proposals are very far from the concept of an emissions or deposit allowances market and are more in the spirit and form of political agreements.

Meanwhile, an original feature of the Oslo Protocol was the great attention paid to the cost and economic efficiency dimension of the new measures. A specific committee (Working Group on Strategies) was in charge of this dimension. This group's objective was to sketch emission abatement scenarios which could simultaneously take into account the benchmark of

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10.- A Working Group has been set up, within the Executive body of the Convention, to develop these rules for joint implementation. It proposes that "*a joint implementation agreement shall lead to a decrease in the difference between depositions of sulphur resulting from the emission ceilings listed in annex II and the critical sulphur depositions within the geographical scope of EMEP*" (UNECE, 1995).

critical loads and minimise the total economic cost of abatement. This resulted in a set of targets differentiated by country.

This new concern for the economic costs of acid rain policy is quite understandable. The more stringent regulations are, the greater the risk that they will impose unduly high costs, since it is generally accepted that the marginal cost of abatement is increasing. For instance, simulations from the RAINS (Regional Acidification Information and Simulation) model have estimated that the regulatory approach in the 1988 LCPD, making use of emission and technological standards, increased costs by around 50% compared to the level of costs that would have been incurred using a flexible, incentive-based approach – for the same level of environmental performance. Uniformly tightening current regulations and standards could again prove excessively costly, at least as far as there still exist alternative courses of action available at the plant level, and abatement costs differ across the whole population of plants.[11] At the same time, emissions standards, by themselves, bring no guarantee about the respect of critical loads targets.

Economic instruments, tradable permits particularly, can be credited with a significant potential for cost-saving in situations where a lot of economic and technological information required by centralised executive agencies is not at hand, and where is a presumption that marginal costs of abatement are quite different between countries and between plants. This seems to be the case with long range SO2 pollution, for which the importance of sources of uncertainty has been documented by economic studies (Maler, 1989 ; Newbery 1990).

1.2. A short theoretical review of emission trading systems

The first goal of environmental policy instruments is to achieve some environmental end. Economic aspects are not supposed to be the prime concern. Nevertheless, with the development of environmental policies, the weight of economic costs and benefits and the possible conflicts between economic development and environmental protection have become increasingly important. This is a logical consequence of the extension of environmental policies. Cost-effectiveness cannot be overlooked when a policy may lead to a significant or high level of economic costs. This is now the case for policy towards air pollution.

11.- If objectives are set at a level so stringent that they can only be reached with all existing plants using the same specific means (one sort of scrubber, for instance), there is no place for cost-savings to be obtained by more flexible incentive-based approaches intended to achieve the same level of environmental performance.

1.2.1. Two major features: securing a global environmental performance and minimising total abatement costs

A regulatory and an economic approach to pollution control do have the same ultimate purpose - a reduction in environmental damage. However, they do not cope with this issue in the same way. Where standards and limits are set, they are usually uniform within a few broad classes of plants, with the classes varying according to the scale of capacity and whether the plants are new or already existing. The US experience shows that when the regulatory system is based on environmental quality standards, a rigid CAC approach could lead to such extreme requirements as a ban on any new economic development in "non-attainment" zones incapable, on a long term basis, of satisfying these standards: growth of economic activity continuously offsets individual efforts to cut emissions. Avoiding the need to block economic development for environmental reasons was one of the main reasons for introducing tradable permits in the USA in the seventies (Hahn and Hester, 1989), first for tackling local pollution issues (Dwyer, 1992) and secondly for addressing the acid rain problem countrywide (Rico, 1995).

A brief comparison with an approach based on emission standards (Emission Standards Approach) may be useful for eliciting arguments in favour of tradable permits. The first point concerns the securing of a global cap on emissions of pollutants. Within an ESA, constraining sources to reduce their emissions to the maximum level economically possible is seen as the most direct means of decreasing the total amount of pollution flows. With this approach, it is difficult to assess *ex ante* the total amount of emissions which might result from the regulations. This will depend on the level of activity of sources and the dynamics of development for the population of sources involved (i.e. closure of some facilities, creation of new sources). Though existing and new sources do not generally face the same level of constraints, construction of a new facility satisfying environmental regulations will add to the global level of emissions, since there is no automatic offsetting change in the behaviour of existing facilities.

With an emission trading system, the most interesting approach[12] is to establish a global cap over the total amount of emissions. This cap provides global control over and across existing and new sources. As they are derived from this global cap, it follows that individual allowances will be compatible with the overall emissions targets.[13] In this respect

12 .- An alternative is the crediting approach: individual facilities having received individual caps are given credits for additional reductions they achieve in excess of the legal requirements. This piecemeal approach does not allow an easy management of a global constraint.

13.- Illegal practices and emissions may occur. But this possibility may be even greater with a CAC approach. With tradable permits, there is a general incentive for all owners of permits to preserve the value of their permits and to avoid illegal free-riding by others. Their vigilance may be useful as regards the seriousness of control of entitlements. CAC does not provide such an incentive.

tradable permits provide a level of environmental security which is quite superior to that reached by a traditional ESA approach.

More generally, the two approaches do not imply the same obligations and opportunities or the same individual and social costs. Tradable permits generate more cost-effectiveness since they allow to catch the potential of cost-minimisation created by individual differences. Let us illustrate these differences with the following situation. Suppose we have two sources, S_1 and S_2 which have different marginal cost functions MC_1 and MC_2. Regulator decides to decrease emissions by a fixed percentage relative to some reference year. For instance, the regulator can set a target of a 50% reduction in emission levels. This is illustrated in Figure 1. S_1^0 is the quantity of emissions from source 1 at time 0; S_1^1 is the quantity of emissions S_1 has to reach at time 1; and so on for S_2 ... The direct costs for achieving these 50% reductions are as follows:

- S_1: C + D + E
- S_2: B
- Total social costs: B + C + D + E

If the sources are allowed to trade on the basis of their allocated quotas of emissions, they get another equilibrium. The sources will exchange permits as long as their marginal costs are still different. At equilibrium, ***x*** allowances will be traded at a price ***p***.

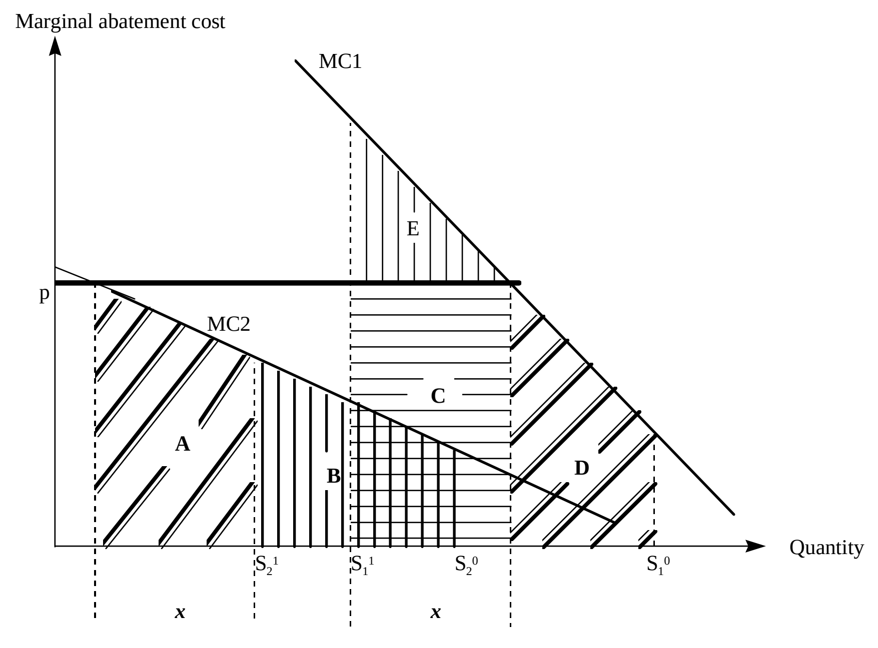

Figure 1: a 50% abatement

Finally, after trading, including transfers payments, the total abatement costs are allocated as follows:

- S_1: (D) + C
- S_2: (A + B) - C
- Total social costs: A + B + D, with A << C + E

1.2.2. Additional advantages of tradable permits

Additional advantages attributed to tradable permits by the economic literature are the following:

- *Limiting the information needed by administrative authorities to adequately manage the regulatory regime*. The authorities do not have to know the abatement cost functions of individual sources. If the initial allocation of permits does not match the real cost structure of individual sources, trading among sources will correct the situation up to a point where marginal costs will more or less be equalised.
- *Providing a permanent incentive to reduce pollution beyond what is required by administrative authorities*. This is because additional abatement efforts can be made profitable: for instance, the allowances saved can be banked for a future use, when this opportunity is permitted, or sold for money to other firms.
- *Introducing flexibility into the response functions*. Tradable allowances let decentralised agents invent new types of responses or new combinations of responses. In this respect, this instrument stimulates technological and organisational innovation and will contribute to an improvement in the conditions under which firms have to address the pollution problem in the future. At the same time it avoids the unnecessary costs that could have been imposed by a technological forcing based on a wrong ex ante assessment of the costs and economic conditions involved, as it was shown by the beginnings (1992-1997) of the Acid Rain Program where the actual prices on the SO_2 allowance market have reached much lower levels than generally expected by nearly an order of magnitude. Changes in the economic context (for instance, deregulation of tariffs for railway transportation) as well as incentives provided by the new regime (innovation in the scrubber business) have been responsible for lowering marginal costs of abatement (Ellerman et al., 1996; Burtraw, 1997). This demonstrates that allowance trading may be a source of efficiency not only by its own sake but also through avoiding costs that would have been imposed by other approaches.

1.2.3. From emission permits to deposition permits

The most spontaneous way to think of tradable permits in the field of pollution prevention are tradable <u>emission</u> permits. In most countries, emissions are already regulated through administrative measures; monitoring systems have been developed, and so on. To make permits tradable is just one step further added on existing regulatory practices. Imposing a global cap on emissions for a given territory (yearly, monthly,...) sets a quantitative rationing that may give birth to a market, once economic agents (polluting firms) are allocated initial allowances.

However, the framework of a trading permit system cannot be the same for pollutants which are uniformly absorbed by the environment and those which are not, and for pollutants which accumulate in ecosystems and those which do not. In this respect, SO_2 is a non-uniformly mixed, accumulative pollutant. This means that the location of the sources (and receptors, of course) of the pollutant does matter. If ambient concentration[14] and deposits are too high in some places, though less than the mean value in other places, it generates net damage, with no physical compensation taking place. A trading permit system should therefore be established which takes into account the differential effect of pollutants on the ambient atmosphere and the receptors. Theoretically, this could lead alternatively to what is called an « ambient permit system » or a « deposition permit system ». In these cases, the permits are defined in terms of impacts of pollutant flows on ambient concentration or deposition flows for each zone. In both cases, there are as many markets as zones.

