Discussion Paper No. 98-15

Tradable SO_2-Permits in the European Union: A Practicable Scheme for Public Utilities

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Non-technical summary

The acidification of ecosystems is still an unsolved problem in Europe. Thus, in the Sulphur Protocol of Oslo, signed in 1994, most European countries agreed on national sulphur emission ceilings for the year 2000 that have been derived mainly on the basis of the critical loads concept. In view of this, the paper develops a practicable model of tradable SO_2-permits for the EU-15 public power producers who contribute to about 30% of all anthropogenic SO_2-emissions. For this sector the scheme would become the main instrument to curb SO_2-emissions. A short evaluation of the literature on spatially differentiated permit systems, and the empirical evidence on the U.S. Acid Rain Program and the Californian RECLAIM Program lead to the choice of a spatially undifferentiated SO_2-permit system as a starting-point for the model's design. The inherent conflict between ecological effectivity and economic efficiency is assessed using an applied general equilibrium model for the European Union. Simulations indicate that an undifferentiated SO_2-permit system will save costs, but violates the national deposition targets in all countries with the exceptions of Greece, Portugal and Spain. The macroecenomic impacts turn out to be small; they lay within a range of ±0.5 per cent for all countries (based on the business-as-usual case). In order to address the ecological needs a bundle of measures counteracting possible hot spots is proposed whose use should be graded according to their intensity of interference, in order to keep the degrees of freedom for all agents in the market as high as possible. Concerning the initial allocation of SO_2-permits to the public power producers a long-term transition from a mode of grandfathering to the mode of a free auction is chosen. This "limited grandfathering" is implemented by a primary distribution of permits to existing sources which only covers the expected remaining regular lifetime of the respective plant type.

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A Practicable Scheme for Public Utilities

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Abstract

In this paper, a practicable scheme of SO_2-emission permits for European power producers is developed. Background is the second UN-ECE Sulphur Protocol from 1994 (Protocol of Oslo). After discussing some theoretical models of spatially differentiated permit schemes, evaluating the U.S. Acid Rain and RECLAIM Program, and considering the setting in the EU-15 countries, a scheme of locally undifferentiated emission permits is proposed which is distinguished by a high degree of both economic efficiency and market functioning. However, as our model simulations indicate, national deposition targets will be violated in all probability due to the scheme's missing differentiation regarding the receptors. The risk of hot spots is addressed adequately by a differentiated bundle of countermeasures. The general economic impact of an EU-wide permit scheme is low, and, in terms of change in GDP, lower compared to a non-coordinated SO_2 policy. The proposed mode of the initial permit allocation allows for early price signals and guarantees maximum static and dynamic efficiency. Balancing the interests of existing and new emitters, a long-term transition from the grandfathering to the free auction procedure is chosen.

Acknowledgement

This research is based on a study financed by the German Federal Ministry of Economics.[1] We are grateful to Marcus Stronzik and Dr. Heidi Bergmann (both ZEW) for their collaboration. Nevertheless, we take responsibility for all errors and omissions that might have remained.

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[1] H. Koschel, K.L. Brockmann, T.F.N. Schmidt, M. Stronzik, H. Bergmann, Handelbare SO_2-Zertifikate für Europa - Konzeption und Wirkungsanalyse eines Modellvorschlags, Heidelberg: Physica (forthcoming).

1 Introduction

Acidification is a still unsolved problem in Europe. Consequently, Sweden, which is among the countries most affected, prompted a request from the Environment Council to the European Commission to develop a coherent acidification strategy (ENVIRONMENT WATCH 1997). In March 1997, the Commission published its "Communication to the Council and the European Parliament on a Community Strategy to Combat Acidification" (COM(97) 88 final). It states that in 1990 the critical loads[2] for acidification were exceeded over an area of more than 32 million hectares, i.e. 24 per cent of the ecosystems were unprotected. Projections indicate that, if current, and if well-advance planned legislation is fully implemented in all fifteen European Union (EU)-member countries, the ecosystem protection would increase to 93.5 per cent in 2010. Nevertheless, to reach the declared 50 per cent gap-closure interim target[3] across the EU, a protection rate of 96.7 per cent is necessary. This implies an EU-wide reduction of the projected SO_2-emissions in 2010 of 5.6 million tons to 2.7 million tons.

Consequently, the Commission proposes further measures beyond existing legislation. Key elements are national emission ceilings for a number of key pollutants, the ratification of the 1994 Sulphur Protocol of Oslo, and a Directive on the sulphur content of gas oils and heavy fuel oils. In the Protocol of Oslo, 28 European countries, as well as Canada, agreed on national sulphur emission ceilings for the year 2000 (for some countries, 2005 and 2010, too). Due to a slow process of national ratification, the Protocol has not yet been put in force.

Under the heading "economic instruments", the Commission enumerates in its strategy paper the main types of instruments: charges/taxes, subsidies, tradable emission permits, and environmental agreements. The proposed national ceilings are considered as "anchoring points for the member states for designing national economic instruments (or regulations) that go beyond common minimum environmental requirements" (COM(97) 88 final, Section 4.9). Concerning the

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2 The Commission gives a very vivid definition: "The critical load indicates the sensitivity of a particular environment by defining how much exposure to pollution it can tolerate before a long-lasting or other significant damage occurs. [...] depositions above the critical loads are not sustainable in the long term". (COM(97) 88 final, Section 1 of the Annex).

3 This gap-closure concept aims at closing the difference between the level of ecosystem protection in 1990 and the ultimate target of 100 per cent ecosystem protection, by 50 per cent in each EMEP grid cell in the EC by the year 2010 (cf. COM(97) 88 final, Section 2 of the Annex). An EMEP grid cell is a 150×150 kilometres cell of a mapping scheme used to evaluate critical loads in Europe.

ceilings from the Protocol of Oslo, the United Nations Economic Commission for Europe states, that "in order to deal with this inherent uncertainty [on abatement costs], countries could be given some flexibility in how they meet their commitments. One way is to give countries the option to exchange emission reduction commitments. […] The possibility for exchange will contribute to cost-effectiveness in the allocation of abatement measures over time …" (UN-ECE 1991:§22).

In line with this political development, the paper proposes a practicable model of tradable SO_2-permits for the EU-15 public power producers who contribute to about 30% of all anthropogenic SO_2-emissions. For this sector, the scheme would become the main instrument to curb SO_2-emissions. It would mean a clear turning-away from a policy which is dominated by command and control measures. On the EU level, these are mainly the directives on large combustion plants (88/609/EEC) and on sulphur in liquid fuels (93/12/EEC), laying down limit values for emissions, and for sulphur content of certain liquid fuels. On the national level, patterns of environmental regulation of air pollutants differ between countries. While Germany and Austria confine themselves to command and control policies, Denmark, Finland and Sweden use emission limit values in conjunction with taxes and charges. The southern countries tend to prefer a combination of emission limit values and subsidies.[4]

In the following, we summarize the theoretical literature on tradable emission permits with emphasis on their ability to address spatial aspects (Section 2). Section 3 contains general equilibrium modelling results of the possible effects of an EU-wide scheme of spatially undifferentiated permits. The aim is to assess the inherent conflict between ecological effectivity of such permits and their economic efficiency. Section 4 contains empirical evidence on the functioning of permits markets, namely of the U.S. Acid Rain Program and the Californian RECLAIM Program. Section 5 addresses the European energy sector, i.e. the existing pattern of SO_2-emission control, and the potential limits for a functioning permits market by market power and low trading volumes. Finally, we present the proposed scheme in Section 6, and draw conclusions in Section 7.

2 Theory of environmental tradable permits

Environmental permits, partly rooted in the property rights based Coase-concept, constitute a solution to environmental problems which is highly conformant to the market system. The state merely establishes an ecological framework, and permit trade allows for an efficient allocation of the distributed 'rights to pollute'.

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[4] See KOSCHEL et al. (1998) for further details.

