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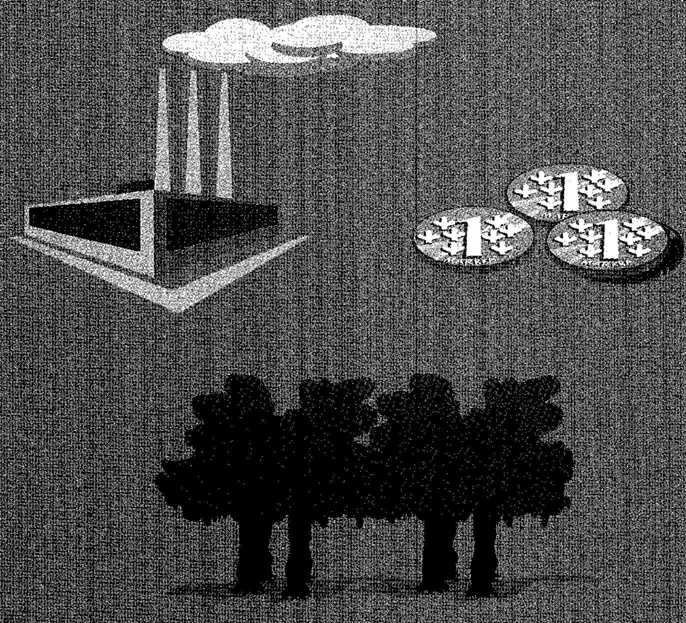
PROCEEDINGS OF THE WORKSHOP ON ECONOMIC INSTRUMENTS IN ENVIRONMENTAL POLICY

Edited by
Seppo Leppänen *Pirkko Valppu*



VALTION TALOUDELLINEN TUTKIMUSKESKUS
Government Institute for Economic Research

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ABSTRACT: Different aspects of the use of economic incentives in environmental policy are dealt with in four papers that were presented in the workshop arranged by the Government Institute for Economic Research on the 9th of November 1990. Jean-Philippe Barde presents definitions of economic instruments and describes recent trends in their use for environmental protection in OECD countries. In the paper by Ilkka Savolainen a model system is presented for the estimation of future SO_2 emissions in Finland. The model system is employed to find cost-effective emission reduction strategies under given sulphur deposition targets. Olli Tahvonen discusses the role different types of economic instruments like emission charges and emission trading might have in practical environmental policy. A model is presented to attain target sulphur deposition levels in Finland and nearby regions of the Soviet Union with minimum possible abatement costs. Tellervo Kylä-Harakka-Ruonala discusses the prerequisites and adequate preparations for the environmental charges from the point of view of industry.

KEY WORDS: Environmental policy, economic instruments.

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TIIVISTELMÄ: Taloudellisten ohjauskeinojen käyttöä ympäristöpolitiikassa käsitellään neljässä artikkelissa, jotka perustuvat Valtion taloudellisen tutkimuskeskuksen 9.11.1991 järjestämässä seminaarissa pidettyihin esitelmiin. Jean-Philippe Barde määrittelee taloudelliset ohjauskeinot ja esittelee niiden käyttöä viime aikoina OECD-maissa. Ilkka Savolaisen artikkelissa kuvataan Suomen tulevien rikkidioksidipäästöjen arviointimalli. Mallin avulla pyritään myös löytämään kustannustehokas päästöjen vähentämisstrategia, kun rikkilaskeumalle on määritelty tavoitearvot. Olli Tahvonen arvioi erilaisten taloudellisten ohjauskeinojen kuten päästömaksujen ja päästökiintiöiden kaupan merkitystä käytännön ympäristöpolitiikassa. Artikkelissa esitellään myös malli, jolla pyritään selvittämään, miten Suomen ja Neuvostoliiton lähialueiden rikkipäästöjä voitaisiin vähentää tavoitetasolle minimikustannuksin. Tellervo Kylä-Harakka-Ruonalan aiheena on ympäristömaksuille asetettavat vaatimukset ja niiden asianmukainen valmistelu teollisuuden näkökulmasta.

ASIASANAT: Ympäristöpolitiikka, taloudelliset ohjauskeinot.

FOREWORD

One of the central activities of the Government Institute for Economic Research is to arrange workshops concerning questions important to Finland. In addition to Finnish experts, leading foreign researchers are called upon to participate in the workshops. The main point of the workshops is to create a dialogue between experts from research institutes, universities and administration.

The workshop on economic instruments in environmental policy on the 9th of November 1990 was the first of its kind. The subject is very actual from both international and Finnish points of view. In this decade the role of the economic control mechanisms as a complement to the command and control measures will be emphasized in environmental protection. Wide spread environmental problems, cost-effectiveness and incitement of control measures as well as the need to permanently affect the behaviour of firms and consumers call for economic solutions besides the traditional command and control measures. In environmental protection, as in all economic activity, more and more responsibility for decision making will be delegated to the consumers and firms. With the assistance of economic control measures economic agents can be forced to seek for themselves the best solutions to decrease the emissions.

The workshop on economic instruments in environmental policy also spurred the work of a team of specialists from five Ministries. On behalf of the Government Institute for Economic Research I wish to thank all the speakers and those who took part in the discussions. I owe special thanks to the coeditor of this survey, Researcher Pirkko Valppu, for her conscientious work.

Helsinki, June 1991
Seppo Leppänen

CONTENTS

RECENT TRENDS IN THE USE OF ECONOMIC INSTRUMENTS FOR ENVIRONMENTAL PROTECTION IN OECD COUNTRIES

Jean-Philippe Barde[1]

When environmental policies were adopted in the late sixties and early seventies, the authorities, in most industrialised countries turned largely to regulatory controls, either by creating new regulations or by adapting existing ones. So called "economic instruments" were used in exceptional circumstances only and were subject to significant controversy and strong resistance in industrial, governmental and general public circles.

This situation has drastically changed over the last 10-15 years and is likely to further evolve rapidly in the future. The economic dimension of environmental policy is now widely recognised and most governments of OECD Member countries are strongly supporting the use of market based approaches for environmental protection. In June 1989, the Communiqué of the OECD ministerial Conference (annual meeting of OECD finance and foreign affairs ministers) asked that "*new grounds*" be broken in "*determining how price and other mechanisms can be used to achieve environmental objectives*". In May 1990, the Ministerial Communiqué asked the OECD "*to design guidelines for the use of economic instruments and other market mechanisms*". These "guidelines are being developed by the OECD and will be submitted to ministers of the environment of OECD countries when they meet on 30th - 31st January 1991).

The purpose of this paper is to briefly review this evolution in the use of economic instruments in environmental policy and to identify future trends.

1 WHAT IS MEANT BY ECONOMIC INSTRUMENT IN THE OECD CONTEXT

It is important to give a precise definition of an economic instrument (EI) particularly because in the recent environment literature, references are made to "market based approaches" or "market instruments" which encompass a mix of policy instruments designed to influence producers' and consumers' behavior (e.g. product labelling or strict liability rules). EIs provide market signals in the form of a modification of relative prices (e.g. taxation on certain products) and/or a financial transfer (payment of a charge). An important feature is that EIs leave freedom of choise to economic agents such as polluters who can select the most advantageous solution i.e. in case of pollution charges, paying the charge of investing in pollution control.

Hence, this survey covers three main categories of EIs:
- All types of environmental charges or taxes.
- Marketable permits.
- Deposit refund systems.

Subsidies also constitute a type of EI which can be environmentally effective, although economically inefficient in the long run and, except in certain cases, incompatible with the "Polluter Pays Principle". This is not a new approach and will only be alluded to.

A differentiation also needs to be made between "charges" and "taxes" although both words are often used indifferently. The difference lies in the affectation of revenue: in the case of charges, the revenue is affected to special funds and can be earmarked for environmental purposes (e.g. charges collected and managed by river basin agencies); in the case of taxes, the revenue is paid into the general government budget with no a priori earmarking.