For an « ambient permit scheme », the system originates in the setting-up of a maximum value for ambient concentrations of a given pollutant. Such concentrations are connected to emissions from various sources. Provided that appropriate data and modelling capabilities are available, each source is receiving an allocation of permits defined in terms of impact of emissions on ambient concentration for each relevant zone. To implement this procedure, it should be possible to assess the dispersion of the pollution flow from one source throughout the various zones of interest and to calculate equivalence rates between unit emissions from different sources according to their respective impact on atmospheric concentrations in each zone. One single emission flow will have to jointly meet ***n*** ambient concentration ceilings, defined by ***n*** different sorts of ambient permits related to ***n*** receptor zones $R_{\boldsymbol{n}}$. If a source decides to trade some of its permits, its trading activity on the ***n*** markets will be interdependent, with the objective of minimising the constraint of the most binding R***i*** at the least cost and to maximise the value of permits it holds. All these transactions should be ideally organised in flexible, simultaneous markets.

A deposition permit system looks the same as the ambient permit one, but it focuses on maximum achievable deposits in a zone. It requires the same high level of information and modelling capabilities about physical dispersion and transportation of pollutants from sources to receptors, in order to translate a given flow of emissions into several zone flows of deposition.

14.- LRTAP also refers to "critical levels" of ambient atmospheric concentrations of pollutants.

In practical terms, both ambient and deposition permit systems may be much demanding and entail organisational complications, depending on the number of zones they involve. They have not yet been experimented with at all. Meanwhile, intellectually, such schemes suit the regulation of the SO_2 problem, to the extent that the Oslo Protocol poses a general reference to acid critical loads by unit zone.

1.2.4. Some real-life features of allowance trading

It is widely accepted that a tradable permit system can be cost-effective in a competitive environment, and so generate important savings in compliance costs. There is also a rather widespread view that some "real-life" features may reduce the amount of these potential benefits or add new relevant dimensions for the choice of a policy instrument. Some important features are now considered.

The context of rules

The institutional context is of great importance to how a market is run. The authorities have to define precisely what constitutes a tradable allowance. Potential participants have to know exactly what their rights and obligations are and what the legal background (as regards fiscal aspects, or civil and penal responsibility, for instance) is. A stringent programme of emissions monitoring is needed to ascertain the tradable allowances. A register has to be set up to keep track of each transaction so as to update the asset count of each decentralised agent. Previous experience has shown how important the attitude of the authorities is regarding the development of allowance trading, the restrictions maintained, the extent of regulatory control of each trade (preliminary authorisation,...), the change of the rules, and so on. For instance, if administrative services express a basic suspicion of trading, through an accumulation of regulatory constraints or a fiscal penalty on benefits, the market will be thin or non-existent. This is not a defect of tradable permits as such, but of the way their introduction is managed.

The general evolution of economic institutions may also have a positive or negative influence on the development of trading, by changing the perceptions of the legitimacy of the instrument. If the EU practice of applying quotas in other economic sectors (fisheries, agriculture, air traffic, and so on) had been based for some time on a regime of tradable quotas or licences, the legitimacy of trading emissions allowances would not be seen to be as much of an obstacle.

The issue of initial allocation of allowances

To launch an allowance trading system, it is necessary to design a rule for making an initial allocation of allowances among sources. Politically, this is not an easy task, since political realism and principles of justice and fairness may be in conflict. Different rules for allocating permits can be envisaged (auctions, free distribution according to various criteria such as "grandfathering", level of technological capabilities, gross product, the potential for emissions abatement, and so on).

In practical terms, grandfathering is the most frequent criterion of allocation that has been used in the USA, most recently within the framework of the 1990 Clean Air Act Amendments (CAAA). With this rule, the initial allocation of permits is based on past emissions at a conventional reference year or period, to achieve a prorata allocation of the total cap. So, the more a firm has been polluting in the past, the more it will receive permits. Three sorts of justification are generally given for this criterion: a) since pollution is a consequence of some industrial activity, it is fair that each firm receives an allocation reflecting the technological conditions of its own activity; b) since past pollution was accepted by the authorities, some common law right of usage would have to be acknowledged; c) this is the allocation generating the least perturbation in business activities. Nevertheless firms which have not yet installed desulphuring equipment will greatly benefit, compared to those who have installed such equipment in the past. Giving such an advantage to big polluters is often said to be unfair, and immoral, though it may be a convenient way to avoid strong opposition from them.

In a context of perfect competition and information, the general view is that the initial allocation would have no implications for economic efficiency, even if the distributive implications are important. Whatever allocation rule is used, the market mechanism will re-allocate the emission allowances in a cost-effective manner. But in practice, transactions costs do restrict the fluidity of the market and so distributive and efficiency considerations do get mixed together (Stavins, 1995). Consequently, the goal of economic efficiency would be advantageously considered at the stage of the initial allocation of allowances.

As regards equity, two dimensions relating to the financial burden are generally discussed (Tietenberg, 1985):

- Vertical equity refers to a judgement on how to treat people having unequal levels of income or economic capability.
- Horizontal equity refers to the conditions of equal treatment given to equals.

Another distinction is between a judgement on the quality of the procedure (fair procedures, procedural justice) and a judgement on the justice of the end-results of a process.

Finding a rule for making an initial allocation which can guarantee a satisfactory treatment of all these various dimensions and concepts looks quite impossible. Due to the unpredictability of the final allocation of allowances which results from the combination of the initial allocation and the flow of trades, it is generally impossible to implement an "end-result" criterion for equity. Therefore attention is usually focused on the procedure. If the initial allocation is considered to be fair, letting people trade cannot produce a result which is unfair, provided that no Third Party is affected by a transaction.

One advantage of auctions is that they could deliver, at the very beginning of the process, a reference price on which participants can base their calculations and elaborate their strategies. However, this method places a higher financial burden, in relative terms, on the poorest participants[15] and on the biggest polluters. Both consequences entail a significant political disadvantage. Since the goal of public environmental policy is generally not to push industrial firms out of business, but to implement technological means ensuring that industrial activity becomes more compatible with environmental quality, without impairing economic competitiveness, this auction approach does not seem to have so much appeal to governments that are interested in preserving their industrial basis. Some mixed allocation rule may be envisaged such as 70 % allocated according to the grandfathering rule and 30% auctioned.

Transaction costs

The higher the transaction costs, the lower cost-effectiveness of an emission trading system will be. A key feature of transaction costs is access to information, in particular identifying potential trade partners. Searching procedures have proven to be costly to participants when the market is thin. Another feature is the regulatory constraints imposed by the authorities (various restrictions, administrative files, delays, unpredictability of administrative decisions). A third aspect is related to the scale of the market. As emissions allowances are not ordinary commodities, the level of emissions depends more on investment choices about the technology than day-to-day management. Consequently, in some cases, the volume of transactions may not be sufficient to sustain a regular market. Accordingly transactions are going to be episodic and bilateral, and they will have a strategic dimension. Bilateral transactions sequences will almost certainly not lead to an optimum outcome. The United States experience in the seventies showed that transaction costs could be as high as 10 to 30% of the total value of transactions. Brokers could reduce transaction costs by capturing and centralising information and facilitating meetings between potential partners, but their fees will cover part of the savings made.

It is worth noting that the Acid Rain Program was explicitly designed so as to limit transactions costs for both the administration and utilities, and reduce the administrative

15.- In relative terms, they have to spend a higher part of their resources than others to buy allowances.

burden on the instrument. So much lower transaction costs are now expected, though transactions have not been so numerous until 1995.

Effects on technological change and progress

In competitive conditions, using an economic instrument will generate an incentive to incorporate technological progress. The opportunity to trade the allowances saved is a permanent incentive to look for means of achieving additional reduction of emissions beyond the allocated quotas. The technological flexibility also avoids drawbacks of technological forcing and opens the door to a search of the cheapest means of satisfying environmental requirements.

Most importantly, technology should not be thought of as something fixed, with the regulatory mechanism enforcing its use in some optimal way. In the medium and long term, technology should be seen as an induced-variable,[16] which depends on the choice of the policy instrument. Some instruments may stimulate technological innovation, just as others impede innovation. Enforcing a rigid technological standard can curb down the dynamics of innovation. An evolutionary standard, corresponding to the concept of the best available technology, may not be sufficient to counterbalance such a negative effect. More often than not, performance standards are set implicitly with reference to a specific technology.

There is another critical aspect to technological progress. Investing in a scrubber is an irreversible decision, involving sunk costs. After such an investment, a company will not be ready to take other abatement actions for a long time. Since an investment fixes a technology (performance and cost), a premature regulatory enforcement of this type of investment obliges firms to forego the possible benefits from innovations yet to come on stream. With a trading permit approach, firms can calculate the best time to invest in abatement, taking into account the possible development of cost-saving innovations.

Summary conditions of successful tradable permits

On the whole, tradable allowance systems need a conjunction of several features if they are to run in a way which allows all potential efficiency gains to be exploited. Hahn and Noll (1990) elicit some desirable features of trading schemes regarding micro-economic efficiency:

- the overall number of emissions allowances needs to be well defined and limited;
- allowances should be as freely tradable as possible, without restrictions;
- it should be possible to capitalise allowances;

16.- It can be referred to the general category of endogenous technological progress, though this category is mixing several different things.

- trading of permits should be made inexpensive (lowering transaction costs);
- sanctions for cases of emissions exceeding allowances should be set at a sufficiently high level so that firms have a strong incentive to keep playing within the rules of the allowance system;
- emission allowances should be expropriated only in extreme circumstances;
- firms should be allowed to retain a significant share of the profits obtained through each trade.

Choosing the less damaging uncertainty in the long run

The pervasive lack of appropriate information is critical in implementing environmental policies. After all, if all the existing information could be easily gathered, it would be possible to centrally define a detailed plan of optimal abatement efforts, which could be implemented by administrative regulatory measures. Then there would be no case for introducing economic instruments. In real-world conditions, administrative standards may be poorly implemented and entailed important hidden costs. Economic instruments cannot avoid this uncertainty issue either. It means that choosing a type of instrument comes down, to a large extent, to choosing which variables are going to be left uncertain. No instrument can provide certainty for all variables.

With tradable permits, a global emissions cap may be enforced and guaranteed to some extent, but the counterpart is uncertainty about the market price of allowances and uncertainty about the exact location of emissions, and therefore localised damage. With taxes and charges, the rate of which is defined by public authorities, certainty is obtained on the maximum unit abatement cost to be paid by polluters. The counterpart to this is a range of uncertainty on the environmental performance obtained during a given period, since price elasticities are not generally known with great precision.

Which uncertainty is the least desirable is a matter for debate, since a short term view and a long run view will not necessarily come to the same conclusion. Less certainty about short run environmental performance may be linked, through lower abatement costs, to better long term environmental performance. Conversely, obsession with short run environmental certainty may induce higher economic abatement cost and contribute to a limited improvement of environmental quality in the longer term (Godard, 1993).

1.3. Sources of the attractiveness of SO_2 trading in the EU

To define centrally a credible international plan for a cost-effective abatement of emissions would require relevant information in a number of different fields:

- the listing of emission sources and their precise location;
- techniques in use, and the exact quantity of emissions at any time;
- potential techniques and action-mix for decreasing emissions for each source;
- the costs of alternative technologies, and the competitive effect of their implementation;
- the marginal costs of reducing pollution for each source;
- trajectories of transport of pollutants from the source to the location of deposits;
- potential chemical reactions in the air and on the ground, and their ecological impact;
- effects upon ambient concentrations and ground deposition;

and so on.

The state of information is generally rather far from perfect information on all these points. If central modelling and planning may be useful to arrive at some international agreement on targets, information gaps and asymmetries plea for the supplementary introduction of an economic mechanism to implement the agreement in a cost-effective way. Let us check some of the listed points in the context of the LRTAP Convention.