Basically, a permit system consists of three elements (KOUTSTAAL/NENTJES 1995, p. 220):

- The *ecological element* concerns a politically desired amount of total emissions for a number of countries - mostly signatories of an international agreement - or a single nation. The quantity of allowed emissions must be attested in an equivalent number of emission rights. Fixing the total amount of emissions reduces the control authority's uncertainty about environmental effectiveness and adjustment costs. Even without any information about aggregate marginal cost curves, the control authority can be sure that the environmental target will be met.[5]
- The *distributive element* considers the initial allocation of tradable permits among nations or between sectors and specific sources within one country. Comparable to a rule for the reimbursement of tax revenues, the rule for the initial allocation mainly determines the burden sharing of costs and, thus, concerns equity aspects.
- The *economic element* concerns the efficiency induced by trade. Tradable permits theoretically constitute a cost-efficient option for implementing emission reduction goals, provided that some conditions are satisfied (MONTGOMERY 1972). These include negligible transaction costs, a competitive permit market[6], and the assumption that sources minimize their control costs (i.e. the costs of control technology investments and the net revenue of trading permits).

The functioning of tradable permits can be explained by the following mechanism: Within an emission permit system, the firms can choose between, 1. the purchase of tradable permits (or renunciation of selling permits) and emission of the corresponding amount of pollutants, or 2. the investment in new emission control technologies and renunciation of purchase of permits (or sale of unused permits). Each firm decides whether it is more efficient to buy a permit or to invest in additional, potentially improved control technologies. Whereas a policy of technical standards reduces the firm's private autonomy and its flexibility of technology choice considerably, a policy of emission permits (as well as of emission charges) guarantees the maximum degree of freedom concerning the individual adjustment strategy. As all private decisions are made to fit in with the same permit price that clears the market, marginal abatement costs are equalized across all firms participating in trade. The costs of meeting a given emission target are minimized.

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[5] In contrast to an emission charge in which the total amount of actual emissions is not fixed, but the price is.

[6] The problem of strategic manipulation and oligopolistic interaction in tradable permit markets has been addressed in some studies, such as HAHN (1984), TIETENBERG (1990), MISIOLEK/ELDER (1989) and MØRCH VON DER FEHR (1993). Indeed, when competition is not perfect, i.e. a single firm has some market power, it may use this to manipulate the market for permits to its own advantage. Thus, it is important to guarantee that a sufficient number of firms is involved.

Moreover, the price signals of the permits markets not only assure a short-term efficient allocation of abatement measures, but also enhance competition between existing abatement options and give incentives to the invention and diffusion of new abatement options. Compared to regulatory instruments, tradable permits are dynamically more efficient. Since unused permits can be sold on the market and revenue can be used for financing investment, environmental technical progress will be stimulated permanently, as long as any ’opportunity costs’ of using a permit exist (TIETENBERG 1994).

It was also shown by MONTGOMERY (1972) that, given a set of conditions, the initial permit allocation has no consequences for the allocative efficiency: it represents a lump-sum endowment which does not affect marginal choices. As within a permit system equity and efficiency aspects can be handled separately, the initial allocation can be used to accomplish distributional goals without interfering with cost-efficiency goals (TIETENBERG 1983, p. 240, 1990, p. 22). The absence of the usual equity-efficiency tradeoff is an attractive characteristic of the tradable permit approach, in particular for its application at the international level. For example, an international CO_2 permit system could address questions of inter-country equity arising from the concept of sustainable development without interfering with the system’s efficiency (ROSE/STEVENS 1996). However, a study of SCHMIDT/KOSCHEL (1998) emphasizes the importance of considering full general equilibrium effects when analysing burden sharing among several countries under different equity rules within a tradable permit system.

An SO_2 tradable permit regime can operate at the national or international level. Implementing a *national tradable permit system* requires national emission reduction targets that can be drawn from an international agreement such as the Protocol of Oslo. These targets will be realized exactly and cost-efficiently within the boundaries of each country. Obviously, the national emission reduction targets laid down in the Protocol of Oslo will very probably not ensure a cost-efficient solution at the international level, especially if abatement costs differ across countries. Thus, a national implementation of a tradable permit system for SO_2 gives away cost saving potentials. In contrast to this, an *international tradable permit system* offers more flexibility concerning the international emission structure. The emission reduction targets emerging from the Protocol of Oslo now could serve as the basis for the initial allocation of permits across all participating nations. As already mentioned, the initial allocation is a critical point of a tradable permit system as it is the main factor for the burden sharing among countries. Ultimately, the Protocol of Oslo only constitutes the ‘distributive element’ of a permit system. Only the subsequent reallocation of permits via trade between countries may lead to a cost-efficient allocation of emission reduction measures.

Basically, the ecologically optimal design and appropriateness of tradable permits crucially depend on the type of pollutant that has to be controlled. As Table 1 indicates, economic theory suggests many tradable permits models with different spatial dimension (see also KLAASSEN 1996b, and TIETENBERG 1995). Unfortunately, the models with the highest appeal in terms of ecological effectivity are characterised by a lack in practicability. This is due to the fact that the higher the degree of spatial differentiation, the higher the ecological goal-conformity and transaction costs related to the gathering and evaluation of information.

Table 1: Evaluation of emission permits schemes for SO_2

Permits Scheme / Criteria	**AP** (ambient permits)	**ADP** (ambient differentiated permits)	**EDP** (emission discharge permits)	**LDP** (local discharge permits)	**ERT** (exchange-rate trading)	**UDP** (undifferentiated discharge permits)
Division of the region into zones?	no	yes, with interzonal trade	yes, without interzonal trade	yes, without interzonal trade	yes, with interzonal trade	no
Number of independent permits markets	one deposition target per receptor / one permits market per receptor	one deposition target per receptor / deposition targets are operationalizied by emission targets / one permits market per receptor	receptor-based deposition targets are operationalized by a single emission target, valid for all zones / one permits market per zone	receptor-based deposition targets are operationalized by zonal emission targets / one permits market per zone	one emission target (derived from the set of deposition targets) - one permit market with fixed exchange-rate emission trading	one emission target (derived from the set of deposition targets) - one permits market
Information requirements on the part of the trading partners	individual emitter: own emissions and individual matrix of transport coefficients	individual emitter: own emissions	individual emitter: own emissions	individual emitter: own emissions	countries/zones: own emissions and interzonal exchange rates	individual emitter: own emissions
Information requirements on the part of the authority	---	matrix of transport coefficients of the emitters covered by each zone	matrix of transport coefficients of the emitters covered by each zone ; individual cost functions of all emitters	matrix of transport coefficients of the emitters covered by each zone; individual cost functions of all emitters	ratios of marginal abatement costs in the cost-minimum (in order to fix exchange rates between countries)	cost functions of emitters and ex post-market allocation
Ecological effectivity (in practice, i.e. when considering information deficits)	assured	relatively well assured	not assured	not assured; even less assured than with EDP	not assured	not assured (assured only if total emissions are reduced sufficiently)
Cost-efficiency (in practice)	assured	relatively high, but lower than with an AP	lower than with an ADP (thin market problem)	lower than with an EDP (thin market problem)	efficiency gains possible vs. cost minimum plus current reduction plan	low because the overall reduction of emissions is too high
Transaction costs	very high	high	low	low	very low	very low
Practical experience	---	---	---	---	---	ARP, RECLAIM, Basler emissions trading
Practicability for SO_2	not practicable: diffusion too complex, transaction costs too high	potentially practicable, yet institutions for lowering transaction costs are necessary	potentially practicable, yet the problem of thin markets arises	less practicable than UDP	possibly practicable if modified adequately	potentially practicable if used in combination with measures of ecological fine tuning

An ambient permits scheme, for example (see Figure 1), would theoretically establish one market for each receptor point, thus demanding emission sources to purchase a high number of different permits on different markets according to the diffusion characteristics of its emissions. The parallelism of several permits markets

- which is an inherent feature of all spatially differentiated schemes - raises the risk costs of emission sources. As the different markets will tend to be small, they may not obtain all necessary permits, or only at prices that are difficult to forecast. This again raises the opportunity costs of relying on permits and thus the attractiveness of technical solutions (e.g. a flue gas desulphurization process).