EIs comprise a number of intrinsic qualities:

- **Cost effectiveness:** When fixed at a proper level, emission charges (for taxes) ensure the achievement of objectives at minimum overall cost (by equalising marginal abatement costs at the level of the charge rate). Marketable permits also lead to minimum cost situations.

- **Incentive:** EIs are a permanent incentive for "environment friendly" behavior. In particular, emission charges are a permanent inducement to abate pollution as long as a payment is made. They also encourage technical change through the research and development of more effective pollution control technologies, "clean" production processes and new non polluting products.

- **Flexibility:** EIs provide flexibility both to public authorities and private entities; for the former, it is easier to modify and adjust the rate of a charge than to change regulations; for the latter, freedom of choice and adjustment is preserved.

- **Revenue raising:** Charges are a source of revenue which can be used for environmental protection or, in the case of taxes, allocated to the general government budget.

- **Resource conservation and transmission:** Pricing environmental resources is an essential component of a sustainable development path and should ensure an efficient use of these resources and their transmission to future generations.

2 MAIN FEATURES OF THE PRESENT SITUATION IN OECD COUNTRIES

2.1 Past and present trends

As mentioned before, when environmental policies started in the early seventies, the "command and control" i.e. regulatory approach was almost exclusively used although economists were already making a strong plea for the economic approach, but other concerned parties were almost unanimously opposed to it.

Industry was opposed, in particular to pollution charges, mainly on the grounds that they would entail additional constraints and financial burden. Industrialists were also fearing that EIs would reduce their bargaining power vis à vis public authorities (there is more room for negotiating a permit than the payment of a charge).

Governments were also reluctant as it was assumed that EIs would in fact restrain their control over polluters, a control that could be better enforced through the traditional command and control system.

The general public, finally, was also opposed because charging for pollution was considered as "purchasing the right to pollute". There was also in "green" circles a general contention that as market mechanisms were the very cause of environmental degradation, they should not be used for environmental protection.

One can say that, to a large extent, this debate is now obsolete. Industry realizes that EIs are cost minimising devices, can ensure a better cost sharing and leave maximum flexibility in adaptation. There is still, however, reluctance to pay charges. Governments, faced with growing demand for better environmental quality and increasing complex issues, are striving for more efficient policy tools and additional financial means. Generally speaking, direct regulation of societal processes seems to have reached a level of decreasing efficiency resulting in calls for "deregulation" or for regulatory reforms. In fact, the enforcement of regulations itself turns out to de difficult, costly and, in many cases, insufficient. Finally, public awareness about these concerns and successful experiences in some countries has, to a large extent, weakened the opposition to market mechanisms.

As a matter of fact, the situation in OECD countries evolved considerably over the last 10-15 years. In the mid seventies, EIs were used in very rare instances except in a few significant cases like the water management systems in France and the Netherlands, which rely heavily on waste water pollution charges. A recent OECD survey[2] shows that the situation has drastically changed over the last ten to fifteen years: In fourteen OECD countries, 150 cases of EIs were identified (including subsidies) out of which 80 were environmental charges. Furthermore, since the publication of this study, the situation has continued to evolve and a number of countries have implemented or are intending to introduce a number of EIs. This is particularly true for Nordic countries (Denmark, Finland, Norway, Sweden) were a number of "product charges" have been introduced (e.g. on fuels, fertilizers, pesticides, CFCs). Other countries like France, The Netherlands, Germany and Italy have announced plans thereon[3].

The present trend can be characterised by five main features:

(i) Presently, almost all countries are introducing EIs or are contemplating to do so.

(ii) The focus is rather on product than emission charges or taxes.

(iii) The issue of "eco taxes" is becoming more and more relevant, in particular in the framework of fiscal reforms taking into account the environment.

(iv) New EIs are increasingly designed for incentive rather than for revenue raising purpose.

(v) In fact of the growing concern about international environmental problems such as global warming, transfrontier pollution flows and preservation of natural assets, the role EIs might play is becoming more and more topical.

2.2 Main characteristics of the present situation

The "state of the art" in the use of EIs can be characterised by five highlights.

1 - The existence of mixed systems

Past controversy about EIs was principally focussed on the issue of EIs *versus* regulation. In fact, the present situation is characterised by the prevalence of "mixed systems" where EIs are used as an *adjunct* to direct regulations. In such systems EIs complement regulation by providing additional incentive for pollution abatement and a source of revenue for financing environmental measures such as treatment of effluents, waste collection and processing etc.

The actual combination of EIs and regulations varies considerably between countries and according to the type of pollution. In some cases, EIs constitute the cornerstone of the policy (in particular, waste water charges in France, Germany and the Netherlands); in other instances, EIs only provide an additional financial incentive device (e.g. some types of product charges).

2 - A great variety of EIs and situations

The existence of a large number of cases where EIs are used in OECD countries covers in fact a great variety of situations. In some fields and in some countries EIs play a significant role, particularly for water and waste management.

EIs are gaining importance in air pollution abatement policies but remain weak for noise abatement, despite a great potential role. Table 1 gives an overview of the state of the art for environmental charges in OECD countries at the end of 1990.

Emission charges (i.e. payment on the quantity and quality of pollutant discharged) are the most commonly used instrument. They are applied in virtually all environmental fields and in all countries, although with varying intensity. Water effluent charges form the backbone of water management systems in France, Germany and the Netherlands but play a limited role in other countries. Waste charges are also quite common but with varying degree of sophistication and coverage. Noise charges are applied to aircraft in a few countries ranging from crude to more elaborated systems.

User charges (payment for the cost of collective collection and treatment facilities) are commonly used by local authorities for the collection and treatment of solid waste and sewage water. They are a purely financing device.

Product charges or taxes are applied to the prices of products which create pollution either as they are manufactured, consumed or disposed of. Examples are lubricants (France, Finland, Germany, Italy, Norway, the Netherlands), sulphur in fuels (Netherlands, Norway), fertilizers (Norway, Sweden), non returnable containers (Finland, Norway, Sweden), mercury and cadmium batteries (Norway, Sweden), base, i.e. "feedstock" chemicals (United States). Product charges or taxes are intended to modify the relative prices of the products and/or to finance collection and treatment systems.

Administrative charges are chiefly aimed partly or totally, at funding systems of licensing and license monitoring. Many countries apply them (see table), for example, in Norway a charge is levied on registering new chemical products.

Tax differentiation modifies the relative price of products by penalising those harmful to the environment. This is tantamount to product taxes but relies on existing tax structure rather than introducing new taxes or charges. For instance, the existing taxation of fuels is adapted to meet environmental objectives (higher tax on leaded petrol, higher tax on polluting or noisy vehicles).

As a matter of fact, charges, in particular product charges and tax differentiation, raise the issue of so called "eco taxes", i.e. of significant modification of the fiscal system to take into account environmental considerations. This raises other major issues such as the non neutrality of taxes and the budget neutrality of tax revenue, the imposition of new eco taxes being offset by reductions in existing taxes. This approach is now followed in Sweden, in the context of a major tax reform.

Marketable permits (also referred to as emission trading) are based on the principle that any increase in emission must be offset by a decrease of emission of an equivalent, and sometimes greater, quantity. For example, when a statutory ceiling on pollution levels is fixed for a given area, a polluting firm can set up of expand its activity only if its additional pollution emissions are nil, which is usually technically and/or economically impossible. The firm must therefore buy "rights" to pollute from other

Table 1. Charge systems in use (October 1990)

	Effluent							
Country	Air	Water	Waste	Noise	User	Product	Administrative	Tax Differentiation
Australia		X	X		X		X	
Austria		(X)	X			X		X
Belgium	(X)	X	X		X		X	X
Canada					X	X		X
Denmark			X		X	X	X	X
Finland	(X)	(X)	(X)			X	X	X
France	X	X	(X)		X	X		
Germany		X	(X)	X	X	X	X	(X)
Greece	(X)					X		X
Italy		X			X	X		
Japan	X			X				
Netherlands		X	X	X	X	X	X	X
New Zealand						X(1)		
Norway					X	X	X	X
Portugal	X	X	X		X	X		X
Spain			X		X		X	
Sweden	X(2)				X	X	X	X
Switzerland	(X)			X	X	(X)	X	
Turkey	X							
United Kingdom		X		X	X		X	X
United States				X	X	X	X	

X= Applied (X) = Under consideration
(1) = Will be introduced at 1.1.1992 (2) = Will be introduced at 1.1.1992
Source: OECD

firms located in the same control area which are then required to abate their emission by an amount equal to the additional pollution emitted by the new activity.