Technical-economic data

As regards the identification of emissions sources, existing directories listing the power plants in the ex-EEC (UDI, 1993) does not give information about the location of plants within each country and does not include data on desulphuring equipment being installed or not installed. No systematic, detailed information is provided about SO_2 emissions by plant. As regards information on technical options for abating SO_2 emissions, the literature focuses on techniques corresponding to the concept of Best Available. Since BATNEEC was enforceable for new plants only, a lot of existing plants have not used them.

Existing assessments of desulphuring costs (average and marginal) do not provide costs plant by plant, but a broad evaluation of the possible range of variation of costs. Unsurprisingly, costs depend a lot on the techniques used. At the same time, and more surprisingly, it has been discovered that plants often do not choose the least expensive techniques first. This is because several very different factors influence the choice of a technological response, such as plant size, position in the life-cycle and previous technological choices.

For instance, among the possible actions in response to an increase in the emissions constraint is fuel substitution according to the sulphur content of fuels. The respective prices of various categories of fuel depend on the international market. Variations in prices, and gaps between them, are therefore a key feature. But the price gap between high and low sulphur fuels has shown to be very volatile.

So, the cost estimates that have been used in the modelling exercises developed in the context of the LRTAP convention, have to be seen as fragile and approximate. They may keep their usefulness in macro-assessments, not as a description of the real costs borne by individual plants due to SO_2 emissions constraints. There is a need for an economic mechanism to reveal what the real costs are.

Environmental data

UNECE is implementing a pollutant transport model that was developed in the context of the LRTAP Convention. This is the EMEP program. This model has achieved a lot and is appropriate for giving a broad assessment of long-range transboundary pollution, but it has more limited predictive qualities for local effects, since the level and timing of localised emissions are not known precisely. The concept of critical loads of rather small European territorial units (150km X 150 km) should also be taken with some distance since it has been shown that the internal dispersion of acid carrying capacity may be often greater than the dispersion across units.

The Oslo Protocol

- In the Oslo Protocol, the searched "optimum" is understood as that allocation which minimises total costs of all parties, while being compatible with the constraint of abating 60 % of the gap between deposits and the 5-percentile critical loads for each cell of the territorial grid where critical loads are exceeded. To declare national targets to be at the "optimum" would require that the negotiated targets correspond strictly to the results of an economic modelling exercise, and that this modelling exercise has been fed by perfect ecological (emission and transportation of pollutants from each source, deposits and critical loads) and economic (abatement costs function for each source) information.

Several integrated models have been used to assess the impacts of a plan on abatement costs and environmental deposition. In spite of similarities of construction, unresolved differences remain between the results of models (UNECE, 1993, R 38). The extent of variation in the results for different plans supposed to meet the same framework of optimisation under the same constraints is a good way to appreciate the overall range of uncertainty as regards the various components of the long range transboundary transport of pollutants. Although results are stable or quasi-stable for some countries, they are significantly different for others. Differences vary from 10 to 50% of the emissions abatement required from a country. Overall reduction costs also vary by a factor of two. In some extreme cases, recommendations may be even reversed: for example, in the case of Albania, for which one model advises a 4% reduction, others would allow a 30% increase.

On the whole, several sources of gaps and imperfections point to the need to use an economic mechanism for implementing the LRTAP Convention:

- The targets which have been adopted in the Protocol are different from the supposedly optimal targets which resulted from modelling exercises;
- In spite of the progress achieved in data collection and modelling, the authorities cannot be credited with accurate information regarding the transport of pollutants and their impacts; for instance, the RAINS model is based on aggregate national data of emissions, not on monitoring of individual sources;
- The way the abatement cost curves have been built makes them rather arbitrary top-down translation of mean values based on assessments by classes of techniques. This does not reflect the true differences and variety of specific cost functions of individual sources.

Lack of appropriate information is supporting the introduction of a trading scheme, provided that such a scheme is not placed under the pressure of having to prove ex ante its performance with the kind of detailed justification that would only be possible with nearly perfect information. Clearly, there would be a paradox in requiring that an envisaged economic instrument has to demonstrate ex ante the benefits and impacts from its introduction through exact calculations, since it is only economically efficient to introduce such an instrument because of imperfections in the information available to centralised authorities.

The available information collected and used in the modelling exercises has permitted important progress in the tracing of the possible differential effects of SO_2 emissions according to the location of sources. This progress has allowed a new approach to the negotiation of national targets for future abatement within the Oslo Protocol. But the information that could allow an optimal plan for emissions abatement to be defined centrally is not available. Therefore there is a need to supplement the present state of the regulatory system with an economic instrument which can help reveal costs, encourage further progress in cutting the cost of abatement technologies, and improve the cost effectiveness of the negotiated allocation of targets. One difficulty on the way of this economic instrument may be raised by the level of stringency of the obligation to forecast the impact of trading on the location of deposits, so as to prove that the objective of a 60% reduction in the gap between deposits and the 5-percentile critical loads is being respected. Some trade-off between economic efficiency and short term environmental assurance is inescapable.

2. TRADING SO_2 EMISSION ALLOWANCESBETWEEN THERMAL POWER PLANTS IN THE EU: POSSIBLE FRAMEWORKS

To design a tradable permits system in the context of the Oslo Protocol for SO_2 involves a choice of several key variables. The goal of this article is to consider some possible combinations of these variables, those able to catch a significant part of the potential for economic efficiency while being manageable. Administrative and practical workability is a key condition for acceptability and success of policy innovation.

We consider first the choices at the level of variables taken independently. On this basis we describe three alternatives proposals for designing a SO_2 trading scheme in the EU. Eventually we address the specific topic of zoning, which is a critical issue for our proposals.

2.1. Key variables for the design of a trading scheme

Six variables have been selected as key variables to be reviewed: basic constraints of the regime; who are the basic agents taking part to the system; the initial allocation of allowances; the administrative mechanisms of delivering permits to trade allowances; the exchange rate; timing and periodicity of trades. At the end of the presentation, a synthesis table will gather the main options together in one frame.

2.1.1. Basic constraints of the game

For any trading scheme, fundamental constraints originate in the specific goal of the regime, and the specific institutional framework in which the new regime is introduced. The Geneva Convention, with its Oslo Protocol, sets the appropriate background. It addresses long range transboundary transport of acid pollutants. This physical interregional dimension explains why European institutions are concerned. According to the subsidiarity principle, the EU is not directly responsible for the management of local pollution. So all issues of local quality of ambient air for direct health[17] purposes are outside the responsibility of LRTAP Convention and outside the scope of the trading regime that is being drawn up in this article. As already said, we interpret the Oslo Protocol requirements as involving a double constraint to satisfy for the design of a trading scheme:

* overall national targets related to emissions;

17.- This Convention does refer to the protection of health as one of its objectives, but only inasmuch as health issues can be generated by long run transportation of pollutants. It is not covering action against intense local pollution.

* the 60% abatement target[18] as regards deposition in zones in excess of critical loads; for zones in which critical loads are not presently exceeded, respecting critical loads in the future as well will be the constraint.

There is no reason why both constraints should automatically coincide; how to meet both of them poses a difficult challenge for the design of a trading system. A key feature of this article is to address this specific issue of satisfying two types of constraints when developing an allowance trading scheme. The joint implementation of the first constraint by the EU countries provides a global EU cap on emissions, leading to allowances that can be directly expressed in quantities of emissions. The second constraint introduces much more complexity into the system and leads directly to allowances expressed in terms of quantities of deposits by unit zones for the whole European territory.

2.1.2. Basic agents

Governments or firms?

A trading scheme authorises exchanges of allowances among entitled agents. Who should be the players of the European SO_2 game? Two basic types of agents are difficult to avoid: governments and firms that operate plants. This arises because both types of agent are necessarily involved. Governments are parties to the Oslo Protocol and have accepted national ceilings that they may want to modify in the future through trading. This would lead to joint implementation between states. At the same time, the agents having emissions directly under their control are power utilities and other firms operating large combustion plants. Three solutions may be considered, provided that they are designed to be compatible with the second constraint concerning critical loads:

- *a governmental "joint implementation" trading system*: governments may develop joint implementation agreements in order to modify their Oslo obligations;
- *an EU plant trading system*: utilities of EU countries could directly exchange the allowances received from national authorities. In this case, governments would be rather passive actors, once the phase of initial allocation of allowances to plants was achieved;
- *a two-level (governmental and plant) European trading scheme*: both systems coexist and have to be co-ordinated in a precise, predictable way, presumably through a differentiation of time scales in the two markets.

In the context of this paper, we have chosen to draw up a framework for trading schemes involving plants as the main focus. This choice is consistent with the concern for economic efficiency. From the viewpoint of economics of information, the potential for cost-

18.- Later on, more stringent objectives as regards critical loads (say 75% and 90% abatement rate of the exceedance of deposits) may be adopted.

effectiveness can only be exploited by giving appropriate incentives to decentralised management units i.e. to those who can most easily obtain the appropriate information concerning available opportunities, technologies and abatement costs. This is what allowance trading is intended to achieve. If governments were to be considered as the basic agents of the system, they would still miss some important information necessary to minimise the social cost of abatement.

Why begin with the power generation sector?

At the EU level, 88% of all SO_2 emissions in 1990 were released by combustion facilities, and 65% by power plants. It therefore seems quite natural to begin to implement trading schemes with this sector, on the basis of the bubble concept. This sector-based approach could be preferred to avoid unwanted interactions between sectors, which could make business more uncertain for all operators, since their own activity would be made dependent on actions and strategies from outsiders who do not belong to their usual business environment. Introducing a regime respecting sectoral boundaries, at least in an initial stage, expresses a precautionary attitude towards existing economic and industrial organisation.

But what about introducing economic incentives into a sector of production that is largely oligopolistic, and even monopolistic in some countries? This specific industrial structure may be an obstacle to the development of trade. Oligopolistic and monopolistic companies do not face the same pressures to take advantage of any opportunity to make profits or minimise costs as competitive firms are supposed to do (Burtraw, 1994). They may prefer to make decisions supporting a good relationship with regulatory authorities and public opinion.

Several arguments can be put forward that limit the weight of the previous objection. In a sense, if power generation is concentrated in a few companies, this may reduce transaction costs and facilitate a form of trading compatible with firms' strategic planning. An agreement between a limited number of producers is less costly to obtain, though the counterpart may be strategic biases. Companies are used to being in contact and negotiating between themselves, and to developing co-operative relations within professional organisations at national and international levels.[19] Moreover, to some extent, the re-organisation of the EU market for power, while introducing competition between producers to satisfy the demand of large consumers and to extend the possibilities of own-production with appropriate technologies (combined cycle gas plants, co-generation), may already be seen as an active incentive for improving competitiveness and increasing sensitivity to opportunities

19.- The most successful past experience of permit trading in the United States was the trading scheme of lead in gasoline (OECD, 1992b; Howe, 1994). Pre-existing routines of exchanges and negotiations between refineries were emphasised as an important component of this success (Godard, 1994).

for cutting costs.[20] Finally, the response to the existence of national quasi-monopolies is to be found in the setting-up of a EU regime for SO_2 trading, which enlarges competitive opportunities.