As the permits market size corrrelates positively with its liquidity and with the stability of the price signals sent out, a permits scheme should establish as big and as few as possible permits markets. However, not only low risk costs but also low transaction costs contribute to a functioning permits market. Thus, the information requirement for the affected emission sources during the program should be kept low, and practicability high. Also, administrative costs, fees etc. should be taken into consideration in order to increase the scheme's acceptance from the side of the emission sources and the involved supervising agencies. Comparing the schemes discussed in Table 1 from this perspective, the models with the highest appeal in terms of maximum permits market size and minimum transaction costs are the model of exchange-rate trading (ERT), proposed by KLAASSEN et al. (1994), as well as a scheme of locally undifferentiated discharge permits (UDP). Only these both models seem to be possible for the design of a European SO_2-permit system.

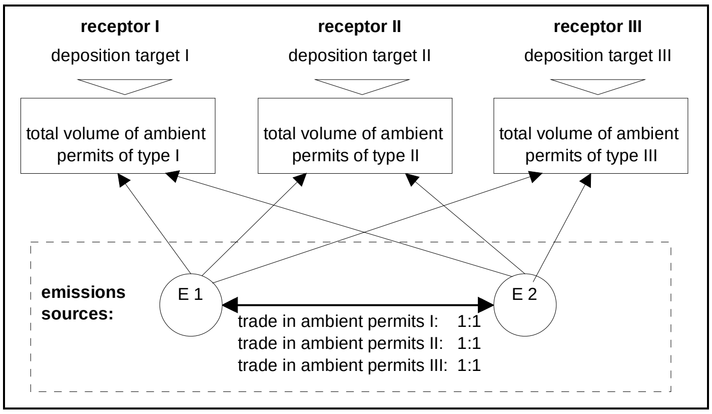

Figure 1: Ambient permits (AP)

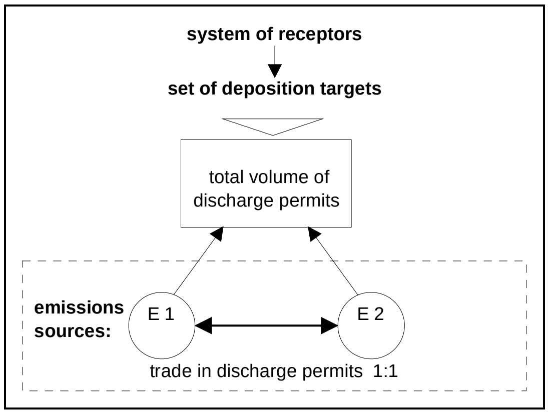

Figure 2: Undifferentiated discharge permits (UDP)

In the European context, a pure UDP-system establishes a single permits market and allows all emission sources to trade permits within the whole European region on a one-to-one basis (see Figure 2). Following the UDP-approach, Klaassen et al. suggests a relatively simple system with a single market for tradable emission permits, too. But, considering the local dimension of SO_2 emissions, they divide the European market region into several zones which are represented by European countries. Between these zones, emission permits can be traded on the basis of (initially) fixed exchange rates that account for the impact of the location of the emission sources on the deposition. "The exchange rate gives the volume of emissions one source has to decrease when another source increases its emissions with one unit" (KLAASSEN et al. 1994, p. 309). Based on the cost-optimal solution[7], in the ERT-model of Klaassen et al. the exchange rate between two sources is based on the ratio of the marginal abatement costs in the cost minimum. This takes into account the sum of the transportation coefficients weighted by the shadow price of the binding receptors in the optimum.

A comparison of the two models - in view of the same emission reduction target for a whole region - is not easy to draw. The UDP-scheme is administratively very simple to implement. In the ERT-model, too, the addressees of the scheme can easily grasp its mechanisms and its economic implications as the information requirements are low and as exchange rates are fixed initially. In comparison to a situation without any emission trading, cost savings will be obtained in both cases. Under a UDP-scheme, the market volume would tend to be higher as it eases the exchange of emission permits that are not equivalent from an ecological perspective. Interestingly, it was exactly this argument that led the U.S. Senate to drop an earlier proposal for a trading scheme that included spatial trade restrictions (see WASMEIER 1992, p. 224).

Different from a CO_2-emission permits scheme, location issues cannot be ignored in the context of SO_2 for ecological reasons. Theoretically, a UDP-permit system could result in deleterious emission concentrations and depositions. The ERT-model tries to cushion this conflict by fixed exchange-rate emission trading between countries. But as the problem of information connected to the fixing and the regular revision of the exchange rates cannot be solved completely, the fulfillment of the deposition targets can not be guaranteed, either. In practice, it would therefore be necessary to combine such a system with measures preventing a violation of the targets.

In all probability, the ecological deficiencies are greater with a pure UDP-scheme than under an ERT-scheme. The empirical evidence on this topic is tested in the next section. As the results indicate violations of some regional deposition targets, a UDP-system must, in practice, be combined with measures of ecological fine tuning ("hot spot measures"). Such a combination would nevertheless appear to be more attractive for empirical application than an ERT-scheme (combined with similar hot

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[7] The optimisation problem asks for the emission vector for which the desired levels of deposition at the receptor points are realised at minimal total costs (aggregated over all source abatement costs). A necessary condition for an interior solution is that the marginal abatement costs of source i equals the sum of the shadow price weighted transportation coefficients for emissions of source i to the several receptors.

spot measures) as it avoids the aforementioned information problems for the central authority when fixing the exchange rates. In addition, we can look back to some practical experiences in the U.S. with UDP-schemes for SO_2 (see Section 4).

What is more, the cost efficiency of a an UDP-scheme enables the execution of more ambitious emission reduction goals in the future and would therefore increase the dynamic efficiency of the entire set of environmental policy measures in Europe. An ecologically accurate tradable permits system with non-liquid markets and unstable prices would be more likely to run contrary to the long-term aim of a sustainable management of emissions in the sense of the critical loads concept pursued by the Protocol of Oslo.

3 Macro-economic and sectoral impacts of an EU-wide tradable permits scheme for SO_2

To estimate the economic and ecological effects of a European scheme of spatially undifferentiated SO_2-permits (UDP) for public power producers, two scenarios were simulated using the computable general equilibrium model GEM-E3[8] for eleven EU-member states:[9]

- In Scenario 1, emission reduction targets for the national public utilities, which were derived from the Protocol of Oslo,[10] are put into action for the electricity sector on a national level using nationally tradable permits systems (non-coordinated policy).
- In Scenario 2, the power producers emission reduction targets are aggregated for the eleven countries covered in the model. This single reduction target is achieved by imposing a single, EU-wide market for tradable permits. In this type of policy, the opportunities of emission reduction will be exhausted in the different countries according to their cost-effectiveness (coordinated policy).

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[8] The GEM-E3 model was developed on behalf of the European Commission (DGXII) by P. Capros, T. Georgakopoulos (National Technical University of Athens), S. Proost, D. Van Regemorter (Catholic University of Leuven), K. Conrad, T.F.N. Schmidt (University of Mannheim, ZEW Mannheim). Further references and information are given in CAPROS et al. (1997).

[9] See also SCHMIDT (1998).

[10] Column *SO_2-Reduction PP* in Scenario 1 of Table 2 contains the power producers' reduction rates (2005 vs. 1990) on which the calculations in both scenarios are based. They are derived from the respective national total emission ceilings laid down in the Protocol of Oslo. The guiding principle was to let power producers with high SO_2-emission reduction rates in the past contribute less to the national commitment than in those countries where their contribution was minor.

The economic effects of the non-coordinated and the coordinated policies are minor (see Table 2). The variation in the rates of all aggregated macro variables lies in both scenarios in general (with the exception of Spain) within a range of ± 0,5 per cent.[11]

Due to transboundary air pollution, the development of national depositions of sulphur is not proportional to the national abatement efforts in both scenarios. In an EU-wide scheme of permit trade Belgium, Germany, Denmark, France, Ireland, Italy, the Netherlands and the United Kingdom observe higher depositions than in the non-coordinated Scenario 1, whereas depositions are lower in Greece, Portugal and Spain. This corresponds with deviations from the national emission ceilings agreed on in the Protocol of Oslo.