The objective of this approach is twofold: First, to achieve cost minimising solutions (by inducing firms high marginal abatement cost to purchase abatement from firms with low marginal abatement cost). Second, to reconcile economic development activity with environmental protection by allowing new activities to set up in a control area without increasing the total amount of emission with it.

This approach has been developed in the United States, mainly in the field of air pollution and provides substantial cost savings, although the implementation process seems complex and burdensome. Germany also intends to develop marketable permits.

Deposit-refund systems are also widely applied in OECD countries in particular for beverage containers.

3 - Limited incentive impact and predominance of revenue raising

Economists are making a strong plea for EIs as an economically efficient, i.e. cost minimising, mechanism. Marketable permits seem to meet this criterion. However, this is hardly the case for charges, simply because they are set at too low a level to induce polluters to abate their emission. This is why emission charges are mainly used primarily for revenue raising purpose. Hence, they are usually referred to as "financing" or "redistributive" charges, by contrast to "incentive" charges. Hence the effectiveness of the charge is linked to the earmarking of revenue for financing individual or collective pollution abatement facilities.

4 - Easy enforcement

The OECD review of the practice of EIs in Member countries indicates that there are so far no major difficulties in application. This does not mean, however, that enforcement is always easy. OECD Guidelines[4] for the application of EIs underline that the following factors should facilitate application:

- *A clear framework and objective:* the purpose of EIs should be specified, in particular their relative role vis à vis regulation and the type of affectation for revenue. In the case of charges, the revenue raising purpose should be clearly separated from the incentive objective.

- *A well defined field of operation* in terms of pollutants, processes and target groups (point vs non point sources, mobile vs stationary sources, types of industry or users etc.)

- *A simple mode of operation*: the more complex EIs are, the more difficult is their implementation. Complexity affects both responsible authorities who find it difficult to implement and polluters who find it hard to understand and to agree upon. However, one must strike a fine balance between undue sophistication and complexity that would hamper implementation and excessive simplicity which would lessen the efficiency of the instrument. For instance, a number of simple product charges have a limited effectiveness, on the other hand, sophisticated marketable permit systems often prove difficult to implement.

- *Acceptability* increases if adequate and timely information is provided to all interested parties (e.g. on type of instrument, objective and rationale, time of implementation etc.). Consultation with polluters and progressive implementation (e.g. progressive increase in the level of charges) also contribute to greater acceptability.

- *Integration with sectoral policies* is of utmost importance: for instance charges and taxes on transport vehicles and infrastructures should be compatible with environmental objectives and the introduction of new EIs should take into account existing fiscal and pricing structures. EIs can be useless if existing distorting fiscal and pricing practices such as distorting agricultural subsidies or inappropriate taxation of road freight transport, are not corrected in the first instance. If environmental costs are to be truly reflected in the price of goods and services, existing "government failures" must be removed first.

- *Reasonable cost of implementation must be maintained.*

- *An assessment of economic and distributive consequences*, in particular in comparison with the existing or potential effects of alternative approaches. The impact of EIs on the general fiscal system needs to be carefully evaluated.

- *Conformity with international policy and rules* must be ascertained. This applies to general principles, like the Polluter-Pays-Principle, international conventions (Basel, Montreal, etc.) or GATT rules.

5 - Political acceptability

Although there is still some opposition, in particular in industrial circles, the implementation of EIs seems, by and large, to be well accepted. Governments are now considering that a better use of market forces should be developed and this is testified by the quick increase in the number of EIs applied in OECD countries. In some cases, industry claims that EIs are likely to affect its competitive position on international markets and is demanding international harmonization[5]. On the other hand, a number of business and industry organisations do accept the usefulness of this economic approach to environmental policy.

3 CONCLUSION

A number of factors indicate that the use of EIs in environmental policy will further increase in the future, notwithstanding the fact that several countries have indicated their intention to do so[6]. Main factors are:

i) The need to design more efficient environmental policies, especially when public concern for the environment is growing, and in face of slackening economic growth.

ii) The need to find additional financial means between environmental protection in face of stringent budgetary constraints.

iii) The search for an effective integration between environmental and other policies like transport, energy, agriculture. EIs offer a unique opportunity to achieve such integration for instance, through the adaptation of existing fiscal and pricing systems to environmental objectives.

iv) The gradual move from "curative" to "preventive" policies requires policy instruments which enable a more effective internalisation of environmental costs into the market place, while inducing more efficient pollution control technologies.

v) The growing concern about finding a sustainable development path will likely require a larger role for environmental and natural resource pricing. Although this form of economic instrument is still in its infancy, its actual development and implementation will constitute a major challenge for the years to come.

vi) Finally, it is now widely recognised that EIs should contribute significantly to the solution of international, transfrontier and global, environmental problems such as global warming and acid rain[7].

This does not mean that all problems have been resolved: further work needs to be carried out e.g. on the practicalities of certain approaches and the economic, fiscal and distributive implications of EIs. But the "economic approach" to environmental policy has now become an integral part of policy making.

NOTES

1. Environment Directorate, OECD, Paris. The opinions expressed in this article are the author's own and do not necessarily reflect the views of the OECD.

2. Economic Instruments for Environmental Protection, OECD, Paris 1989.

3. For more details see "Recent Developments in the Use of Economic Instruments for Environmental Protection in OECD Countries", OECD Environment Monograph, Paris, 1991.

4. Guidelines for the Application of Economic Instruments in Environmental Policy, OECD, Paris 1991.

5. This argument needs careful assessment as international harmonization would be needed only in specific cases. Also, there is nothing really different, in this respect, between EIs and other forms of regulation.

6. See "Recent Developments...", op.cit.

7. See the Ministerial Declaration of the Second World Climate Conference (7th November 1990).

OPTIMAL POLICY FOR THE REDUCTION OF SULPHUR EMISSIONS AND DEPOSITION IN FINLAND

Ilkka Savolainen

1 INTRODUCTION

Sulphur emissions from energy production and industry have detrimental impacts on the nature and, in great concentrations, on the human health also. The sulphur emitted to the atmosphere might travel hundreds or thousands of kilometres before it deposits on soil or vegetation. The sulphur deposited on a site considered, a receptor, has been emitted in a large number of sources in a vast area, practically from the whole Europe. Naturally the sources closer to the receptor have greater impact on the deposition than those more far away. However, a considerable reduction in the deposition can usually only be reached if the emissions are reduced on a large area. Typically in Europe, this means also emission reductions in the neighbouring countries. If we consider the sulphur deposition in Finland, a relatively large fraction thereof is caused by the emission sources in USSR close to the Finnish border.

The technological potential for the emission reductions and the costs of the reduction vary from one source to another and from one country to another. As the costs of emission reduction programmes are relatively high, there is a need to use the resources, which can be used to limit the environmental impact, in a cost-effective way.