In fact, several EU countries have already been convinced of the advantages of establishing a "bubble" mechanism in the electric sector. There already exists some experience in Europe on the basis of which trading schemes could be developed:

- In 1984, Denmark enforced legislation setting a national bubble of 125,000 kton SO_2 on the emissions from its power plants, to be met in 1995.
- In 1990, the government of the Netherlands signed a covenant on the reduction of sulphur emissions with the 12 provinces, the association of 178 electricity producers (SEP) and the four individual companies for electricity generation. This agreement concerns a programme to reduce acid emissions up to the year 2000. It establishes ceilings on the total emissions of SO_2 and NOx from the public power plants. (Klaassen, 1996).
- In 1993, EDF, the main electric company in France (with 95% of production) signed a covenant with the government setting an obligation to limit total SO_2 emissions to 220 kton per year by the year 2000.

Other arguments may favour the choice of the power generation sector as the first one to experiment with SO_2 allowance trading. Due to the existing regulatory regimes and the limited number of firms, this approach will avoid many new enforcement costs and leave administrations time to adapt and develop new rules and practices for other sectors (industrial combustion plants, oil refineries). The same sort of choice has been made in the USA.

In the following discussion, we assume that a global cap has been defined on the amount of emissions of the power generation sector in each country. It is convenient to assume that the rate of abatement expected from this sector is the same as that at the national level. But a different cap would not alter the analysis.

2.1.3. The initial allocation of allowances

The Oslo Protocol can be seen as a compromise between an agreement among independent states and a more integrated approach that could be developed if all states chose to behave as the members of a single political community. Establishing emission ceilings on a country basis is a response to the first component of the compromise. The preliminary works of the Protocol were conceived with reference to the second component, with this idea of an integrated optimal plant for acid deposits for the whole European territory.

20.- There is some reminiscence here of the theory of "contestable markets" in industrial economics. A contestable market is when a monopoly firm is placed under the threat of a possible enter of new competitor in the sector and is incited by this threat not to behave as a monopolist firm. See Baumol (1982).

So, a first option is to imagine a EU-wide joint implementation, in which member states accept to transfer their national quotas to an EU Authority that would directly redistribute them to power plants according to some specific EU rules. Is it realistic? This might be in a fully developed European Federal Community, having reached a high level of political integration. It does not fit the present situation in the EU, nor with the context of the negotiations for the Oslo Protocol. So it seems preferable to think that even for an EU allowance trading scheme, the allocation of allowances should be first organised within the national contexts as a means of implementing the national targets fixed in the Oslo Protocol. Such national allowances should be acknowledged by every other country taking part in the trading scheme, so as to permit EU-wide allowance trading. The concern for critical loads will also lead to this initial allocation being supplemented by other procedures and constraints.

This point should remind us that the initial allocation of allowances is always a critical moment for trading schemes, one open to suspicion, lobbying and negotiation. A CAC approach is seemingly less exposed to such a difficult process. When two plants of the same sector are submitted to the same objective constraint, no-one can complain about the implications for competition. However, with regulations there may be exemptions, exceptions and dispensations. The substance of the problem is therefore broadly the same for tradable permits as for CAC, but it is more transparent with trading schemes. In any case, the first source of possible distortions between countries is to be found in the Protocol itself or in the LCPD. Both texts include different targets fixed for each country. This may be seen as appropriate for environmental or political purposes, but at the same time is a potential source of distortion of competition between companies.

What should be the method chosen to allocate allowances in each country? On the basis of past experience in the USA, the general concern of governments to enhance national industries, and the proximity to existing regulatory frameworks, it is reasonable to say that grandfathering is the most probable form of allocation mechanism.

2.1.4. Administrative mechanisms of delivering permits to trade allowances

According to several proposals, one way to avoid impairing the environmental objectives of the Oslo Protocol is to base the "trading mechanism" on the same assessment method and modelling tools that have been used for optimising the distribution of efforts among countries. This approach authorises to address the second, deposition constraint. It leads to a very particular form of trading, i.e. a family of centralised and semi-centralised trading mechanisms using central modelling. At first sight, the value of this proposal depends entirely on the quality of information gathered, aggregated and fed into the models, with a particular concern for the economic information. This is the reason why decentralised solutions are also considered.

Centralised systems

With this purely centralised system, a preliminary plan of potentially profitable trades is elaborated on the basis of physical and economic modelling. Achievement of these trades would increase the overall cost-effectiveness of the allocation, while meeting environmental constraints. Then trading is used to achieve what has not been yet possible in the context of the negotiation of the Protocol for political reasons - a strict application of the cost-effective allocation identified through modelling. The procedure could go this way:

- Running the models could simultaneously provide a least-cost solution and, on the basis of the real allocation of targets in the Protocol, the optimal programme of exchanges between countries that would be required to establish this optimum.
- A comparison of this optima plan and the actual national targets selected by the Protocol is made to prepare a correction programme that would then define a list of profitable allowance exchanges. A matrix synthesises the possibilities, with each vector representing a compatible transaction.
- Each bilateral proposal is compared with the correction programme; any proposal outside of this matrix will be rejected.

Ierland, Kruitwagen and Hendrix (1994) have called this mechanism "guided bilateral trade". "*In guided bilateral trade, the decision by the central authority whether trade is allowed or not, is based on the cost effective emission abatement allocation. Only after all allowed bilateral trade transactions have taken place, the deposition targets will be met*". An emission trading system would then be the linking mechanism between a technical solution, arrived at through modelling and optimising, and a political solution arrived at through negotiation.

This centralised system could have several advantages. In particular, it could generate a high level of environmental and economic predictability and substantial gains in research costs, since potential partners have simply to look up in the correction programme who the right people to deal with are. A clear definition of the sequences of the process is also obtained. Firstly, there are national allocations under national ceilings constraints. Secondly, there is trading under a European critical loads constraint, according to a planned scheme of acceptable exchanges.

Is optimality achievable this way in practice? Economists may recognise in the proposed system a variation of the pure Walrasian market model, which depends on the action of a central co-ordinator, the auctioneer. The auctioneer gathers data about potential quantities (supply and demand) and proposes prices, until an economic equilibrium is achieved, prior to any transaction taking place. This theoretical reference leads to an ambiguous judgement: if a centralised, multilateral process is needed to reach a market optimum that could not be produced by bilateral transactions, then this trading system may not lead to the optimum since it is less than certain that all the necessary transactions will finally take place. A second reservation is linked to the quality of information centrally available, according to the views previously expressed. Because of the intrinsic limitations of information and the risk of partial implementation, a less-demanding use of models may be preferred. This is the case with semi-centralised systems of trading.

A semi-centralised system

This semi-centralised system still uses modelling to guide transactions. However, the basic assumption of this approach is that the centralised economic information is not sufficient to identify the best opportunities for cutting abatement cost. So the economic part of the modelling exercises used in the previous centralised system is put aside, keeping only two models - the first about transports of pollutants (EMEP), and the other about critical loads and deposits - so as to identify current and prospective excesses of acid deposits. The economic dimension of the allocation will be left to decentralised calculations of sources (plants). Sources will have to compute their own strategy and look for interesting opportunities to trade. In this case, the process is as follows:

- a EU Secretariat for SO_2 trading enters the distribution of all the allowances resulting from the national implementation of national ceilings into the physical assessment models;
- after a search period, two sources meet and agree on a trade proposal; they submit it to the Secretariat;
- the projected change in location of emissions is entered in the agreed models which are run to provide forecasts about the environmental impacts for each deposit zone;
- if the project violates the second condition related to the progress towards critical loads, it is not permitted; otherwise it is accepted.

Presumably, there could be two disadvantages of buying this ex ante environmental quasi-certainty by means of this specific procedure. Administrative costs could be too high due to the procedures necessary for delivering a single permit to trade. This point should be elaborated further by simulations to assess orders of magnitude involved and to see whether the weight of the procedure makes trading a poorly attractive instrument in that context. Furthermore, because of the stochastic, bilateral nature of this system, it might not lead to an overall cost-effective allocation – one which would minimise the total abatement cost for a given environmental performance. This is because the sequential order of trades would matter. Whether a transaction is allowed or not may depend on whether or not it is proposed before some other transaction; most interesting trades may be blocked by early transactions exploiting the potential limited by the zone caps. Knowing which one is the most profitable is not the driving force for early trades. However, if reaching a first best economic optimum is not the central concern of authorities, not because of disinterest but because it is acknowledged that this is not feasible, then sequential, bilateral trades can be seen as Pareto improvements, provided no third party is significantly affected. On the whole the initial allocation will be improved by this mechanism.

A decentralised system

Here the administrative requirements are quite limited. On the one hand, countries adopt a procedure for initially allocating allowances to individual sources. On the other hand, simulation models are used to translate the initial allocation of emissions allowances into deposits in receptor units. This simulation is used to define general trading rules that reflect the requirements of the critical loads constraint. They may incorporate zoning -with free trading within one same zone- or offset rates for trades between different zones. In that framework, allowances can be exchanged freely without a specific prior authorisation being imposed for each envisaged trade. All the requirements ensuring progress towards environmental targets are supposed to be fixed within the general rules. Some periodic adjustment of this allocation should be considered to take the evolution of pollution flows into account.

Although theory would render centralised solutions attractive for their predictability and/or optimality features, implementing a decentralised system may be considered as more realistic with respect to the economics of information and administrative running simplicity, but it is much more uncertain as regards the environmental progress, to a degree that may be considered unacceptable in the LRTAP context. In the following, we only consider semi-centralised systems to be a viable proposal.

2.1.5. The exchange (offset) rate

When the damage generated by one unit of a pollutant is independent of the location of the source, trading allowances may be organised on the basis of a ton for ton exchange rate. Because of the non-uniform assimilative property of SO_2, in damage terms, "*one unit from one source cannot be offset by one unit decrease from another source. The offset rate, also termed the exchange rate, may be greater or smaller than one*" (Førsund and Nævdal, 1994). On a theoretical ground, offset rates should reflect the relative intensity of the marginal damage generated by one unit of emissions. It is difficult to find a rule able to reflect this requirement. Firstly, marginal damage functions are not known and some proxy has to be used. To be practical such a rule should keep its value through time, although conditions for optimality require a revision of offset rates to be made after each trade.[21] At the same time, this adaptive approach would make the game unpredictable for agents and complicate investments decisions.

A proxy formula has been proposed by Bailey, Gough and Millock (1994) for defining satisfying exchange rates. These rates are based on transfer coefficients from sources to receptors, weighted by damage weights; here damage weights are just represented by the magnitude of the excess of deposits compared to the critical loads. An exchange rate between two sources will be calculated as a ratio between both transfer coefficients:

$$\text{Exchange rate}_{1,2} = \frac{\sum_k (T_{1,k} \cdot G_k)}{\sum_k (T_{2,k} \cdot G_k)}$$

With $T_{i,k}$ = transfer coefficient from i to k,

and $\sum_k T_{i,k} = 1$

G_k = a damage weight index (from 1 to 8), i.e. a relative measure of how harmful deposition is to different classes of ecosystems, as a function of critical loads (taken from SEI work)

This formula is a useful statistical construct that certainly represents progress towards strict respect for the critical loads targets. Meanwhile, it should be realised that this type of aggregation of values has no immediate empirical correspondence. Specifically, it does not provide a guarantee that the critical load target will not be exceeded in any cell, since it is based on mean values.