The model results for the coordinated scenario suggest two conclusions: 1. the proposed spatially undifferentiated SO_2-permits scheme for European power producers must be augmented by hot spot measures; Section 6 will explain which kind of measures seem appropriate. 2. the Parties of the Protocol will have to agree on rules on how to realize Article 3 (7) of the Protocol, which allows for the joint implementation of the obligations by two or more Parties.

Both scenarios differ in their effect on permit prices. Scenario 2 leads to a single permit price of 1,419 ECU/ton of SO_2 in all EU-11 countries. Plants that already undertook large emission reduction efforts before 1990 prefer to buy permits than to invest in further abatement measures. Hence, there is a net demand for permits in Germany, Denmark, France, Italy, the Netherlands, and the United Kingdom. In the non-coordinated case of Scenario 1 permit prices vary between 250 ECU/ton of SO_2 in Spain and 3,195 ECU/ton of SO_2 in Germany. This outcome reflects the differences in marginal reduction costs and reduction targets of countries. A model run taking into account actual abatement efforts after 1990 may change the results. In particular, German power plants located in the New Bundesländer, which carried out large investments in recent years, can expect to become net sellers of permits and may thus enjoy a partial financial compensation, if permits are initially allocated by a grandfathering procedure.

Both scenarios imply a loss in GDP. At the EU level, this loss is smaller under the coordinated regime of Scenario 2 (-0.08 per cent) than under the regime of Scenario 1 (-0.12 per cent). Under the coordinated policy, the distribution of total economic burden is altered to the disadvantage of those countries that sell permits, i.e. those countries that take the higher reduction efforts in comparison to Scenario 1 are worse off. This is due to the fact that the latter observe higher prices (in particular the price

[11] Percentage change of counterfactual equilibrium (policy scenario) to reference equilibrium (business-as-usual scenario). The business-as-usual scenario considers country specific emission reductions undertaken up to the year 1990.

for electricity) when a coordinated approach is taken. The negative effect of this rise in national prices is not fully compensated by the revenue from the (net) sale of permits to other countries, as the decision on buying permits or abating is taken by the electricity companies, which are interested in minimizing their individual costs. The economy-wide spill-over effects of higher electricity prices on the rest of the economy are not incorporated in their calculation and are therefore not reflected in the permit price.

From this, we draw a the conclusion that some countries may oppose an EU-wide permits scheme for power producers. Thus, we suggest the establishment of a compensation mechanism for the countries selling more permits in the coordinated than in the non-coordinated case. Of course, measurement of economic burdens to the affected countries will be difficult.

According to sectoral effects on an aggregate European level, most sectors (exceptions are the sectors oil, gas and energy intensive industry) have to accept a reduction of their gross production under both a non-coordinated and a coordinated policy. The following statements apply to Scenario 1 as well as Scenario 2 (cf. KOSCHEL et al. 1998):

- The winners of a policy of SO_2 permits are the sectors oil and gas; they show an absolute growth in production, resulting in a growing share of the European gross production.
- The sectors agriculture, consumer goods industries, transport, services and non-market services show absolute decreases of production in comparison to the reference scenario, but nevertheless show a growth of their shares in the whole of the European gross production.
- The losers of a SO_2-permits policy are the sectors coal, electricity, as well as equipment goods industries. Their gross production falls more than the average aggregated over all sectors, which means that their competitive position to the other sectors gets worse.

These results lead to the fourth conclusion: The proposed scheme may be opposed by inter-country coalitions of the sectors severely hit by rising electricity prices. Therefore, the scheme should offer tools to cushion the adaption processes which will be necessary for these sectors.

Table 2: Simulation results of non-coordinated and coordinated SO_2-emission permits schemes in the European Union

	GDP [%]	*Production [%]*	*Private Consumption [%]*	*Investment [%]*	*Exports [%]*	*Imports [%]*	*Employment [%]*
Belgium	-0.01	0.00	0.00	0.01	0.00	0.02	-0.01
Germany	-0.19	-0.08	-0.12	-0.06	-0.15	0.18	-0.01
Denmark	-0.15	-0.04	-0.15	0.00	-0.11	0.05	0.01
France	-0.05	-0.03	-0.02	0.01	-0.10	0.06	-0.01
Greece	-0.04	-0.08	-0.07	-0.12	0.00	-0.10	-0.02
Ireland	-0.02	-0.03	0.03	-0.06	-0.07	-0.04	-0.03
Italy	-0.06	-0.03	-0.01	0.00	-0.13	0.09	-0.01
Netherlands	-0.03	-0.01	-0.02	-0.01	-0.02	0.01	-0.01
Portugal	0.00	0.00	-0.01	-0.02	0.02	-0.01	0.00
Spain	-0.01	-0.02	0.00	0.02	-0.03	0.02	-0.01
Great Britain	-0.24	-0.16	-0.26	0.01	-0.22	0.15	-0.03
EU-11	-0.12	-0.06	-0.09	-0.02	-0.15	0.18	-0.01
Rest of World	-	-	-	-	0.18	-0.15	-

	After Tax Real Wage Rate [%]	*Non-Labour Income [%]*	*Permits Price [ECU/t SO_2]*	*SO_2-Reduction PP [%]*	*national SO_2-Reduction [%]*	*SO_2-Depositions [%]*	*Deviation from Oslo Depositions [%]*
Belgium	-0.01	0.00	1,182	21	8	-30	0
Germany	-0.17	-0.09	3,195	74	41	-22	0
Denmark	-0.18	0.00	2,178	47	31	-30	0
France	-0.03	0.00	2,648	74	21	-17	0
Greece	-0.10	-0.04	719	24	17	-7	0
Ireland	0.01	0.07	749	10	1	-33	0
Italy	-0.02	0.00	1,976	50	22	-12	0
Netherlands	-0.04	-0.01	1,886	54	30	-34	0
Portugal	-0.01	-0.02	0	0	0	-4	0
Spain	-0.01	0.01	250	5	3	-4	0
Great Britain	-0.34	-0.14	1,972	62	41	-36	0
EU-11	-	-	-	42	25	-21	0
Rest of World	-	-	-	-	-	-	-

Scenario 1: Non-coordinated national permits schemes

	GDP [%]	*Production [%]*	*Private Consumption [%]*	*Investment [%]*	*Exports [%]*	*Imports [%]*	*Employment [%]*
Belgium	-0.03	-0.01	0.00	0.02	-0.03	0.01	-0.01
Germany	-0.03	-0.06	-0.14	-0.09	0.06	-0.14	0.00
Denmark	-0.03	-0.05	-0.14	-0.05	-0.01	-0.12	0.00
France	-0.02	-0.02	-0.03	-0.01	-0.01	-0.02	0.00
Greece	-0.16	-0.06	0.03	0.00	-0.29	0.44	-0.01
Ireland	-0.04	-0.03	0.09	-0.02	-0.11	0.01	-0.04
Italy	-0.03	-0.03	-0.05	-0.03	-0.04	-0.05	0.00
Netherlands	-0.02	-0.02	-0.05	-0.03	-0.02	-0.04	-0.01
Portugal	-0.09	0.05	0.26	0.40	-0.37	0.37	-0.06
Spain	-0.47	0.08	0.80	0.86	-1.91	2.77	-0.32
Great Britain	-0.14	-0.17	-0.28	-0.05	-0.08	-0.10	-0.03
EU-11	-0.08	-0.05	-0.04	0.02	-0.14	0.16	-0.04
Rest of World	-	-	-	-	0.16	-0.14	-

	After Tax Real Wage Rate [%]	*Non-Labour Income [%]*	*Permits Price [ECU/t SO_2]*	*SO_2-Reduction PP [%]*	*national SO_2-Reduction [%]*	*SO_2-Depositions [%]*	*Deviation from Oslo Depositions [%]*
Belgium	-0.01	-0.05	1,419	34	13	-14	23
Germany	-0.17	-0.70	1,419	19	10	-7	20
Denmark	-0.17	-0.52	1,419	12	8	-12	27
France	-0.04	-0.24	1,419	40	11	-10	8
Greece	0.02	0.95	1,419	59	42	-14	-8
Ireland	0.09	0.20	1,419	44	6	-23	16
Italy	-0.06	-0.39	1,419	27	12	-7	6
Netherlands	-0.07	-0.22	1,419	35	19	-15	28
Portugal	0.27	1.64	1,419	44	17	-33	-30
Spain	0.83	7.52	1,419	56	38	-32	-29
Great Britain	-0.37	-0.59	1,419	44	29	-25	17
EU-11	-	-	1,419	42	24	-17	5
Rest of World	-	-	-	-	-	-	-

Scenario 2: Coordinated EU-wide permits scheme

Source: KOSCHEL et al. (1998). PP Power Producers.