The objective of this work is to study how the emission reduction measures can be allocated in a cost-optimal way under given sulphur deposition targets. For that purpose, first the emission forecasts have been made for the future. The year 2000 has been used as a basis of the cost-optimization study to allow a realistic time-frame for the emission reduction measures. Then the emission reduction costs have been estimated. The atmospheric transport factors of pollutants from the source areas to deposition receptors in Finland have been derived from the results of two meteorological models. The deposition receptors have been given in a grid covering the whole Finland. The emission sources have been divided into three groups according to the distance from the deposition grid: sources in Finland; sources in the nearby areas of USSR (Estonia, Leningrad area, Karelia, and Kola); and other emission areas (the rest of USSR, and other European countries). The deposition field caused by the emissions from natural sources has also been accounted.

The computer model system used in the study is a part of the Finnish Integrated Acidification Assessment Model system (HAKOMA). Other parts of HAKOMA consist of the modules for nitrogen emissions and deposition, and impacts on forest soils (Johansson et al 1990). The model system has been developed in the cooperation with the Technical Research Centre of Finland (VTT), the Finnish Meteorological Institute (FMI) and with some other organizations in Finland. The development of the HAKOMA system has also included a close collaboration with the IIASA Transboundary Air Pollution Project (Alcamo et al 1990). The work has been financed mainly by the Finnish Acidification Research Project (Hapro), the Ministry of Trade and Industry, and VTT.

In this report an outline of a study considering the minimum costs strategy to reach given sulphur deposition targets in Finland is presented (Johansson et al. 1991; Tähtinen 1991; Savolainen 1990).

2 SULPHUR EMISSION SCENARIOS AND EMISSION REDUCTION COSTS

2.1 Emission scenarios for Finland

Emissions of sulphur dioxide originate mainly from energy use, industry, and, to some extent, from transportation. Sulphur emissions are principally due to sulphur contents of fuels. In conventional burning processes the sulphur in the fuels is released almost totally or totally to the atmosphere. Some fraction of the sulphur emissions originates from raw materials of industrial processes as from the ore in the basic metal industry.

In the integrated model system the emissions of sulphur dioxide in Finland are estimated on the basis of energy use scenarios and on the basis of alternative emission control strategies (Savolainen and Tähtinen, 1990). The energy use scenarios include also assumptions on the development of the production volumes of the process industry.

The basis for the emission calculations for the stationary sources is a plant file made from the register of the Ministry of the Environment. It includes data from about 190 power and industrial plants (about 500 boilers) in Finland. The plant file has also data about the used fuels for each boiler in the reference year which is presently 1986. The plant file is used to give the information needed for the geographical distribution of the emissions.

The emission model considers five energy use sectors which are: industry, electricity production, district heating, domestic heating, and transportation. The industry sector includes also more detailed information for some subsectors for the estimation of process emissions. These subsectors are: forest (pulp) industry, oil refining, basic metal industry, and basic chemical industry. The sector of electricity production consists of conventional condensation power plants only. The industry and district heating sectors produce also electricity which is accounted in the fuel use of the respective sectors. The domestic heating sector also considers the energy use of agriculture, forestry, and households. The fuels considered in the model are: heavy fuel oil, light fuel oil, diesel oil, gasoline, natural gas, hard coal, peat, waste liquors from the pulp industry, and others (mainly wood). Nuclear and hydro power have been accounted for in the energy balance.

The reference energy use scenario considered is based on the long-term prognosis of the Ministry of Trade and Industry (1990) (Abbr. KTM, from the Finnish name of the ministry). In addition to this, two other scenarios have been considered. The objective of these two scenarios is to explore the emission reduction potential which can be achieved with high increase of the use of natural gas and with strong energy conservation. The model has also been used to study emissions from energy use scenarios assuming a slow economic growth (Savolainen and Tähtinen 1988).

The basic energy use scenario assumes that the GDP will increase by 95 % by the year 2025. Most of the growth actually takes place before the year 2010. The total primary energy consumption is assumed to increase by 30 % by 2010, which corresponds approximately to an annual growth rate of 1.3 %. In 1986 - 1988 the primary energy consumption grew on an average of 2.5 % per year in Finland. In the OECD countries the average growth rate was 1.8 % per year. The electricity consumption is assumed to increase by 70 % by the year 2025. In the short term the actual growth rates have exceeded the assumed growth rates of the long term scenario. In the basic scenario the growth of the energy demand is covered to a large extent by increasing the use of hard coal. The shares of natural gas and peat are slowly increasing while the share of oil is decreasing.

Figure 1a. Sulphur emissions [kt(SO_2)/a] by fuels in Finland. Basic scenario of energy use, mandated emission reduction measures.

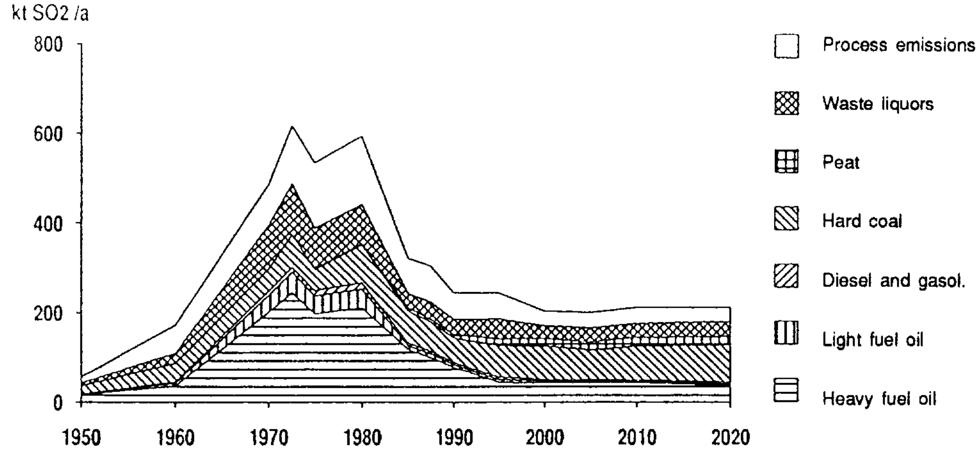
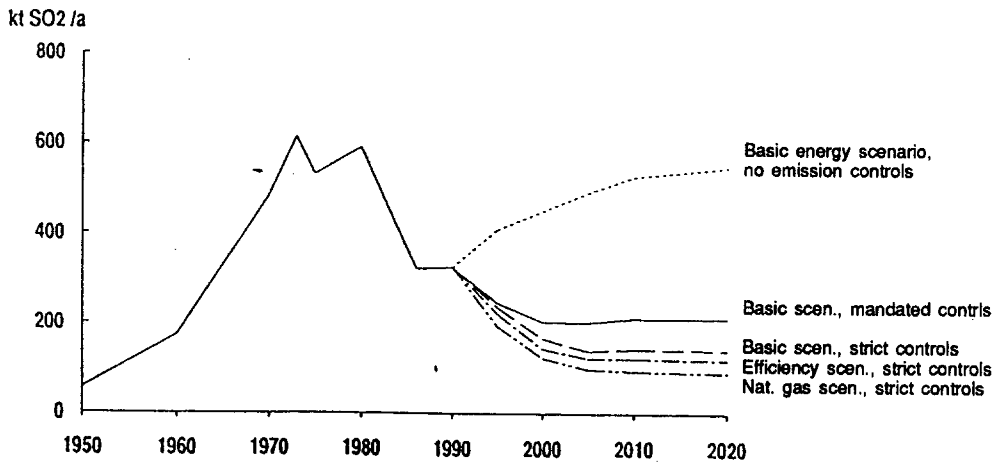


Figure 1b. Alternative scenarios for the development of the sulphur emissions [kt(SO_2)/a] in Finland.