An alternative practical solution is to stick to a 1 to 1 rate within zones considered to be homogeneous. This simple and robust approach may be viewed as more accessible, and easy to implement, being less dependent on central modelling and revision of information. It is not totally satisfying either, since the supposed homogeneity of each zone can only be an artificial construct.

2.1.6. Timing and periodicity of trades

Nowadays, most ordinary commodity markets are quasi-permanent. Such exchanges do not depend on a body of permitting procedures or model simulations as it is the case for SO_2 allowances. In that case, with a rather thin potential for trade, it might be an idea to develop some periodic system of trading, such as old style fairs, in order to get a time concentration of demand and supply and overcome limits of separate bilateral trades. Moreover, in a two-level

21.- This is so because individual trades will not generally entail marginal impacts on the distribution of acid deposits: emissions are concentrated in a limited number of sources, while the territorial units are not so broad.

system of allowance trading, where there are trades between governments in respect to their national caps, and trades between plants once national caps have been decentralised to them, the intergovernmental market should be made highly predictable for plants, in order to ensure the security of the allowances they receive from public authorities, and to allow them rational investment strategies. A clear means of providing this predictability would be to organise a discrete, periodic intergovernmental market (every 4 years, for instance), with advance transactions, i.e. transactions having effect some years later (say 3 years). This would mean that basic plants can move in a predictable institutional environment, with a secure horizon in the range of 3 to 7 years.

An alternative approach for a two-level system would be a flexible one in which governments regulate the total quotas given to plants on a continuous basis, as active operators on national markets. Governments could buy and sell allowances with national plants according to the evolution of their international commitments (intergovernmental market). However, this approach could also induce instability and unpredictability on the market, or raise the fear that governments will behave in an arbitrary manner influenced by lobbies. These factors may turn out to be an obstacle to technological innovation, when the weight and sunk costs of industrial investments in desulphuring equipment are taken into account.

In the case of an EU-wide decentralised trading system between power plants, there should be no time constraint imposed if the type of trade considered is bilateral, once the initial national allocation of allowances has been achieved. By contrast, if some type of general equilibrium of the SO_2 allowances market is preferred, the only practical means is to establish a periodic market where all potential sellers and buyers are invited to present their offers. If the idea of having as many markets as agreed homogeneous zones is accepted, offers in one zone market can only be contingent offers, since their value and relevance depend on the achievement of transactions on complementary zone markets. Ideally, all trades clearly have to be synchronised due to the mutual dependence of these markets. This periodic market will offer an opportunity to minimise transaction costs and reduce possible strategic biases.

One intermediate solution between continuous, bilateral trading and periodic markets, is to combine both of them, along the way the USA have made it by establishing an auctioned SO_2 allowances market which occurs once a year. Such a market provides both a public price and a trading opportunity for plants that have not succeeded to find appropriate partners in a bilateral framework.

2.1.7. A synthesis table

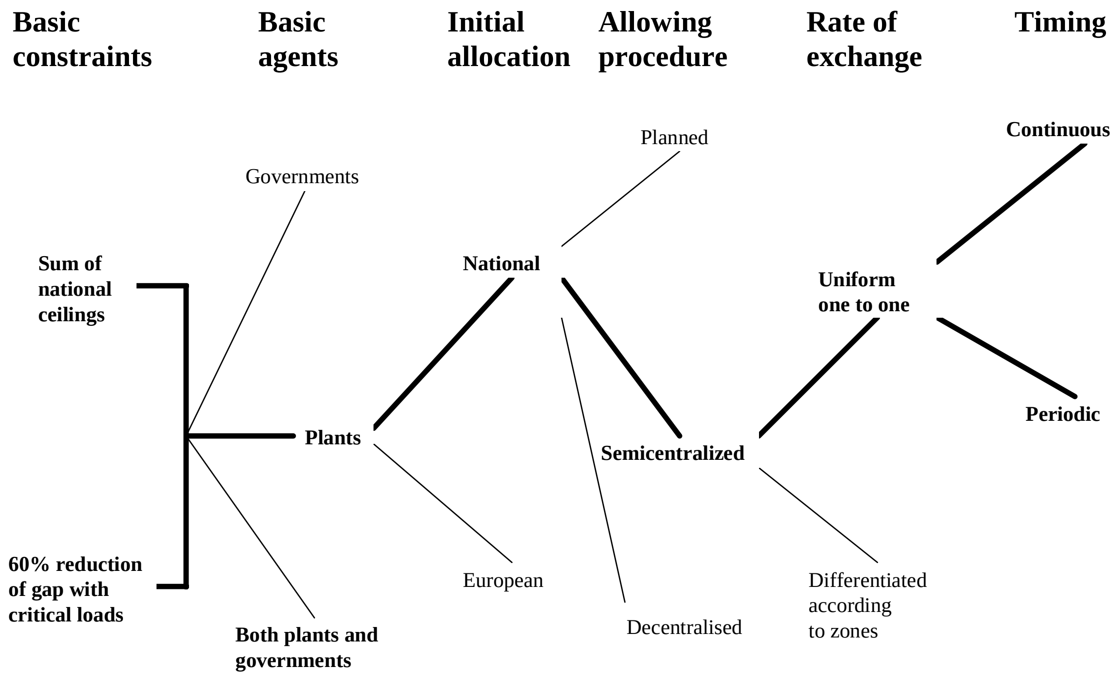

Figure 2: Key design variables

The table in Figure 2 shows the main alternatives that have been considered. Basic variables are indicated on the line at the top of the table. Each column represents alternative possibilities for each variable. Pathways in bold suggest the choices that seem to us the most interesting and practical at the same time. These are the choices that support the three alternative proposals we present in the next section.

2.2. Key alternative proposals

Here, we present three alternative proposals that take in a comprehensive manner options identified as interesting and practical for key design variables. Two directions have been explored to design such proposals. The first one is based on the idea of coupling two types of allowances: emissions ones and deposit ones. The second one is searching an integrated system in which emissions and depositions constraints receive due count for determining the amount of SO_2 allowances that can be traded. Two variants of the latter will be presented. With all three solutions, proposed trades are tested with models of pollutant transport for ascertaining their impact on deposits for each unit zone. This modelling requirement could be judged excessive in launching what is supposed to be a "market" solution. But this input is generally required for the whole regime of the Oslo Protocol - without modelling it would not be possible to guide the progress of European abatement efforts towards the critical loads target.

2.2.1. Implementing a system of two simultaneous, coupled allowance trading mechanisms

Facing with the obligation to take into account two basic heterogeneous constraints (national targets and the goal of a 60% reduction in the gap between deposits and critical loads), a first possibility is to conceive of two different systems of trading, one for each constraint, which are coupled to permit sources to emit a given amount of SO_2. To get the right to emit one ton of SO_2, a source should possess one allowance of each type. The source would not be allowed to use an allowance of one type if it does not have a corresponding allowance of the other type. With such a system, each source would then operate on two types of markets for allowances - one for emissions allowances, working at the EU level and based on initial allocations distributed in national contexts, and one focused on the specific constraints for deposits in each receptor zone in Europe (including non EU regions).

So, the system will take account of emissions from sources which belong to the territory of the EU, but generate acid deposits on European non EU lands. In the framework of the Oslo Protocol, the same basic constraints operate whatever the territory involved. Commitments to progress towards critical loads are not reserved to the territory of the EU. Abatement targets should also be acknowledged by the EU for receptor zones outside the EU inasmuch as deposits depend on EU emissions. Since several sources located in member states of the EU have a joint impact on these foreign receptor zones, deposits markets can be developed for them as well. Such markets should be placed under the authority of EU executive institutions, since this issue engages the responsibility of the EU towards foreign countries.

For this market of deposition allowances there is a specific problem to solve with regard to how trading is combined with zoning. There are two possible solutions:

- one is to only authorise transactions between sources generating deposits within the same receptor zones; in that case, there will be as many markets of the second type as there are receptor zones; if there exist ***n*** unit zones in Europe, a source would have to operate on (at most) ***n + 1*** markets (the ***n*** deposit zones markets and the EU wide market of nationally allocated emissions allowances);
- the other option is to define offset rates to organise trades between emissions generating deposits in the various zones; in that case, the emissions market is EU wide, with a 1 to 1

rate of exchange, and the deposits one is Europe wide, with differentiated rates of exchange; a further difference is linked to the initial allocation of allowances: each system has its own logic of distribution; this offset solution is not explored further, since we have chosen to develop our proposals on the basis of the first option.

The use of a pollutants transportation model such as EMEP cannot be avoided, nor can the mapping of critical loads for achieving the initial allocation of deposit allowances. Existing modelling forecasts actual deposition (in emissions units) and maps the 5-percentile critical loads (also in emissions units). For each zone, we can then deduce the gap between the two (in emissions unit), as well as the authorised amount given by a 60% reduction. Thanks to the EMEP matrix of transport of pollutants, it is possible to proportionally attribute total deposits by zones to individual emission sources and so calculate the allocation of deposit allowances to sources. On the other hand, agreed national emission ceilings are supposed to be allocated to national sources, in each country, according to some national criterion, whichever they choose (grandfathering being the most probable).

The following example illustrates the way this solution might work. It is based on the assumption that trading between deposit allowances linked to different receptor zones is forbidden. Hence there are several European zone markets in which EU sources have to operate under the constraints of zone deposits caps, plus the EU wide emissions allowance market.

Example:

- Given a system with 7 sources of pollutant emissions: S_1, S_2, S_3, S_4, S_5, S_6, S_7, and 4 receptor zones: R_1, R_2, R_3, R_4.
- Given the two types of allowance markets: to be permitted to emit one unit of pollutant, a source has to have one emission allowance P_e, and one deposit allowance P_d for each deposit zone R_i. When the deposit is localised on R_1, the deposit allowance will be indexed P_{d1} (P_{d2} on R_2, P_{d3} on R_3, and P_{d4} on R_4).
- The emission allowances can be traded among all sources, even though the deposit ones can only be traded between sources having emissions falling on the same receptor R_i.
- Given a total quota of 60 units of allowed emissions, distributed between sources as 60 emission allowances: 60 $P_{e.}$
- Considering a receptor zone R_1, the EMEP matrix of pollutants transport involves 3 sources (S_1, S_2, S_3) of concern for this zone.
- S_4, S_5, S_6, S_7 emissions do not have any impact on $R_{1.}$
- The reduction in deposits on R_1 required to reach 60% gap closure, is a reduction in emissions of 8 units. Up to now, S_1 has emitted 16 units of pollutant, S_2 : 12 ; and S_3 : 4, giving a total of 32.