Note: The emission reductions to be realized by the electricity sector via the permit scheme cover only a part of the total national obligations given by the Oslo Protocoll. Hence, the figures presented in the last column of the table (deviation from Oslo deposition) imply that those emission reductions that have to be undertaken by other sectors (and other instruments) are realized with certainty. However, the impacts incured by these ‘non-electricity’ efforts are not considered in the figures of the table.

4 Lessons learned from the United States

Experiences with tradable permits in pollution control were already gained in the United States. The Regional Clean Air Incentives Market (RECLAIM) was implemented in 1994 in the region of Los Angeles; the Acid Rain Program (ARP) started in 1995 on a national scale.[12] Both programs can be classified as UDP-schemes. The ARP sets limits on SO_2-emissions from fossil fuel-fired power plants. The program has a broad range as power stations account for roughly 66 per cent of SO_2-emissions in the U.S. (OECD 1997). RECLAIM establishes caps for emissions of SO_x and NO_x from industrial companies emitting more than 4 tons of either pollutant.

The question raised in this section is whether the two programs established liquid and functioning markets that send out stable price signals. As explained in Section 2, this is a necessary condition for the emission permits approach to develop its full potential as a cost efficient environmental policy instrument.

After eliminating the distorting effect of permits bought by an environmental group, KOSCHEL et al. (1998) calculate for RECLAIM a trading volume of 2% in SO_x permits in the first year - a very low figure. Information on volume and prices in auctions and in bilateral trade is limited for RECLAIM. But the given data indicate that prices are developing unsteadily and are far below the level estimated before the program started. Permits dated 1994 were estimated at 577 US$/ton SO_x before the program started (ZAPFEL 1996, p. 40), whereas the actual average price for this vintage is 13 US$/ton SO_x (SCAQMD 1996, pp. 29,31). Prices for actual vintages are even lower according to recent information of one of the two broker firms (CANTOR FITZGERALD 1998). All this leads to the conclusion that traded volumes are too low to enable a steady movement of prices.

In the ARP, following a period of relatively low prices in early 1996, allowance prices have since risen and are now on a stable path, as can be seen from Figure 3. From the beginning, prices were lower than expected, as Figure 4 demonstrates. Despite low permit prices, the volume of trade in ARP lies below the initial estimates. WINEBRAKE et al. (1995) for example estimated a volume of 30 per cent. KOSCHEL et al. (1998) calculate an attained volume of 17 to 24 per cent, and SCHWARZE (1997, p. 174) 15 per cent.

[12] cf. for ARP WASMEIER (1992), ENDRES/SCHWARZE (1994), and MOSTAGHEL (1995), and for RECLAIM COHEN (1993), BADER/RAHMEYER (1996), FROMM/HANSJÜRGENS (1996,) and SCAQMD (1996, 1997).

Only if markets of tradable permits are liquid and prices show steady movements can the cost savings of a permits approach, in comparison to the traditional EU-command and control policy, be exhausted. Some scepticism about RECLAIM seems to be reasonable in this respect, whereas under ARP the development of prices points to a functioning market. Besides, trade volumes are growing steadily in both programs[13] indicating an increasing acceptance of the tool 'permits trading'.

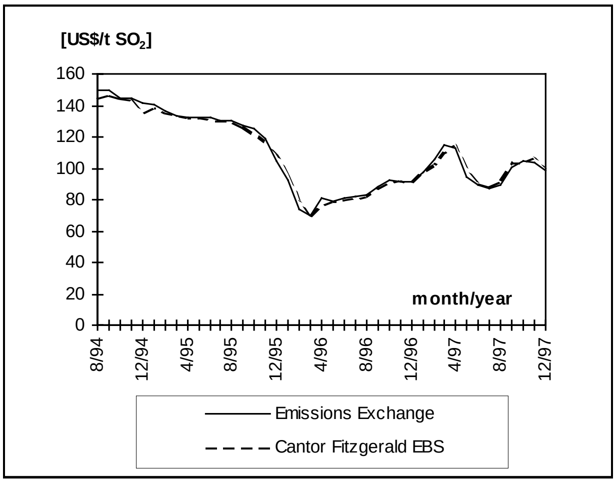

Figure 3: Monthly average SO_2-allowance price under the ARP

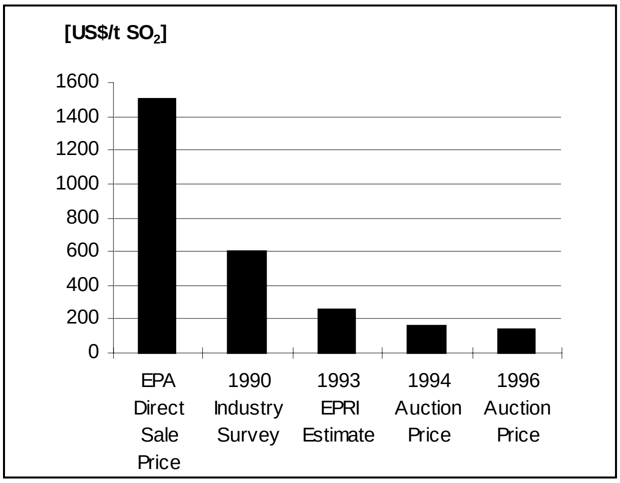

Figure 4: Estimated and realized SO_2-allowance prices under the ARP

Source: U.S. EPA (1996, 1998b).

In order to learn from the U.S. about an appropriate European SO_2-permits scheme, it is necessary to scrutinize the possible reasons for low volumes of trade and erratic or unexpectedly low prices. Definite conclusions regarding the reasons cannot be made yet because of the early program phases. Nevertheless, some preliminary thesis can already be put foreward.

- One reason for "unexpectedly low" prices seems to be the fact that under the predominant policy of command and control, the companies had an incentive to overestimate the abatement costs. Not only does this create a discrepancy between estimated and actual values, but also exerts influence on actual values, as SCHWARZE (1997, p. 177) points out. Emission sources which relied on the distorted information took early action in the form of technical options, as permits trading seemed a too expensive alternative.

[13] cf. U.S. EPA (1998a) for ARP and CANTOR FITZGERALD (1996) for RECLAIM.

- A second reason is that the dynamic efficiency of the permits market was underestimated, i.e. the potential of innovation and the resulting long-term cost reductions of a permits scheme.[14] This again raises the attractivity of technical options.
- The incentives of the permits scheme may have been superimposed by other national and state environmental policy measures. For example, some states established emission limit values for existing or 'best available technology'-prescriptions for new power plants. Also, regulations for particular matters may imply a significant reduction of SO_2-emissions, too (SCHWARZE 1997, pp. 180-181).
- In addition, low prices may be attributed to the generous placing of excess allowances[15] as well as to the relatively generous initial allocation of permits to the companies concerned, which go beyond the real need.[16]

All four factors diminish net demand and raise net supply of permits so that prices will fall. But they do not explain why the trade volumes were lower than expected. Theoretically, volumes may rise, fall or be constant. Two reasons why volumes may be low are:

- Transaction costs may reduce the willingness to pay of potential buyers and the claims of potential sellers (cf. STAVINS 1995 and DOUCET/STRAUSS 1994, p. 766).
- The incentives of the permits scheme may have been superimposed by non-environmental policy measures. For example, cost recovery rules for power producers imply that profits from selling permits have to be passed on to consumers. In addition, at least in Phase I of ARP, power producers may be concerned that they themselves would have to bear the risk that decisions concerning permit transactions might not be acknowledged under the Prudent Investment Test (KOSCHEL et al. 1998).