In the calculation of the sulphur emissions in Finland, three alternative reduction strategies have been considered: no reduction measures as a theoretical reference to show the effectiveness of the reduction measures; reduction measures mandated by the Finnish government; and very strict measures to test the effect of the practically maximum reductions which can be achieved with the employment of the present control techniques. Figure 1a shows the sulphur emissions by fuels in Finland calculated for the the case with the KTM basic energy use scenario and mandated emission controls. Figure 1b shows the total sulphur emissions in Finland for the three reduction strategies in the case of the reference (basic) energy use scenario, and the emissions for the maximum reduction strategy in the cases of natural gas and energy conservation (efficiency) scenarios (Savolainen and Tähtinen 1990). The sulphur emissions are given by provinces for Finland in Table 1. The values for the year 1980 are given because that year is commonly used as the reference in international comparisons.

2.2 Emission reduction costs for Finland

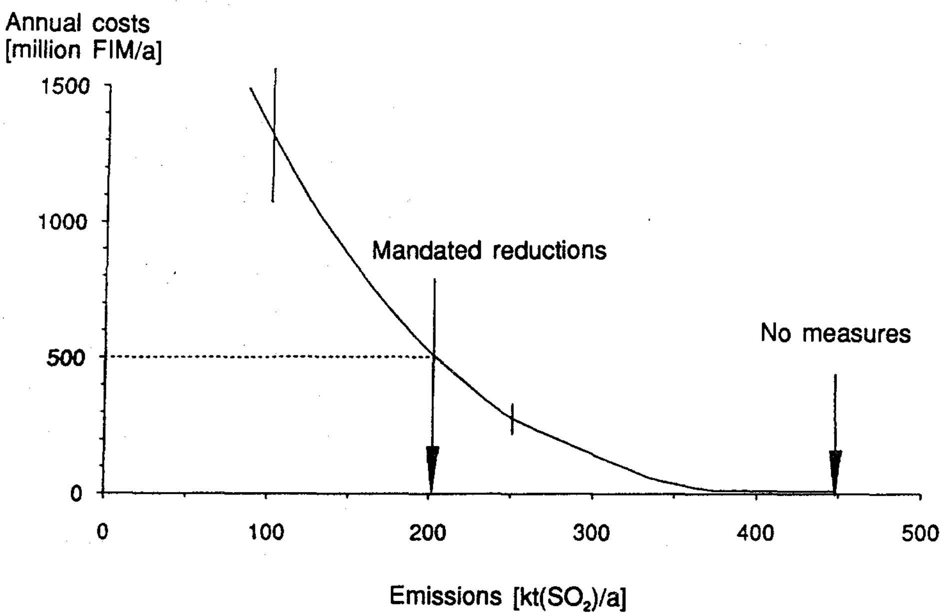
The control costs of sulphur emission reduction are estimated for energy production and process industry. The costs are expressed per removed ton of sulphur dioxide. The control methods considered for energy production are combustion modification (Lifac), spray dryer FGD and wet scrubber FGD. In the calculation of the investment costs the interest rate is assumed to be 8 % per year and the lifetime for the existing plants 15 years and for the new plants 25 years. The investment in the case of the existing plants is assumed to be increased by 30 %. In the operating costs the following factors are taken into account: sorbents, water, waste water, electricity and man-power. For the control of sulphur emissions from energy production, also the switching of heavy fuel oil to oil of a lower content of sulphur and to light fuel oil are considered. The control costs of the process industry emissions are estimated separately for pulp, basic metal, oil refining, and basic chemical industry (Tähtinen 1991).

The sulphur emission control costs are computed for the basic energy scenario of the Ministry of Trade and Industry for the year 2000. The results are expressed in the form of a curve giving the annual costs of achieving a given total emission level in Finland (Figure 2). The results have also been obtained separately for all the provinces in Finland. These type of curves are referred later in the text as cost functions

Table 1. Sulphur emissions by source areas [kt(SO_2)/a].

Source area	Emissions 1980	Emissions 1987	Unabated emissions in 2000 (calculational)
Uusimaa	136	79	97
Turku ja Pori	96	51	81
Häme	65	38	41
Kymi	57	28	35
Mikkeli	11	6	7
Pohjois-Karjala	9	5	4
Kuopio	30	17	19
Keski-Suomi	19	11	10
Vaasa	64	25	81
Oulu	78	46	58
Lappi	27	12	14
Finland (sum)	592	318	447
Estonia	260	207	207
Leningrad area	280	223	223
Karelia	109	170	170
Kola	724	700	700
Rest of USSR	11580	8900	11624
USSR (sum)	12953	10200	12924
Poland	4110	4200	4039
East-Germany	4795	4990	4695
Czechoslovakia	3146	2900	2342
U. K.	4675	3870	4141
West-Germany	3199	2000	2875
Sweden	481	232	369
Rest of Europe	20246	23998	23212
Total sum	54197	42190	55044

Figure 2. Estimated minimum annual costs to achieve a given level of sulphur emissions in Finland. Basic energy use scenario, year 2000.

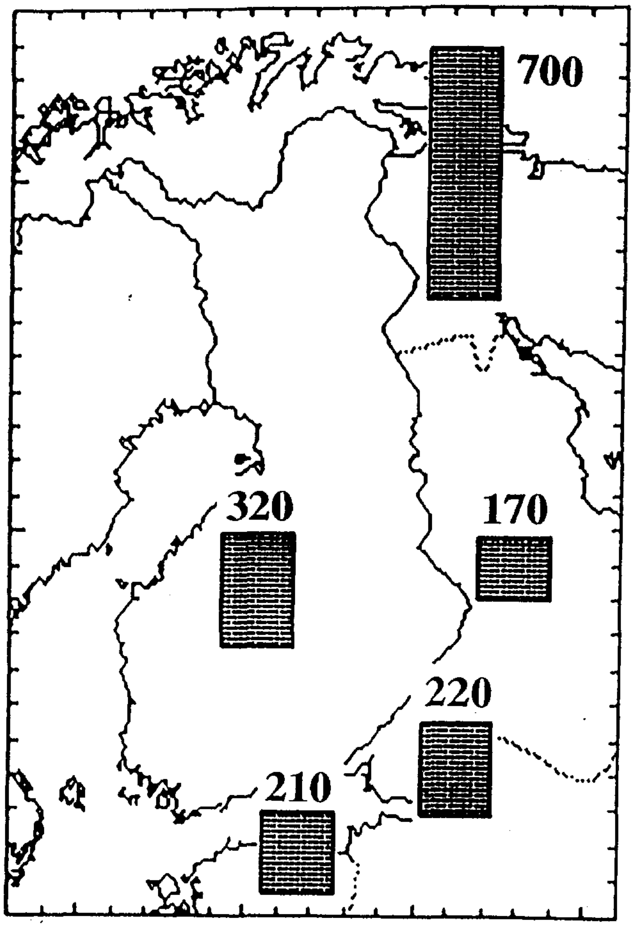


2.3 Soviet Union

Sulphur emissions (Figure 3) of the nearby areas in the Soviet Union are relatively important for the deposition in Finland. The emission data are based on information obtained from the Soviet sources and they have been presented by Kulmala (1989). More detailed information has been received concerning mainly Kola smelters, emissions from Estonian sources (ENMSIC 1990) and especially the oil-shale fired power plants in Estonia (Ots 1990). The sulphur emissions have slightly decreased during the 1980's. It has been assumed in this study that the emissions of the nearby areas will be in the year 2000 on the same level as they were in the late 1980's. The sulphur emissions have been given for Soviet Union in Table 1. The emission values for "the rest of the Soviet Union" have been calculated by subtracting the emissions of the listed nearby areas from the emission estimate of the whole European Soviet Union given by IIASA.

Similar emission reduction cost functions as those for Finland have been estimated also for the sulphur emissions of the Soviet areas close to Finland. The control costs are estimated by sulphur emission source types as smelters, oil shale based electricity production, and pulp industry. (Lehtilä et al. 1991; Johansson et al. 1991).

Figure 3. Sulphur emissions in 1987 [kt(SO_2)].