- Given a proportional distribution of the reduction efforts, S_1 will have to reduce its emissions by 4 units, S_2 by 3, and S_3 by 1. This means that S_1 is allocated 12 P_{d1}, S_2 9 P_{d1}, and S_3 3 P_{d1}.
- Given S_1 has 18 P_e, S_2 : 3 P_e, and S_3 : 4 P_e,

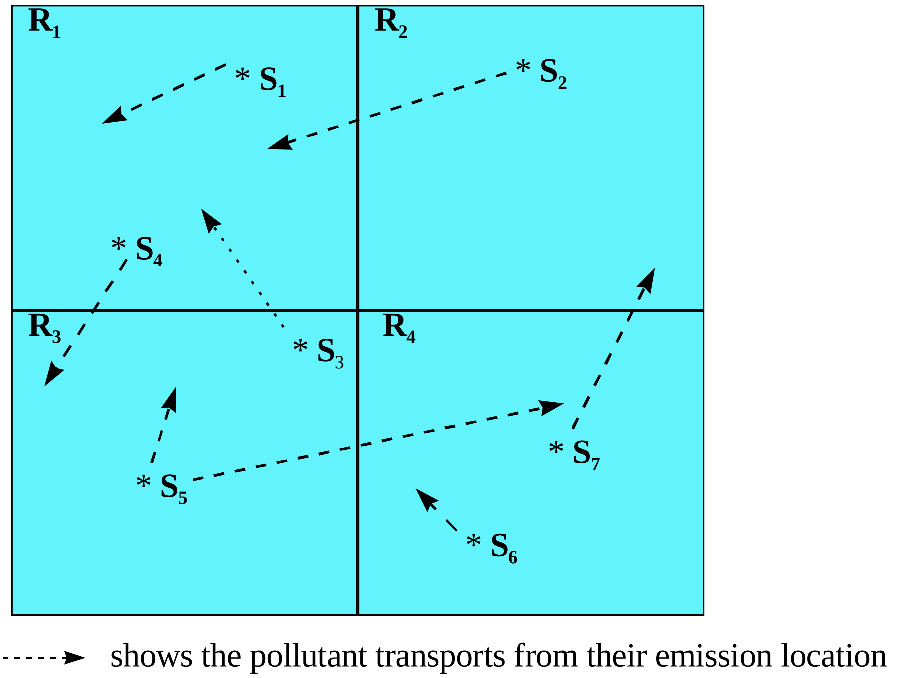

Figure 3: An example of SO_2 transport with 7 sources and 4 receptor zones

For R_1, this allows:

S_1 (12 P_{d1} ; 18 P_e): - to emit 12 units of pollutant and to sell 6 P_e, or,
- to buy 6 P_{d1} and then emit 18 units of pollutant.

S_2 (9 P_{d1} ; 3 P_e) : - to emit 3 units of pollutant and to sell 6 P_{d1}, or,
- to buy 6 P_e and then emit 9 units of pollutant.

S_3 (3 P_{d1} ; 4 P_e) : - to emit 3 units of pollutant and to sell 1 P_e, or,
- to buy 1 P_{d1} and then emit 4 units of pollutant.

In fact, this double system of allowances may be more practical that it seems at first. On the deposit markets, there is a limited number of potential partners. They may be well-known to each potential participant. Thus, the problem of search for potential partners would be rather easy to overcome, thus limiting this component of transaction costs. But the market could be too thin, making it difficult to find partners willing to exchange. Another obstacle is the possibility of strategic interference amongst competitors (market power). If these potential difficulties are confirmed as having practical relevance, they strengthen the argument in favour of some larger grouping of unit zones.

When potential traders know their trading opportunities on the deposit markets, they can then adjust their strategy on the other market, that for emissions. The emissions allowance market provides large opportunities for exchange for suppliers and buyers. No specific additional constraints are necessary on this market since the deposits constraints are tackled by the other type of markets.

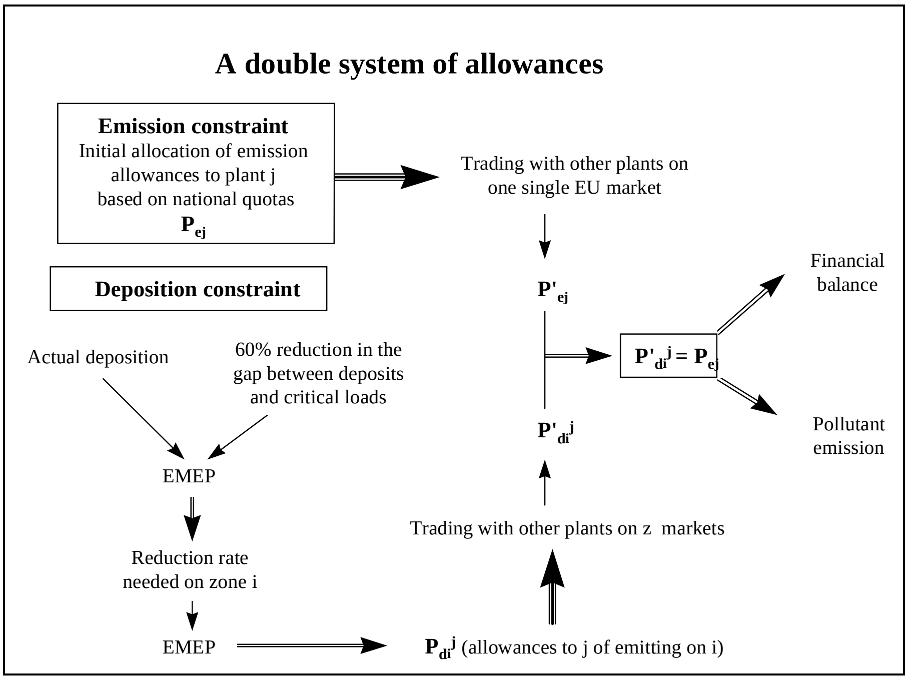

Figure 4: The running of a double coupled system of allowances

The Figure 4 shows that, with the help of the initial allocation and of trading, a source $\boldsymbol{j}$ has to get the same amount of $\boldsymbol{P_{ej}}$ and $\boldsymbol{P_{di}^{j}}$ to be permitted to emit that amount of SO_2.

The heterogeneous combination of two types of allowances can be seen as an incentive to trade. Either participants have both half-allowances (emission and deposits) permitting them to emit, or they only have a certain amount of one type of allowance. In this second case, it is always more interesting for them to sell their unused half-allowances or to find the other half than to stay in their present position.

The next two variants differ as regards the rule for the initial allocation of allowances and the type of incentive mechanism incorporated to make reaching critical loads targets more attractive to plants (variant 1) and governments (variant 2).

2.2.2. An integrated system incorporating an auctioned secondary market for unusable allowances

Here, an allocation of emission allowances to individual sources (plants) by national governments is calculated on the basis of national ceilings and allocation criteria chosen by these governments. This gives the Potential Emission Allowances $\boldsymbol{PP_{ej}}$. The subsequent deposits from each source for each receptor zone are assessed with the help of the EMEP model. In the meantime, the 60% abatement target is used as the basis for a calculation of an overall deposit cap for each receptor zone. These zone deposit caps are then distributed proportionately to the sources responsible for the deposits, also using EMEP. This gives the Potential Deposit Allowances $\boldsymbol{PP_{di}^{j}}$. The two allocations are translated in comparable terms (units of emissions) for each source by using the vector that describes how emissions from a source translate into deposits in the different receptor zones (say 10% on R_1, 30% on R_3, 25% on R_{11}, and so on). Each source will have a different dispersion vector according to its location.

At this moment, for each source, two different amounts of potential emission allowances are considered, the direct "emission" one $\boldsymbol{PP_{ej}}$ and the one derived from "deposits" $\boldsymbol{PP_{d}^{j}}$., with $\boldsymbol{PP_{d}^{j}}$ being equal to the sum of $\boldsymbol{PP_{di}^{j}}$. The lower value of acceptable emissions is then selected, in order to satisfy the more binding constraint. On this basis an *actual* quota of emissions allowances $\boldsymbol{P_{u}^{j}}$ is acknowledged to source $\boldsymbol{j}$. We may call them "usable and tradable allowances". They can alternatively be used directly, i.e. to cover actual emissions of the source, or traded, if sources take measures to abate their emissions under this quota.

At the same time, individual sources (plants) are given an extra amount of potential allowances $\boldsymbol{P_{t}^{j}}$ responding to the difference between the less binding constraint (the emission or deposit one, it depends on the locations) and the more binding one. This extra amount cannot be used directly but only for trading if authorised trades can take place. We may call them "unusable, tradable allowances". The working of the mechanism could be as follows:

- Just like the amount of "usable and tradable allowances", the amount of "tradable, unusable allowances" may evolve with time, following transactions of both types of allowances. At any moment, the net amount of "usable allowances" is defined by the level of the most binding of the two types of potential allowances (emission and deposit), and the amount of unusable allowances can be calculated as the difference between the two types (emission and deposit) of potential allowances.

- A financial mechanism could be set up to facilitate the valuation of unusable allowances on a market, i.e. they may feed an auction market organised by the authorities on behalf of sources. The financial product of auctions would be refunded to the source entitled to it. This "last resort market" would be open to any source, but the buyers would be subject to the same constraints of usage that were previously described for all sources.
- Unusable "deposit" allowances can only be bought for a use touching the same deposit zones in Europe as the ones affected by the original use by the seller. In the latter case, it means that individual transactions involving deposit allowances have to be checked as regards the deposit zones of each trading parts, as it is the case for any exchange of "usable and tradable" allowances. For instance, if 100 tons of unusable deposit allowances are sold by a source to another, what is really sold is a deposition right reflecting the structure of deposits of the seller, say 20 tons in Z_1, 30 tons in Z_2, 50 tons in Z_3. So the entitlement obtained through the purchase of 100 "unusable deposits allowances" is a vector $D_{1,2,3}$ (20, 30, 50). It is possible that the buyer cannot use the whole spectrum of what it buys, due to its own different location and different structure of deposits from its emissions. For instance it may not be able to use more allowances than 30 for Z_2, though it had to buy the whole package of 100 tons to get the 30.

Let us give an illustration. Given two sources (plants) S_1 and S_2, belonging to neighbouring countries, having deposits on the same receptor zones. The potential emission allowances quota to S_1 is set at 1,000 units, though the deposit one would potentially reach 1,100: S_1^E = 1,000 ; S_1^D = 1,100. For S_2, S_2^E = 900 and S_2^D = 700. Two cases have to be considered: (a) the emission formula is more binding than the deposit one; (b) the deposit formula is more binding than the emission one.

(a) In the initial state, S_1 possesses 100 extra unusable deposit allowances and S_2 has got the right to buy and use them, since S_1 and S_2 have deposits on the same receptor zones. The result is now that S'^E_1 = 1,000 ; S'^D_1 = 1,000. For S_2, S'^E_2 = 900 and S'^D_2 = 800. S_1 will be entitled to emit 1,000 tons and S_2 800, for a total amount of 1,800, which meets both emission and deposit constraints.

(b) This case is illustrated by the position of S_2 in the previous case. Even after buying 100 unusable deposit allowances from S_1, S_2 still has 100 unusable emissions allowances it could resell to any other source in the EU, without any specific regulatory constraint. Such a trade may only be of interest to sources more constrained by emission requirements than by deposit ones.

With such a system, all constraints are taken into account without compromising the political commitments behind national ceilings agreed upon in the Oslo Protocol. At the same time, this mechanism generates a general market for allowances alongside bilateral trades, with two goals:

- giving additional flexibility and safety to sources, and avoiding strategic retention of allowances; the mechanism would be similar to auctions organised by the EPA in the USA; any source looking for allowances and not finding them through bilateral trade may enter this recourse market;
- facilitating the emergence of a public price of reference for SO_2 allowances, and authorising comparisons between what is going on in various national markets; when transactions are bilateral, they can be kept private, with no information released about prices paid; the only information that authorities should be entitled to register are the quantities of allowances being exchanged; with the creation of this market, price becomes a public good that helps each individual source to shape its strategy.