In both cases, prices will fall while the development of equilibrium volumes is undetermined. All six aspects seen together can explain the phenomenon of low prices *and* quantities observed under the Acid Rain Program.

To summarize, RECLAIM tells us that small markets and a too generous initial allocation of permits may lead to an erratic development of permit prices. In contrast, the ARP can be valued as being a successful, practicable implementation of the idea of emission permits for the pollutant SO_2. The volume of trade is lower than expected but sufficiently high enough to generate a steady and stable price signal.

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[14] In the ARP, this process was supported significantly by deregulation in the gas industry and in the transport sector (ELLERMAN/MONTERO 1996, p. 5).

[15] Under the ARP (cf. CONRAD/KOHN 1996, pp. 9-10).

[16] Under the RECLAIM (cf. BADER/RAHMEYER 1996, pp. 68-69).

The relatively low permit price is not so much a sign for a non-functioning of the market as a hint to its dynamic efficiency we expected from the theoretical results. Abatement options start to compete, as we see from the fact that fuel blending techniques have been improved considerably and prices for flue gas desulphurisation facilities dropped by 50 per cent since 1989 (BURTRAW 1996, p. 89, and FEDER 1996).

In order to establish a European permits scheme that helps to realize the ceilings of the Protocol of Oslo in a manner that is cost efficient in the short term as well as in the long term,[17] we learn that

- Markets for tradable permits should not be too small.
- The initial allocation of permits must not be too low.
- Transaction costs should be kept low.
- A superimposition of the scheme by other environmental or non-environmental regulations has to be avoided, e.g. 'best available technology' prescription must be eliminated, and emission values have to be abolished or frozen at a moderate level.
- Sectors under pressure should not be assisted by excess allowances but rather by other instruments (e.g. financial transfers).

Finally, one yet neglected aspect shall be mentioned, as it gives us additional insights about the successful implementation and design of a permits scheme. CONRAD and KOHN (1996, p. 6) state that information about the magnitude of possible cost savings as well as the choice of the grandfathering procedure were decisive factors in both the RECLAIM as well as in the Acid Rain Program in order to raise the acceptance of permits trading by the affected sources.

5 The technical and economic setting in Europe

Big thermal power plants in Germany, Belgium, Austria and Finland are already fitted with flue-gas desulphurisation processes to a high degree. In Greece, Portugal, France, Italy, Sweden, Ireland and the Netherlands more than 50 per cent of the installed capacity is based on low sulphur fuels. A low coverage of plants with end-of-pipe sulphur control technologies can be recognized for Greece, France, Portugal and Denmark (between 40 and 50 per cent of the net capacity), as well as for the United Kingdom and Spain (between 80 and 90 per cent). All in all, there is a high

[17] Note that fully functioning permits markets are estimated to bring along cost savings of 40 to 60 per cent for ARP (according to studies of the U.S. Government Accounting Office cited by ZAPFEL, 1996, p. 24, and of ICF Resources Inc. cited by RICO, 1995, p. 120) and about 30 per cent for RECLAIM (cf. KOSCHEL et al. 1998, based on BADER/RAHMEYER 1996, p. 64), compared to command and control measures.

potential for SO_2 emissions reductions in EU-15 electricity production. A big share of existing plants (representing 31 per cent of total net capacity) has no control technology. Another 28 per cent of the capacity is presently fired with gas or other low sulphur fuels and could be combined with additional control technologies (own calculations based on data from EURELECTRIC 1996).

Out of a broad range of established options to curb SO_2-emissions, fuel switching from high sulphur to low sulphur fuels is the less expensive option. But it does not allow for as high degrees of emission reduction as many emission control technologies do. Lime/limestone wet scrubbing for example, the most commonly used flue gas desulphurisation process in Europe, offers a desulphurization rate of more than 90 per cent. Future SO_2-emission reductions according to the Protocol of Oslo will have to go beyond fuel switching or fuel cleaning towards integrated or end-of-pipe solutions in many countries. Installing one of the main emission control technologies will raise power production costs 4 to 14 per cent. But, the costs depend decisively from the size of the emitting unit. Integrated control options - like fluidised-bed combustion with a dry additive for SO_2-removal fed directly into the boiler - are competitive for plants up to a capacity of 250 MW_e. Above this threshold standard, end-of-pipe emission control technologies are less expensive (OECD 1993).

An analysis of the economic setting reveals that a European SO_2-permits market for public utilities would be characterized by a sufficient number of agents. A grandfathering procedure would result in a distribution of emission permits, where 18 public utilities cover approximately 78 per cent and 39 public utilities approximately 92 per cent of all permits (KOSCHEL et al. 1998). Nonetheless, the number of agents seems small enough to keep transaction costs of measuring emissions and supervising the agents low. The figures indicate conditions at least as good as those in Phase I of ARP.[18] All in all, market imperfections in the form of "cost-minimizing manipulation" or "exclusionary manipulation", mentioned on Section 2, are not probable.

Only with full information about the site-specific marginal abatement costs can the question of the potential trading volume under the proposed scheme be answered precisely. The general equilibrium modelling calculations made for public utilities in EU-11 indicate that a share of 31 per cent of all permits may be traded (KOSCHEL et al. 1998). As alredy mentioned, for ARP as well, a volume of 30 per cent had been

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[18] Fossil fired combustion plants participating in Phase I emitted 8,7 million tons SO_2 in 1990, whereas public power producers in EU-15 emitted 8,6 million tons SO_2 in 1990. Phase I of ARP originally covered 111 ‘dirty’ plants with altogether 263 units. The proposed European scheme for power producers would comprise 476 power plants with 671 fossil fired units.

estimated, while in the years 1995 and 1996 only approximately 17 to 24 per cent were realised. Nevertheless, as can be seen from Figure 3, this volume is enough to guarantee a steady development of prices and thus the functioning of the permits market.

The degree of competition in the European national electricity markets differs, but is generally low. Even though we can observe in almost all countries efforts to liberalize the markets, there are still enough distortions to enable most national power producers to pass on the costs of permits or of a new emission control facility to their customers without a major risk of losing market shares or to reduce profits. This situation does not impair the functioning of the permits markets, but implies different cost burdens to different producers. And by that, the effect observed in the previous section may be intensified in particular countries: If within a European permits market power producers reduce more than under a national scheme, and if they operate in monopolistic or oligopolistic national energy markets, the national economic losses will even be higher than under competitive markets. Or, in countries with liberalized energy markets, the danger that a European permits scheme raises economic losses for the whole economy is reduced.

6 A European SO_2-emissions trading scheme

In this section, a concrete SO_2-emissions trading scheme for public utilities is elaborated, based on the previous sections' findings. Public utilities were chosen as addressees of the proposed scheme in order to achieve a certain degree of simplicity in the early phase of the program. They cause approximately 30 per cent of all anthropogenic SO_2-emissions in the EU-15 region. Other sources are intended to join the scheme in a later phase.

There are several principles underlying the scheme's design:

- A functioning permits market needs a sufficient number of agents and a sufficient volume of trade.
  This principle led to the selection of a system of undifferentiated emission permits (UDP) which provides the possibility of banking.
- The mode of the initial allocation should allow for early price signals, in order to make full use of the instrument's potential to discover static and dynamic efficiency gains.
  Consequently, and considering the vested interests of existing emission sources, a long-term transition from a mode of grandfathering to the mode of a free auction was chosen for the initial allocation ("limited grandfathering").
- All mechanisms should be simple and reasonable in order to improve the confidence in the effectiveness of the system.
  Therefore, it is necessary that the emission reduction path (i.e. the number of present and future permits) as well as all rules governing the permit trade are fixed

definitely and in advance, in order to guarantee long-term planning security for all agents involved.

- The maximum capture of the cost-savings potentials involves ecological risks. The limitation of the risks of hot spots must be assured by a catalogue of optional measures with different degrees of intensity of intervention.
  Size and point in time of the intervention have to be chosen in a manner which restricts the degrees of freedom of as few economic agents as possible, and only as far as it is necessary for ecological reasons.