2.4 Other countries

Sulphur emissions for other parts of Europe are mainly based on the information obtained from IIASA (Alcamo et al. 1987) and EMEP (Iversen et al. 1989) (EMEP is an abbreviation from the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe). The future estimates are based on the work at IIASA and on the data of the OECD International Energy Agency and the UN Economic Commission for Europe.

3 ATMOSPHERIC TRANSPORT

3.1 Mesoscale transport

The impact of the emission in a source area to the deposition in a receptor grid cell is described with an atmospheric transfer factor. These factors have been calculated using two atmospheric models. Results of a mesoscale model incorporated in the HAKOMA model have been applied for the transfer factors describing the deposition due to the emissions in Finland or in the nearby areas of the USSR. The atmospheric model used is developed at the Finnish Meteorological Institute (Nordlund and Tuovinen 1988). For the calculation of long-term deposition, dispersion conditions are classified into a set of discrete events, for which the model equations are solved. The precalculated deposition distributions are then weighted according to their frequency of occurrence. The frequencies were calculated from the synoptic meteorological observations over a ten year period for four climatological areas (Johansson et al. 1990).

3.2 Long-range transport

The source-receptor relation of the emissions far from Finland, from the rest of the USSR and from other European countries, has been obtained from the results of the EMEP model (Iversen et al. 1989) and from the modifications of that model developed at the Finnish Meteorological Institute (Tuovinen et al. 1990). Averages over several year results have been used in the calculation to avoid annual stochastic variability.

3.3 Background deposition

The EMEP model gives relatively high values for background or unidentified deposition. This high background consists of natural background and anthropogenic background deposition due to emissions outside of the calculation grid (North-America, North-Africa or Asian part of USSR) or due to sulphur circulating back to the grid area. Re-evaluation of this part of the background (Lehtilä et al. 1991; Iversen et al. 1990) has led to its considerable decrease. The natural background is assumed to be about 40 % of the original one and the rest has been allocated to the emitting countries in proportion to their emissions (Lehtilä et al. 1991).

4 TARGET DEPOSITION

The deposition constraint is given by grid cells. The cell size of the target deposition grid is 1/2 degrees in latitude (north-south direction) and 1 degree in longitude (east-west direction). Expressed in kilometres, the cell size is about 50 km times 50 km in the Southern Finland and somewhat narrower in the Northern Finland.

The value used in the calculational cases with constant deposition target is 0.5 $g(S)/m^2/a$. This value has been accepted by the Finnish government as a long-term goal. This is also about half of the critical load for the forested lands in Finland (Johansson et al. 1991). Some fraction of the critical load should be reserved for the nitrogen deposition due to NO_x and ammonia emissions. If we consider the present deposition situation in the Southern Finland, the potential acidifying impact of sulphur is 50 to 70 % of the total acidifying deposition. The selected deposition target corresponds roughly to the fraction of critical load which can be allocated for sulphur deposition.

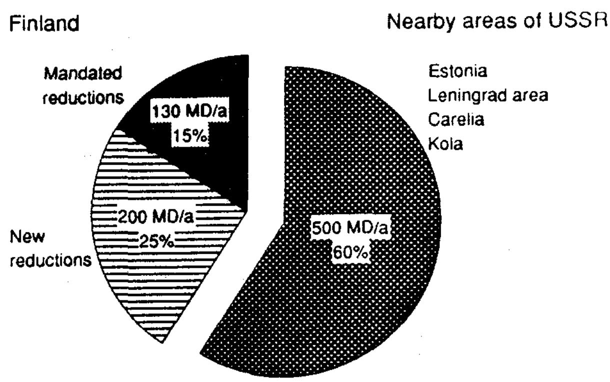
The sulphur deposition targets of this work are based mainly on acidification studies on mineral forest soils. Similar limits can also be derived from lake acidification studies. A possible damage to forests would have clear economic consequences at least in a country like Finland where a major share of export consists of forest products.

5 MINIMUM COST STRATEGY TO REACH THE DEPOSITION TARGET IN FINLAND

As a part of the HAKOMA system, a linear-programming model was constructed for the optimization of the sulphur emission control between the emission sources in Finland and the nearby areas of USSR. The links between emission areas and deposition receptors were described with the atmospheric transfer factors. The deposition field due to the emissions of other countries and due to the natural sources was taken into account. The deposition target or deposition constraint in the receptors was given by grid cells covering the whole Finland. The emission control cost functions were given for eleven provinces in Finland and for four areas in USSR: Estonia, Leningrad area, Karelia, and Kola. Minimum cost solutions were studied using the LP model developed.

If the target deposition of sulphur is assumed to be 0.5 $g(S)/m^2/a$, a feasible solution to the optimization of the emission control costs between Finland and the nearby areas of USSR can be found only, if the emission reduction of other countries is more than 50 % from the level of 1980. By assuming a reduction of 60 % for other countries, the minimum cost solution for the emission reduction in Finland and Soviet nearby areas is that 60 % of the annual costs of control are due to measures in USSR and 40 % in Finland. About 15 % of the Finnish costs is due to existing regulatory measures and 25 % due to required new measures (Figure 4). In this case practically all emission reduction measures described in the cost functions for Southern Finland and Estonia are assumed to be implemented, and also a considerable fraction of the measures for other nearby USSR areas and Northern Finland, like the measures for Kola smelters.

Figure 4. Optimal distribution of the annual costs of sulphur emission control to reach the target deposition of 0.5 $g(S)/m^2/a$ (in million dollars per year [MD/a]). An emission reduction of 60 % from the level of 1980 is assumed for other European countries.



6 DISCUSSION

The calculation method used in this report has been applied to consider the minimum cost strategy to limit the sulphur deposition in Finland only. The sulphur emission control measures in the nearby areas of USSR have been considered from the viewpoint how they affect the deposition in the Finnish side. However, the measures in the Soviet side can be assumed to be done in the first place to better the air quality and deposition situation in USSR.

The most important factors affecting the accuracy of the results are the uncertainty in atmospheric transfer factors and background deposition, and the uncertainty in the emission control cost functions. In the application of atmospheric transport models, it has been assumed that their results are also valid for the lowered emission levels. The transfer factors used have been selected from the transport model results covering a time period as long as possible to avoid inaccuracy due to stochastic variability. According to the sensitivity studies made with a simplier model (Lehtilä et al 1991) the moderate systematic changes in the transfer factors do not have a pronounced impact on the results.

The descriptions of the emission control measures used in the study include uncertainty as well as their cost estimates. Studies considering emission control and its costs have been done at least twice for Finland (Sulphur Commission 1986; Tähtinen 1991). On the basis of these studies the inaccuracy of the cost functions can be estimated to be order of about twenty percent. The control cost estimates for the Soviet side are much more uncertain, although some quite detailed information exists for Kola smelters and oil-shale fired power plants in Estonia.

REFERENCES

Alcamo, J., Amann, M., Hettelingh, J.-P., Holmberg, M., Hordijk, L., Kämäri, J., Kauppi, L., Kornai, G., and Mäkelä, A. 1987. Acidification in Europe: A Simulation Model for Evaluating Control Strategies. Ambio 16:5, s. 232 - 245.

Alcamo, J., Shaw, R., and Hordijk, L. (eds.) 1990. The RAINS model of Acidification: Science and Strategies in Europe. Kluwer Academic Publishers.

ENMSIC 1990. Estonian Nature Management Information Centre. Tallinn.

Iversen, T., Saltbones, J., Sandnes, H., Eliassen, A., and Hov, Ö. 1989. Airborne Transboundary Transport of Sulphur and Nitrogen over Europe - Model Descriptions and Calculations. EMEP MSC-W. The Norwegian Meteorological Institute, Oslo. Technical report no. 80.

Iversen, T., Halvorsen, N. E., Saltbones, J., & Sandnes, H. 1990. Calculated Budgets for Airborne Sulphur and Nitrogen in Europe. EMEP MSC-W. The Norwegian Meteorological Institute, Oslo. Technical report no. 86.