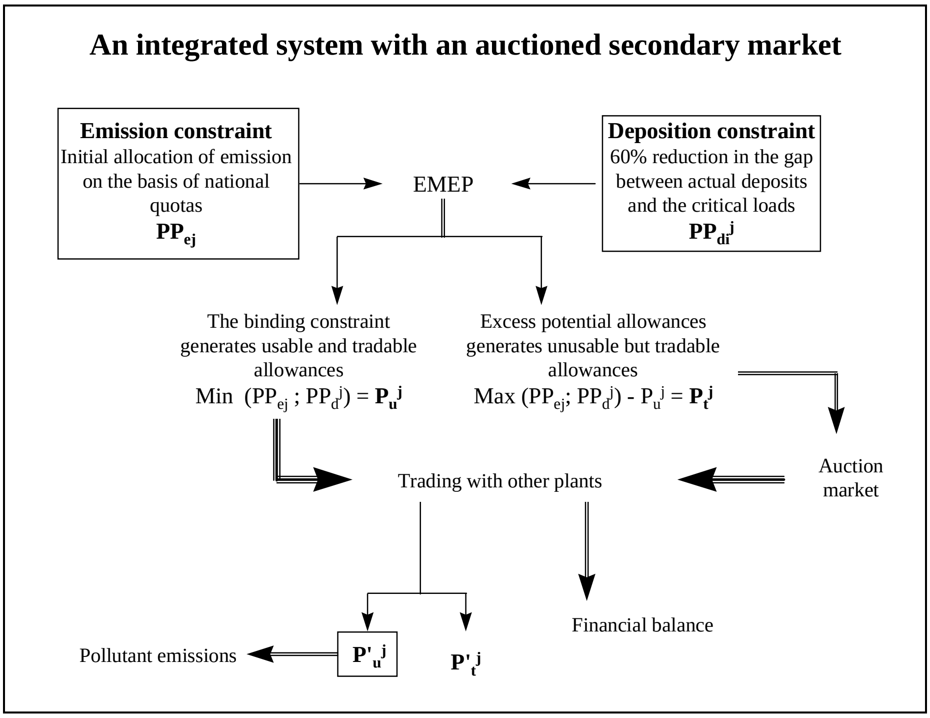

Figure 5: The first variant of an integrated system with an auctioned market

Figure 5 shows that at each moment a source has a certain amount of "usable and tradable" allowances and another amount of "unusable and tradable" allowances. Through trading, it can rearrange both type of assets.

2.2.3. A system incorporating compensations for States

Here, two steps for the initial allocation are still considered, but to some extent they reverse the previous solution. One begins by considering current emissions from sources (plants) and simulates, thanks to EMEP, the subsequent deposits for each basic receptor zone. Two cases are then possible. If the critical loads are not exceeded, the source is credited with a "deposit allowance" $\boldsymbol{D_i}$ corresponding to its current emissions. If the critical loads are exceeded, the target of 60% closure of the gap between deposits and critical loads is used to calculate a deposit cap $\boldsymbol{D_i}$ for the receptor zone; this cap is allocated proportionately to each source having deposits in the zone. This defines the *first* formula for determining the potential SO_2 deposit allowances $\boldsymbol{PP_{di}^j}$ to be received by each individual source $\boldsymbol{j}$ (plants). Consider this example: one source S_1 has 3 tonnes of deposits on a receptor zone Z_1, for which the cap is not exceeded, and 8 tonnes of deposits on Z_2 where the cap is exceeded. Then S_1 will first receive 3 P_{d1}. If Z_2 is receiving a total amount of excess deposits of 20 tonnes and responsibility of S_1 for this is 5%, it will also receive:

$$\{8 - [(20 \text{ x } 60\ \%) \text{ x } 5\ \%]\} = 7.4\ P_{d2}.$$

So the *first* potential deposit allocation of S_1 is: $PP_d^1 = 3\ P_{d1}^1 + 7.4\ P_{d2}^1$

Then the total amount, E_D, of such SO_2 deposition allowances to EU sources is calculated to test the compatibility of this allocation with the Oslo Protocol, as regards abatement commitments expressed in national ceilings:

$$E_D = \sum_{i,j} PP_{di}^j \text{ for each source } \boldsymbol{j} \text{ and zone } \boldsymbol{i}$$

An EU cap on emissions, E_T, is also calculated as the sum of SO_2 emissions compatible with agreed national ceilings. If $E_D \leq E_T$, the first allocation is actually implemented for plants, since it satisfies at the same time the total EU cap and the critical loads target for each European zone. If on the contrary $E_D > E_T$, some additional restriction is needed. It can be argued that a proportional reduction on the *first* formula of allocation of allowances will be the appropriate solution for every individual source. For instance, if $E_D = 1.2 \text{ x } E_T$, the actual initial allocation of S_1 will be:

$$P_d^1 = [(3/1.2\ P_{d1}\ ;\ 7.4/1.2\ P_{d2})] = (2.5\ P_{d1}\ ;\ 6.15\ P_{d2})$$

Such a procedure fits well an integrated EU political context, since member countries are supposed to transfer their national quotas to the EU, so as to obtain a global EU wide cap. The prominent role given to the critical loads targets expresses the same equilibrium. But under what conditions will this solution be acceptable to governments? Some countries will certainly see their actual quota reduced when compared to the agreed national ceilings in the Oslo Protocol or to the first variant considered above. It seems quite natural to envisage some mechanism of financial compensation. It has been proposed to compensate governments rather than sources, since governments have to be convinced to accept additional restrictions.

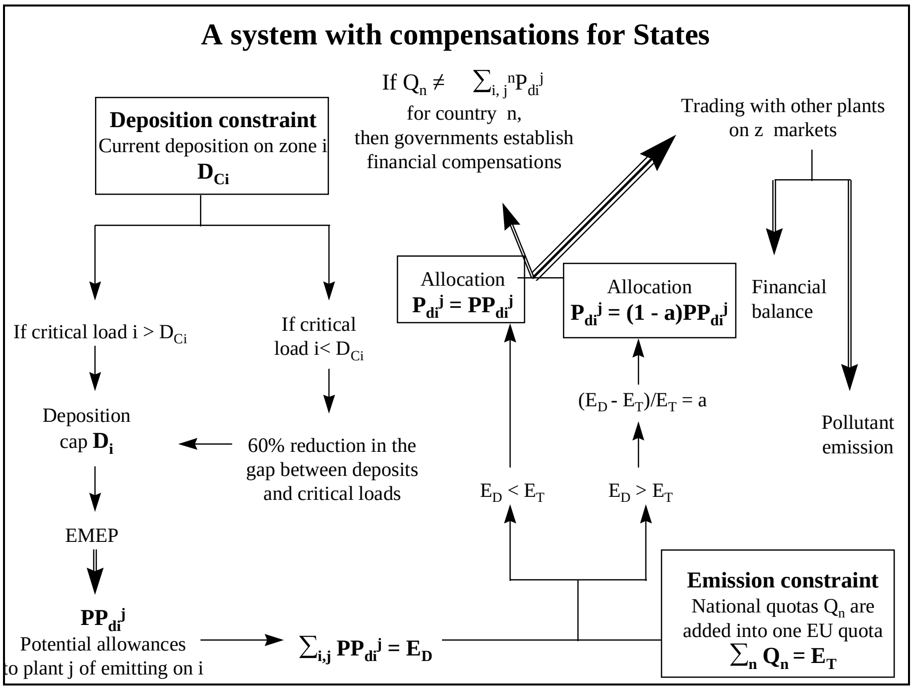

Figure 6: A second variant of an integrated system with compensation for states

What should be the base for this compensation? Obviously, compared to the Oslo Protocol, some countries are going to see their allocation improved and others worsened. It will be easy to see who has to be compensated and who has to pay compensation. In the normal ordinary running of allowance trading, the amount of the compensation could be determined on the basis of the mean market price of allowances. Since this is the initial allocation that is being discussed now, there is still no observable market prices for allowances. They could be proxied by some estimate of marginal costs of meeting constraints on SO_2 emissions. This solution might be empirically accepted on the basis of some field study, but it lacks logical consistency. Trading schemes find their justification in the fact that marginal costs are not appropriately known by central authorities, and may not even be adequately revealed to sources before the latter are dynamically confronted with a new context, including allowing trading opportunities!

There is a conventional way around this issue, which is in the spirit of the Oslo Protocol. Since the breakthrough of this Protocol was only possible because the parties accepted some integrated assessment as a basis for elaborating a rather cost-effective international plan, parties should agree to calculate compensation using the same tool. The compensations table could then be calculated as the difference in national costs resulting from two allocations: the agreed national ceilings of the Protocol and the allocation resulting from the procedure that has been just described.

2.2.3. A comparative summary of the three trading schemes

The three trading schemes we have just examined are supposed to meet the basic constraints of the SO_2 European game as we have interpreted them. However, they are not identical in every respect and implement different institutional and political equilibria; they do not establish the same economic mechanisms either. A comparative approach may help to identify the specific pros and cons of each solution. Four general criteria are now considered: cost-effectiveness; achieving environmental targets; administrative ease; political acceptability. As a reference for the comparison, we also place the existing CAC regime in the comparative table.

Table 2 provides a subjective and qualitative comparative assessment of the basic policy regimes discussed in the previous sections. Some critical features of the comparison are not easily caught in such a table, which is not a substitute for the detailed discussion of the previous sections. The general conclusion illustrated by this table is that some trade-off has to be built between cost-effectiveness, administrative ease and political acceptability.

	Cost-effectiveness	**Environmental achievement**	**Administrative ease**	**Political acceptability**
Existing CAC	Low or medium (with central economic modelling)	Rather low: no guarantee on global and localised performance; non attainment of the critical loads target	Medium: based on existing routines; intensive use of modelling Some risks of implementation failure regarding monitoring	High for administrative services; mean for firms; low for Ministers of Finance
Coupled emissions and deposit tradable allowances	rather high flexibility and cost-effectiveness; bilateral trades; n+1 markets→ rather high transaction costs	High may achieve greater progress in SO_2 abatement because of the critical loads constraints	Medium modelling used only for the initial allocation; stringent monitoring of emissions and trades	Looks cumbersome; no incentive to firms and governments to go beyond agreed national ceilings
Integrated scheme with two types of tradable allowances: usable and unusable	High cost-effectiveness (three types of markets: usable, unusable deposits, unusable emission Bilateral trade + second market; public price generated by auction of unusable allowances.) But rather high transaction costs	High may achieve greater progress in SO_2 abatement because of the critical loads targets	Rather low complex monitoring of emissions, trades and allowances; modelling used for each proposed trade for usable and unusable deposit allowances	Provides incentive to accept the critical loads targets (entitlements of plants for unusable allowances)
Integrated scheme with compensation to governments	Upper medium Bilateral trades; no public price; high transaction costs	High may achieve greater progress in SO_2 abatement because of the critical loads targets	Medium monitoring of emissions and trades; modelling used for each proposed trade for deposit allowances	Provides incentive to accept the critical loads targets (compensations to governments) But political reluctance in respect to the idea of compensation among governments

Table 2: A comparative, qualitative assessment of alternative schemes

2.3. About zoning and scaling

The issue of zoning has been touched upon several times in this paper. This issue deserves consideration regarding the two alternative ways to achieve a zoning for trading. Two main problems need to be addressed: the first concerns the scale of receptor zones; the second concerns the way zones are defined.