During the scheme's conception, the Acid Rain Program functioned as a model. The major differences lie in the long-term transition in the initial allocation of emission permits from grandfathering to an auction and in a broader set of options to avoid hot spots. The details of the proposed scheme are sketched in the following (for a summary see the Appendix).

As the model shall be obligatory for all EU-15 countries, it is necessary to set up a single *European certificate agency*. A structure should be chosen for the certificate agency, which is divided into an administration unit and an emission council. The emission council would be authorised to initiate measures which keep the permits system functioning, such as measures to counteract possible hot spots, or measures for the fine tuning of the market. The administration - which may be a private company - will manage the "daily business" of the permit trade, of booking, and so on.

As *criterion for the initial allocation* of the permits, the product of fuel consumption and an emission factor typical for this fuel will be selected. An assignment according to the actual emissions is rejected, because "pioneers" of emissions control would be penalized by a low assignment. The emission factor will have to be *inter*nationally differentiated. This is necessary for two reasons. First of all, the national emission ceilings of the Protocol of Oslo differ from each other. Second, each country is going to select a different contribution of its public utilities to the overall national reduction target in order to minimize national reduction costs.

*Intra*nationally, a single emission factor for each fuel should be applied to all national public utilities. A differentiation into different fuels is necessary, as, for example, gas has a significantly lower sulphur content than coal. If such a differentiation did not take place and an average value for all fuels was chosen, the allocation of permits would be unrealistically low for coal-fired and unrealistically high for gas-fired plants. A differentiation in terms of a high or low sulphur content in coal, oil or gas is denied. Regarding desulphurised fuels, again the "pioneers" would be penalized. A differentiation according to the natural sulphur content is rejected because it would imply a lower potential volume of trade: The initial allocation would closely adapt to the actual need, and for any plant the average demand with respect to the supply of permits would decrease.

Legal construction: The permits assign the right to discharge one ton of SO_2 in a stated year; banking is allowed, but emission debts will not be granted. The permits are freely tradable, the owner can keep them, sell them, lease them, or may give them away. Should one of the utilities shut down a plant, it definitely keeps the permits assigned to it for the years coming. A withdrawal of the permits if a plant is closed down would give an incentive to delay an investment into modern and ecologically friendly technologies. In contrast, the continuing validity of the permits for future years creates an incentive to replace old plants earlier than planned. Banking, too, may give similar incentives which in the case of SO_2 are meaningful from the ecological point of view. In the Acid Rain Program we can observe that banking led to overcompliance in Phase I, in 1996 SO_2-emissions stayed 35 per cent below the legal level (U.S. EPA 1998d).

In order to hand over the control and reduction of emissions to the permits scheme, all *emission standards* for existing plants or units have to be frozen on a status quo basis. In particular, all dynamic standards have to be either anulled or substituted by explicit standards. New, more strict standards, including those of Annex V of the Protocol of Oslo, should not be introduced as they constrict the scope of the permits scheme.

In consideration of the traditional patterns of using the environment, and in order to avoid abrupt changes, the *initial allocation procedure* of grandfathering is chosen. This principle is going to be broken moderately at two points. On the one hand, in the first years a small amount of approximately 3 per cent of all permits is distributed by the central certificate agency through auctions and fixed price sales and is not booked on the accounts of the public utilities. On the other hand, the initial allocation of permits to existing sources covers only the expected remaining regular lifetime of the respective plant type. To reach a higher acceptance, a generously defined "regular technical lifetime" of a plant must be considered. It seems adequate to take a value of 35 to 40 years. The reasons which support this procedure of a *limited grandfathering* trace back on the one hand to distributional aspects and aspects of competition, and on the other hand to aspects of the functioning of the permits market. In the first place, the transfer of capital to the existing sources, which is connected with the grandfathering of tradable permits, should be minimised, otherwise a distributionally not justifiable preferential treatment of existing sources vs. newcomers would take place. Secondly, in order to promote competition in the energy market, it is useful to provide for a long-term rise of the share of permits which can be auctioned; this makes it easier for new sources to purchase permits. A third argument is that a long-term growing amount of auctionable permits improves the price signals which come from each auction.

It is important for the achievement of the ecological targets that the permits, which rest at the agency because of the limited grandfathering, will not stay there, but will be distributed to new and old sources by spot and advance auctions. Only in this way will the emission reduction path announced at the beginning of the program be met. In a system of limited grandfathering, a rising share of permits stays with the certificate agency the longer the program runs, because more and more old plants exceed the regular technical lifetime. As just mentioned, these permits will be recycled to the agents via auctions in order to maintain the announced emission reduction path. At these auctions, growing revenues will be achieved during the years. They can be used for the coverage of the administration costs of the certificate agency and for adjustment programs for extremely affected plants, sectors or regions and countries, as well as for a reserve pool for the fine tuning of the permits market.

The auctions should be carried out by an established *stock exchange*, which has experiences with futures markets, in the order of the certificate agency. Because of the European context, one of the more important European stock markets should be selected as the main stock exchange. Other parallel stock markets should be excluded in order to maximize the market volume, liquidity and efficiency of the main market place. One may consider the establishment of an automatic computer-supported stock exchange, because of the greater possibility of small frequency of trade in permits in comparison to other futures markets.

In the U.S. *bonus permits* were used as an effective instrument to avoid too much friction. JOSKOW and SCHMALENSEE (1996) state that ARP excess allowances helped to reduce political resistance, in particular from the side of the coal states in the Middle West characterized by relatively old power plants. It is possible that such a need for political cushioning also comes up in the heterogeneous economic landscape of the EU-15 countries. But, other than in the U.S., this need should not be managed via special and additional assignments of permits, but via other instruments, such as financial transfers. A too generous allocation of permits bares risks concerning the functioning of the permits market.

The binding prior announcement of the emission reduction path and the distributed permits are major parts of a permits policy which is orientated towards planning security and, therefore, towards functioning and efficiency of the permits market. For the same reason, an ongoing *rough tuning* of the volume of circulating permits is not planned; it would impair the planning security of the public utilities considerably. But it could well be that due to progress in natural sciences, the emission ceilings decided in Oslo could mean a fall below, or an exceeding of, the emission ceilings now considered necessary. Such a unique rough tuning is acceptable, but one should take the vested interests of the public utilities into consideration. For example, it could be decided that rough tuning can only be implemented as part of new negotiations of the Protocol of Olso or via a decision of the Council of Ministers.

A permits system can only correspond to the receptor-oriented approach of the Protocol of Oslo if *precautions against hot spots* are taken. This need can be found in Art. 2 (1) of the Protocol, which admittedly does not set binding measures to avoid hot spots, but asks for long-term containment of the critical loads. One can imagine different measures in this context, which to a certain extent add up to the permits system without destroying its basic flexiblity and still look useful to avoid hot spots:

1. Promotion and extension of the estimative capability of existing monitoring systems about the effects of acid rain in critical regions.
2. Documentation of all permit transactions and emissions of "critical sources" (power plants whose emissions may contribute to a hot spot problem).
3. Obligation to register for all bilateral permit trades.

This set of informational instruments establishes an early warning system for hot spots and prepares adequate countermeasures. If it indicates the emergence of hot spots, out of the following spectrum of instruments the one should be selected with the lowest intensity of intervention and which least interfers in the mechanisms of the permits market. The instruments are command and control measures, but, different from former policies, they will be implemented on a case by case basis only for single "critical sources" and only as long as the hot spot problem goes on.

4. Integration of an assessment of risk concerning the effects on imissions into the approval procedure for new sources in regions where emissions cause a major problem.
5. Permit trade restrictions for "critical sources" (concerning trade with less "critical" sources, or, ultimately, even trade among themselves).

Measure 4 is more of a preventive nature, whereas the 5th Measure is put into action. But, the precondition is that these limitations, which mainly concern the spot market and the spot auction, are accompanied by preparatory informational measures concerning all market transactions taking place earlier (bilateral and organized futures markets and advance auctions). Consequently, this Measure must be linked to Measure 2.