Johansson, M., Kämäri, J., Pipatti, R., Savolainen, I., Tuovinen, J.-P., and Tähtinen, M. 1990. Development of an integrated model for the assessment of acidification in Finland. In: Kauppi, P., Kenttämies, K., and Anttila, P. (eds.) Acidification in Finland. Springer, Heidelberg, pp. 1171-1193.

Johansson, M., Tähtinen, M., & Amann, M. 1991. Optimal Strategies to Achieve Critical Loads in Finland. International Symposium on Energy and Environment, 25 - 28 August 1991, Espoo, Finland.

Kulmala, A. 1989. Sulphur Dioxide Emissions in the Northwestern Regions of USSR. Interim report, Finnish Meteorological Institute, Helsinki.

Lehtilä, A., Savolainen, I., and Tuovinen, J.-P. 1991. Cost-Efficiency of the Measures to Reduce Sulphur Deposition (in Finnish). Technical Research Centre of Finland, Espoo, Research notes no. 1212. 47p.

Ministry of Trade and Industry, 1990. Finnish energy economy up to 2025 - some development paths (in Finnish) Energy Department, KTM series B :70. Helsinki.

Nordlund, G., and Tuovinen, J.-P. 1988. Modelling Long-term Averages of Sulphur Deposition on a Regional Scale. In: Proceedings of the WMO conference on air pollution modelling and its application (vol. III), 19-24 May 1986, Leningrad. WMO/TD No. 187, pp 53-61.

Ots, A. 1990. Use of Oil-shale as Fuel in Thermal Power Plants (in Finnish). Seminar on Energy, 25 January 1990, Jyväskylä, Finland. Technical Research Centre of Finland, Laboratory for Combustion and Thermal Engineering.

Savolainen, I., and Tähtinen, M. 1988. Estimation of the Emission Inventories for the Finnish Integrated Acidification Model. NILU/IIASA Task Force Meeting on Accuracy of Emission Inventories, 8 - 10 March 1988, Laxenburg, Austria.

Savolainen, I., and Tähtinen, M. 1989. Emissions of SO_2, NO_x and CO_2 in Finland - Future Control Scenarios. In: Kraftwerk und Umwelt 1989, p. 51-55. VGB-Kraftwerkstechnik GMBH, Essen.

Savolainen, I., and Tähtinen, M. 1990. Sulphur dioxide and nitrogen oxide emission scenarios to 2040. In: Kauppi, P., Kenttämies, K., & Anttila, P. (eds.) Acidification in Finland. Springer, Heidelberg, pp. 3-19.

Savolainen, I. 1990. Estimates of the Development of Acidification. Chapter 4 in: Kauppi, P. et al. Acidification in Finland - the Final Report of the HAPRO Project (in Finnish). Ministry of Environment, Helsinki. Series A 89.

Sulphur Commission, 1986. Report of the Finnish Sulphur Commission (in Finnish). Government Printing Centre, Commission Report 1986:33. Helsinki.

Tähtinen, M. 1991. Emission scenarios of SO_2 and NO_x for Finland and costs of emission control (in Finnish). Technical Research Centre of Finland, Espoo. Research notes no. 1199. 53p.

Tuovinen, J.-P., Kangas, L., and Nordlund, G. 1990. Model Calculations of Sulphur and Nitrogen Deposition in Finland. In: Kauppi, P., Kenttämies, K., and Anttila, P. (eds.) Acidification in Finland. Springer, Heidelberg, pp. 167-197.

ECONOMIC INSTRUMENTS AND SULPHUR DIOXIDE ABATEMENT IN FINLAND

Olli Tahvonen

1 INTRODUCTION

This paper considers two questions: First, do economic instruments have any role in practical environmental policy or are they only a piece of abstract economic theory? Second, what are the most serious problems we face if we try to apply economic instruments to sulphur abatement in Finland? When I consider the first question I refer to the implementation of emission trading in the United States and to the emission charges used in Europe. Both of these experiments have been evaluated in two recent articles. One is by T. Tietenberg (1990) and another by R.W. Hahn (1989). My views concerning the second question are based on an ongoing research project "Economic evaluation of the acid rain game between Finland and the Soviet Union" by V. Kaitala (Helsinki University of Technology), Matti Pohjola (ETLA) and Olli Tahvonen (Helsinki School of Economics, The Academy of Finland) (see Kaitala et al. 1990a,b, and 1991a,b).

2 ECONOMIC INSTRUMENTS IN THE U.S. AND IN EUROPE

There are basically two kinds of economic instruments to be used in pollution control: emission trading and emission charges. I will first consider emission trading. There appear to be four existing applications of this method: three of them in the U.S. and one in Germany. The most complicated system is designed to control air pollution, the second involves trading of lead used in gasoline and the third addresses the control of water pollution on the Wisconsin Fox river. The German application involves air pollution trading. I will concentrate only on air pollution trading in the U.S.

The U.S. emission trading program is designed to increase the flexibility of the command and control system without increasing the level of emissions.

The idea of this program involves the following basic concepts. First, *emission reduction credits* (ERCs): if a polluting source reduces its emissions more than required by source specific standards, it gets an emission reduction credit. ERCs are defined in terms of a particular pollutant and can be used to satisfy emission standards at other discharge points controlled by the same source or the credit can be sold to other sources. Thus the ERC is the currency used in emission trading. This currency can be used according to the following rules: 1. The *offset policy* is used in heavily polluted areas. New firms must buy so many credits from existing firms that the level of emissions is lower after their entry than before. Thus by introducing the offset policy economic growth is allowed to continue without increases in emissions. 2. The *bubble policy* is based on an idea that only a total amount of emissions is controlled in a given region (in a bubble) while the emission trading market allocates optimally the total amount of emissions among the emitters. There are two kinds of bubbles: multiplant bubbles and bubbles which include only one plant with several emission sources. 3. *Netting* allows modifying or expanding sources to escape from the need to meet the requirements of the rather stringent new source review process so long as any net increase in emissions (counting any ERCs earned elsewhere in the plant) is below an established threshold. 4. *Emission banking* allows firms to store ERCs for future use or for sale to other sources.

Perhaps the most critical question in emission trading is how to distribute the initial amount of emission reduction credits. There are basically two possibilities: *auction markets* and *grandfathering*. In grandfathering the rights to pollute are given to existing firms while when using the auction markets the existing firms must buy the rights from the government. The latter method is of course much more expensive to the existing firms. The U.S. program is based on grandfathering. I will later turn back to this important question.

The U.S. experiment has been considered to be quite successful. The programme has unquestionably and substantially reduced the costs of complying with the requirements of the command-and-control system. According to some estimates the accumulating capital cost savings for all components of the programme are about 10 billion U.S. dollars. Second, the method has considerably increased the flexibility of the command-and-control system from the point of view of polluting firms. Third, air quality has improved in the most polluted areas while economic growth continues. One drawback to the system is that transaction costs have been quite high i.e. it is quite complicated to do business with ERCs.

Let us next consider the emission charge experiments in Europe. Emission charges are used mainly in water pollution control. In air pollution they are applied in France and in Japan. In Europe they are used mainly for revenue raising purposes. The revenues are earmarked for specific environmental purposes. The level of charges are not calculated according to economic theory. The level of charges are designed according to some financial objectives of the local environmental programmes. This policy has lead to very low charge levels with very weak incentive effects on polluting sources. In fact no efficient charge (i.e. a charge calculated for reducing emissions in a given region to the optimal level) nor cost effective charge (i.e. a charge calculated for reducing emissions to some specified level) has been applied. Despite this, emission charges have motivated firms to investments in water pollution control and emissions reduction in general. This has happened especially in the Netherlands. The emission charge system applied in Germany was initially designed according to the cost effective objectives. However, the strong opposition of the polluting industry reduces the level of charges below the originally designed cost effective levels.