At one extreme, we have grid-cells, i.e. relatively small territorial units of 150 km X 150 km. At the other extreme, we face one unique zone, the European territory concerned by the LRTAP Convention. The higher the scale, the more attractive the potential for economic efficiency gains from trading. The lower the scale, the more the market will take account of localised environmental differences, though the potential gains from trade will be lower. Maintaining practical viability with sufficient potential for economic efficiency gains should be considered the relevant criteria of choice for the "best" scale, not just having a complete guarantee about the environmental evolution of every small part of the European territory. If such an extreme requirement is imposed, it would be paying too much for environmental certainty. But how can we proceed in this direction?

If the existing grid of 150 km X 150 km is to be maintained as a framework for organising allowance trading, defining a matrix of rates of exchanges (offset rates) between all zones is inescapable to find a sufficient flexibility. This was not the way explored in this article. We advocate to keep with a 1 to 1 rate of exchange within homogeneous zones. In that case, the solution is to constitute a limited number of macro zones to give sources a sufficient margin of flexibility.

There are two main possibilities for organising such macro zones. The first consists of setting a number of classes of excess over critical loads and to map the territory according to these classes. Two territorial units belonging to the same class may not be adjacent. Allowing a 1 to 1 rate of exchange within each equivalence class is appealing, since emissions will have a broadly similar effect on the environment, though the risk of having hot-spot problems, with an unduly large concentration of pollutants in some places, cannot be excluded. So it may be useful and prudent to introduce some restriction.

This is provided by the alternative way of designing zoning - identifying homogeneous geographical zones i.e. zones having a geographical unity in terms of contiguity and at the same time the same broad level of excess of deposits over critical loads. Several adjacent cells with the same sensitivity to deposition could be joined in a single macro zone. Such a grouping extends the trading possibilities between deposits allowances. Trade would be allowed only between sources having emissions falling into the same macro zone. Figure 7 is an illustration of this conception.

- As a first step, zoning is roughly defined. Sources having emissions falling on a macro zone of the same sensitivity can trade. For instance, sources from which emissions are falling on (R1, R2, R3, R10, R11, R12, R19) can trade deposits allowances between themselves. In the same way, sources having emissions falling on (R51, R58, R59) can trade together;
- Conversely, sources generating deposits onto R8 would not be allowed to trade with those having deposits on R58. An increase in deposits in R8 cannot be compensated for by a reduction in R58, due to compliance with critical loads.
- Sources belonging to different macro zones but placed in the same class of environmental excess are not allowed to trade; as mentioned above, this could generate hot-spots of concentration of pollutants. Zone Z1 could be made up of R4, R5, R6, R13, R14, R16, R21, R22, R23, R24, R28, R29, R30, R31, R32 as an homogeneous trading zone.

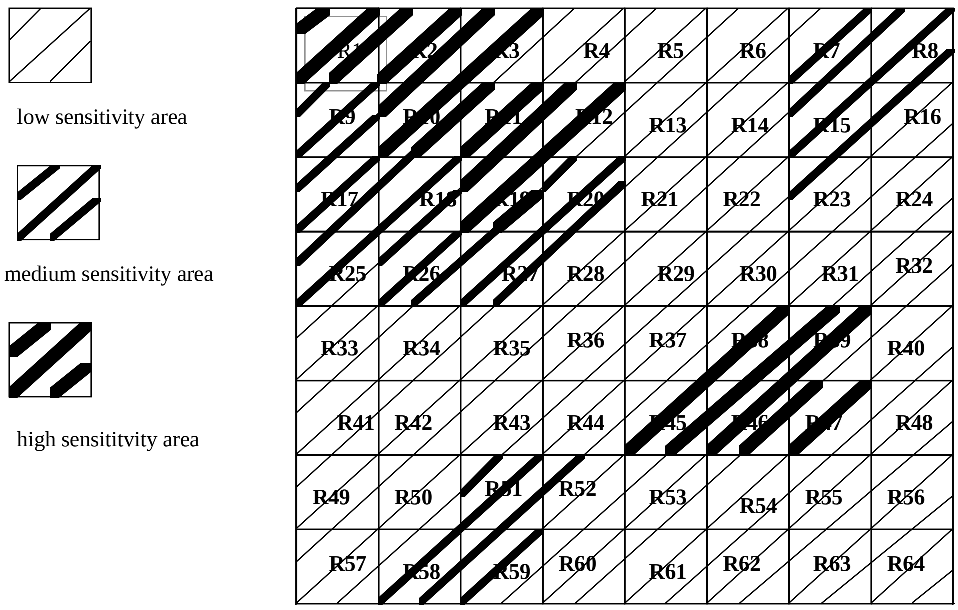

Figure 7: Example of adjacent zoning

Such a grouping into macro zones can be made reversible. Since the ultimate target is formulated in terms of respecting critical loads for each basic territorial unit, progress in that direction may be supported by a transitional approach to the scaling of trading zones. The initial step would be organised on the basis of a limited number of macro zones, to give sufficient economic flexibility according to the present state of emissions and national targets. Such macro zones would not constrain sources enough to ensure compliance with critical loads targets for each unit zone. At later stages, these zones could be scaled down. For example, we can divide each of the previous macro zone into several parts:

Z1 : → z1(R4, R5, R6, R13, R14),
→ z2(R21, R22, R28, R29, R30),
→ z3(R16, R23, R24, R31, R32)

and so on for any macro zone ...

One critical point for the dynamics of scaling from an incentive viewpoint is that the future evolution of the grid should be communicated to participants well in advance so as they can elaborate strategic plans of compliance incorporating early adaptation. Otherwise the outcome could be very inefficient. For instance, mistakes in capital investment might be induced. The authorities might therefore announce that the existing zones would be narrowed five years later, and then again 10 years after. Plants could then elaborate strategies for complying with the constraints and benefiting from opportunities. Such announcements of changes in the scale of trading zones would limit the problem of hot spots from the start, because for every decision having a medium or long term time horizon, specifically for planning investments (desulphuring equipment, etc.), plant operators will have to take the announced changes into account. By the end of the process, the long run targets fixed by the Oslo Protocol, i.e. respective critical loads at the level of the grid-cell, will have to be met and this will give much less scope for trading.

With respect to practical matters, what type of zoning may reasonably be considered in an initial step? It seems that defining five trading macro zones in which critical loads are exceeded may make sense on both economic and ecological grounds. For instance, this is the recommendation proposed by Bailey, Gough et Millock (1994). Here macro zones are made of a grouping of unit zones having adjacent sensitivity. One procedure, suggested by these authors, is to set five classes of acid sensitivity and to classify each grid cell according to this gradation. Sensitivity $\boldsymbol{x}$ is defined by the value of critical loads, i.e. as the amount of acid deposits that a zone can absorb without being significantly damaged. $\boldsymbol{x}$ is expressed in $keqH^{+}km^{2}yr^{-1}$. The five classes are as follows:

$$(\boldsymbol{x} \leq 20) \; ; \; (20 < \boldsymbol{x} \leq 40) \; ; \; (40 < \boldsymbol{x} \leq 80) \; ; \; (80 < \boldsymbol{x} \leq 160) \; ; \; (160 < \boldsymbol{x})$$

An alternative approach is to classify grid cells according to the level of excess deposits. This leads to another mapping. The following maps give an illustration of these classifications. Map 1 shows how five sensitivity classes are split into macrozones. This « sensitivity » classification is not very satisfactory: two areas classified in the same sensitivity class may suffer unequal damage due to additional deposits; marginal damage depends not only on sensitivity levels but also on basic deposits received by zones in excess over critical loads. This is a reason why we suggest to consider the second type of zoning based on excess deposits over critical loads. With five classes of excess deposits, we can distinguish five critical macrozones surrounded by large areas where critical loads are not exceeded. These are given in Map 2.

These maps convincingly show that drawing macro zones is not an entirely arbitrary exercise. By accepting some kind of *"sacrifice"*[22] for a few cells, it is possible to identify homogeneous zones of a large scale. It should be noticed that significant superficies are not really affected by acid deposition. These zones have deposits that do not exceed critical loads. The 60% abatement constraint will not be binding for them, but only respecting critical loads. Countries like Spain, Greece and Portugal are broadly in this category.

CONCLUSION

Allowance trading can be economically and environmentally advantageous when compared to a homogeneous tightening of emission standards. In the case of a EU SO_2 trading scheme, the system would incorporate a double institutional constraint (national overall targets, a target of a 60% reduction in the excess of deposits over the 5-percentile critical loads). This could make it more complicated than imagined at first sight, and entail significant organisational costs, thus limiting the incentives given to companies to commit themselves to trading. This may be an obstacle. Incorporating a EU trading scheme into the framework of the Oslo Protocol would be a delicate operation, needing to avoid several obstacles. The design of the instrument should seek to match the political compromise established by this Protocol, between a more federal-oriented, integrated approach and a more national-oriented one. Three possible solutions have been considered. Firstly, a double, coupled, system of allowances in which basic operators have to gather the same amount of the two sorts of allowances to obtain the right to emit the corresponding amount of SO_2. Secondly, an integrated system giving due account to both constraints with the introduction of a distinction between "usable and tradable" allowances and "unusable and tradable" ones. Thirdly, an integrated system focused on deposition allowances trading, equilibrated by financial compensation between governments.

22.- Macrozoning does not exclude the risk that, in some areas, deposits may increase or may not decrease, though a significant decrease will be achieved in other parts of the same macrozone. Nevertheless, it should be stressed that the target of a 60% abatement rate of excess over critical loads does not directly refer to damage. In places where critical loads may be slightly exceeded, the target is the same as in places where the excess is of a greater magnitude

The most critical point for implementing these solutions will be to find an agreement on the simplification of zoning. Drawing five homogenous zones in Europe, within which trading could be free, is the way we suggest. Such an approach would mean that an individual source should operate in a maximum of five different zones markets, depending on the dispersion of pollutants it emits. This construct relies on the capacity of EMEP to reliably model the transport of pollutants from sources to receptors.

One important advantage of a SO_2 trading scheme might be to allow a better management of the timing of progress towards the ultimate goal of respecting critical loads everywhere in Europe. This idea of transition can be understood both at the global EU level, where allowance trading may help progress by reducing the economic cost of the trajectory, and at the utility level, where the new flexibility permits an optimisation of the timing of investment devoted to the abatement of pollutants. Depending on their specific situation, not all plants will be obliged to achieve their adaptation in the same way, at the same pace. This can be contrasted with the usual requirement of CAC.

Due to the novelty of the instrument in Europe, it does not seem appropriate to extend the trading mechanism to other sectors (all large combustion plants, refineries) from the outset. A risk of destabilisation of sectoral economic conditions may raise strategies of protection which are not those being aimed at. Keeping such an extension to a second step, after seven or ten years of initial experiment within the power generation sector, would allow the experience gained to be exploited in extending the scheme to other sectors.

Finally, emissions trading should not be designed and considered as a pure application of textbook economic theory, nor as an end in itself, but as the instrument of a cost-effective institutional evolution, achieving a political transition towards greater integration of environmental policy. As Baron and Hourcade (1993) have said in the context of CO_2, "hybrid schemes", compromising political rationale and specific institutional dynamics at the national and international level may represent the most practical way forward available at present.

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