In case the previously shown instruments are not sufficient to avoid the appearance of hot spots, ultimately, one has to fall back on a short term and restrictive command and control instrument:

6. Restrictions in the validity of permits held by "critical sources".

A bubble within this group should be allowed. But ultimately, the affected "critical sources" will have to implement technical solutions to restrict emissions. Within the traditional command and control approach, this option is compulsory for all sources and from the beginning. The proposed permits scheme just takes it as a "lender of last resort" and thus offers a considerably higher degree of flexibility.

7 Conclusions

This paper examines theory and experiences with SO_2-permits trade and proposes a practicable scheme of SO_2-emission permits for European power producers. A main finding is that considering the setting in the EU-15 countries, the proposed scheme of undifferentiated emission permits seems to be economically advantageous. But, there is an inherent conflict between ecological effectivity and economic efficiency in a UDP-scheme. Due to the missing differentiation regarding the receptors compared to other emissions trading schemes, the risk of hot spots increases in the short run. On the other hand, this risk is lower in the long run, as the cost efficiency of this type of scheme facilitates the enforcement of new and ambitious emission reduction plans in the future.

The ecological risks of the scheme seem to be justifiable and should be accepted, in order to make full use of the gains in static and dynamic efficiency. Nevertheless, a differentiated bundle of measures counteracting possible hot spots should take a central role within the practicable scheme proposed in this paper. The use of the measures should be graded according to their intensity of interference in order to keep the degrees of freedom for all agents in the market as high as possible.

The cost saving potentials - a lesson learned from the American experience - of an EU-wide permits scheme may increase the acceptability on the side of the public utilities and may thus contribute to an acceleration of the decision making process. The simplicity and the high practicabilitiy of the proposed scheme will support this process, too.

The mode of primary allocation of permits should allow for early price signals, in order to make full use of the instrument’s potential to discover static and dynamic efficiency gains. Under additional consideration of the vested interests of the existing emission sources, a long-term transition from a mode of grandfathering to the mode of a free auction was chosen in the proposed scheme. This "limited grandfathering" is implemented by a primary allocation of permits to existing sources which only covers the expected remaining regular lifetime of the respective plant type.

Two scenarios of a set of non-coordinated national permit systems and of a EU-wide (EU-11) tradable permit system were simulated using the applied general equilibrium model GEM-E3. The computed variation in the rates of all aggregated macroeconomic variables caused by an emission permits scheme in EU-11 lies in both scenarios generally within a range of ± 0.5 per cent. In particular, the potential seller countries of permits bare the risk of (small) losses, in terms of GDP, as a sectoral permits system only allows for the minimization of the sectoral costs (of public utilities). The revenues from selling permits to other countries do not necessarily cover all national costs arising from the higher degree of emission reduction in an EU-wide scheme. The purchasing countries shift a part of the emission reduction costs on the selling countries. Therefore, a financial compensation mechanism compensating the divergent national costs of the scheme should be taken into consideration. This scheme would also allow for an inter-country compensation of the deviations of the actual national emissions (realized under the scheme) from the levels fixed in the Protocol of Oslo.

Appendix: A European SO_2-Emissions Trading Scheme for Public Utilities

<table>
<tr><td>addressees</td><td colspan="2">- large combustion plants in the EU-15 countries
- opt-in for industrial power plants and production processes with combustion
- extension to Middle-East- and East-European countries in the long-run</td></tr>
<tr><td>permit design</td><td colspan="2">- locally undifferentiated discharge permits, dated for a specified year
- unrestricted banking for all years and phases
- no emission debts</td></tr>
<tr><td>assessment basis</td><td colspan="2">- SO_2 emssions to be monitored by continuous emission monitoring systems</td></tr>
<tr><td>criterion for the initial allocation</td><td colspan="2">- product of fuel consumption and an emission factor typical for the fuel used
- internationally differentiated emission factors
- intranationally a single emission factor for each type of fuel</td></tr>
<tr><td>legal construction</td><td colspan="2">- right to discharge one ton of SO_2 in the stated year
- permits are not discounted
- free permit trade (buy, lease, rent, or give away)
- if a plant is shut down before the end of its regular technical lifetime, the owner keeps the rest of the permits assigned (even those dated for future years)</td></tr>
<tr><td>procedure over time</td><td colspan="2">- preparatory phase before start of program, incl. advance auctions and bilateral trade
- constant yearly permit allocation for all years of each phase
- dynamics by establishing two phases with different overall emission levels</td></tr>
<tr><td>emission standards for existing plants or units</td><td colspan="2">- all emission standards are set on a status-quo basis
- all dynamic standards are either abolished or substituted by explicit standards
- new standards, including those of Annex V of the Protocol of Oslo, should not be introduced. At least, the standards of Annex V should be postponed from July 1st, 2004 to the starting date of Phase II</td></tr>
<tr><td>emission standards for new plants</td><td colspan="2">- are to be omitted or to be formulated explicitly and moderately</td></tr>
<tr><td rowspan="4">initial allocation mechanism</td><td colspan="2">Limited Grandfathering
- grandfathering for existing plants before start of program for the defined regular technical lifetime; the liftetime is defined generously
- 3 per cent of the initial allocation is kept as reserve for auctions and fixed price sales as long as the agency itself does not dispose over a sufficiently large number of permits</td></tr>
<tr><td colspan="2">Stock-Exchange Auctions
- in the long run the share of permits initially allocated by auction rises, as for late years the certificate agency disposes over a larger number of permits remaining at the agency due to the system of limited grandfathering
- zero-revenue auction if permits have been cut off from the sources’ initial allocation</td></tr>
<tr><td>Spot-Auction
- permits dated for the present year
- once or twice a year
- approximately 0,6 per cent of a year´s permits</td><td>Advance-Auction
- permits dated for future years
- 4, 5, and 6 years in advance
- at least approximately 0,6 per cent of each year´s permits
- permits resting with the agency due to limited grandfathering are to be added</td></tr>
<tr><td>Direct Sales from Fixed Price Sales Reserve
- approximately 0,5 per cent of each year´s permits
- a fair part of the revenue from those permits that were cut off from existing sources is redistributed to them</td><td>- no fixed price sales of permits dated for future years</td></tr>
</table>

Appendix, continued: A European SO_2-Emissions Trading Scheme for Public Utilities

secondary allocation	*Bilateral Trades* - informally by brokers or via stock-exchange *Spot*: - presently valid permits *Futures*: - permits valid in future years - futures and options
choice of stock market	- existing stock exchange experienced with futures - large European stock exchange as central stock exchange; no parallel stock markets - possibly automatic computer-supported stock exchange
monitoring	- continous emission monitoring systems - spot checks
enforcement	- automatic enforcement - fee of approximately 1,500 ECU per ton SO_2 not covered by permits - corresponding number of permits is subtracted from the next year´s allocation
balance period	- one year - those months with extreme peaks or fluctuations in electricity production are not to be set at the end of the period
compensation for countries and sectors	- no bonus permits for sectors severely hit; other instruments to cushion too much friction, such as financial transfers - no bonus permits for countries suffering an additional economic burden from an EU-wide scheme; instead scheme for financial compensation
rough tuning	- no ongoing rough tuning by the central agency - an additional reduction of allocated SO_2 permits only when taking into account the plants´ vested interests and only as part of new negotiations of the Protocol of Oslo or via decision of the Council of Ministers
fine tuning	- done by the certificate agency - aiming at stable prices and a stable market volume when supply bottlenecks, speculative tendencies and other misdevelopments in the permits market occur - open market operations, no discount rate policy
avoiding hot spots	- various instruments with different intensity of intervention 1. promotion and extension of the estimative capability of existing monitoring systems about the effects of acid rain in critical regions 2. documentation of all permit transactions and emissions of "critical sources" 3. obligation to register for all bilateral permit trades 4. integration of an assessment of risk concerning the effects on imissions into the approval procedure for new sources in regions whose emissions cause a problem 5. permit trade restrictions for "critical sources" 6. restrictions in the validity of permits hold by "critical sources". A bubble within this group should be allowed - in order to reach an identified ecological target, the instrument having the lowest intensity of intervention and interfering least with the functioning of the permits market is chosen

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