I next come to one of the most important problems concerning the implementation of the economic incentive methods. This is the fact that emission control measures always change the distribution of income in the society. The right to pollute is becoming an extremely valuable economic good. Because of historical reasons these rights are now "owned" mainly by polluting sources. However, the economic welfare with rational environmental policy can be best achieved only when these rights are owned by the government, which can sell them to the polluting sources. The redistribution of these valuable rights nonetheless reduces the profits of polluting industries and this has been reflected in strong opposition to the most effective economic instruments. The most powerful instruments cause two components of expenditure to polluting firms: emission control costs and expenditures on permits or on emission charges. While only the abatement costs represent real costs to the whole society both sums represent a financial burden to the firms. Usually the sum of the emission charges or expenditures on permits is higher than the sum of the abatement costs. One should keep in mind that the sum the firms must pay the government after reducing emissions to the optimal level serves several important economic efficiency purposes: First, it is a normal payment that firms have to pay for using a scarce resource. Second, this payment makes it profitable to develop new and cleaner production and emission abatement technology. Third, it allocates the capital resources of the economy to those industries which can produce commodities most efficiently including the economic scarcity of the environment. Thus although there were no technological possibilities to cut emissions below a certain level, there are several economic efficiency reasons why firms should pay charges according to the emissions left unabated. In the long run there may occur technological development, reallocation of capital and changes in the patterns of demand and consumption.

Distributive problems are reflected in the design of the European emission charge experiment as well as in the U.S. emission trading programme. One main reason why the emission charges in Europe are used only for revenue raising purposes is the strong opposition of firms against higher and economically efficient charges (OECD 1989). Accordingly, the U.S. emission trading programme is based on grandfathering, which actually means that the government has given firms the right to pollute at zero cost. Grandfathering guarantees that the profits of existing firms do not decline from the levels which will occur if the ordinary command-and-control method is used. However, grandfathering possesses some problems of its own (see Tietenberg 1990 and Hahn 1989). There may also be other ways to solve the distributive effect of the economic instruments. One proposal is to reduce the taxes of the whole industry for compensation.

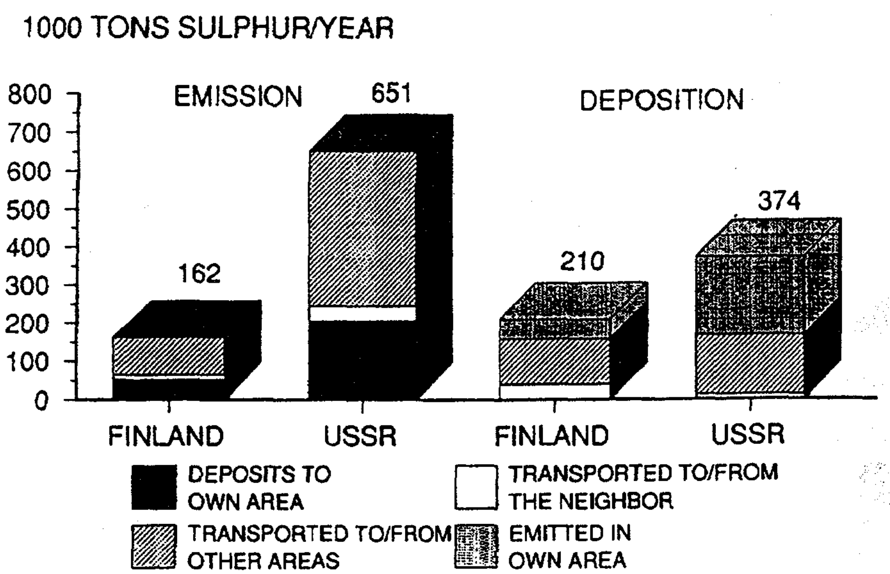
There is quite well developed economic theory concerning the choice between emission charges and emission trading (Weitzman 1974). However, practical experiments suggest that charges may work better when firms are small. This is simply because transaction costs may be quite high in emission trading.

In general it can be argued that the role of economic incentive methods will rise in the future. This is because these methods seemed to work best in the types of pollution problems we will face in the future. These problems include global warming, acid rain and the ozone depletion.

3 SULPHUR DEPOSITION AND EMISSION CHARGES: THE MOST SERIOUS DIFFICULTIES IN THE FINNISH CASE

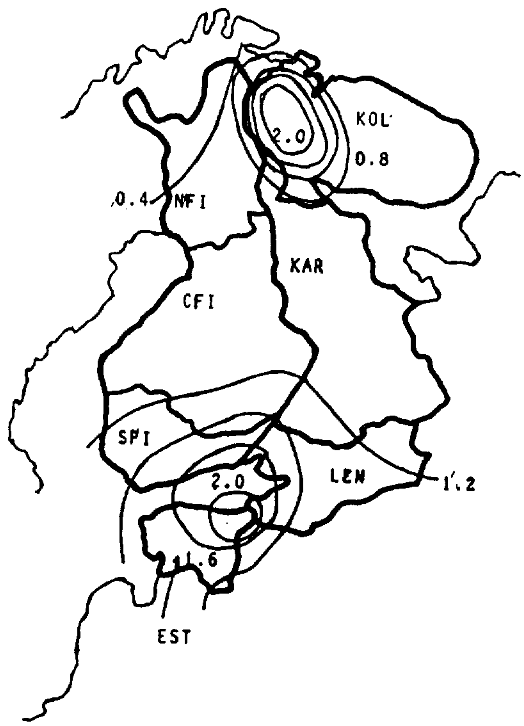
To get a general picture of the sulphur dioxide problem in Finland consider Figure 1, which presents the sulphur budgets between Finland and the Soviet Union in 1987. The Soviet Union here refers only to four nearby regions: Kola, Karelia, Leningrad area and Estonia. Of the Finnish emissions 32.1 % contributes to the deposition of Finland while 6.1 % adds to the Soviet deposition. The rest of these emissions goes outside Finland and the nearby regions of the Soviet Union. Of the Soviet emissions 31.6 % adds to the deposition of the nearby regions of the Soviet Union while 8 % comes to Finland. Because the Soviet emissions are much higher than those of Finland, the Soviet Union is the origin of about 19 % of the Finnish deposition. It is important to note that only about 3.5 % of the Soviet deposition comes from Finland. Together this means that while the Finnish sulphur deposition levels heavily depend on the Soviet emissions, the Soviet deposition levels depend mostly on their own emissions. These relationships have strong implications on the Finnish sulphur abatement policy. When calculating the appropriate emission abatement policy and emission charge levels in Finland, one has to take into account the emission levels in the Soviet Union. As we will see different emission levels in the Soviet Union imply quite different emission charge levels in Finland.

Figure 1. Sulphur budgets in 1987.



Another serious difficulty is that the sulphur deposition level is very different in different regions in Finland (Figure 2.). As can be seen the deposition levels are much higher in north-east and in south-east parts of Finland than in the western parts of the country. This kind of variation in sulphur deposition levels implies that one has to use sulphur dioxide transport models in order to calculate the right abatement levels and appropriate emission charges in different regions. In addition it is necessary to specify optimal size of regional units used in the calculations. Here Finland is divided to three regions: Northern Finland (NFI), Central Finland (CFI) and Southern Finland (SFI). From the Soviet Union four nearby regions are taken into account: Kola (KOL), Karelia (KAR), Leningrad area (LEN) and Estonia (EST).

Figure 2. Sulphur deposition in Finland and in the nearby regions of the Soviet Union in 1980. Unit g(S)/m²/a. (Source: Tuovinen et al. 1990).



The transport matrix has been constructed at the Finnish Meteorological Institute by Tuovinen et al. (1990) by applying the long-range sulphur transport model developed at the Western Meteorological Center in Oslo. The parameters of the matrix and the exogenous depositions are shown in Table 1.

Table 1. The transport coefficient matrix and annual exogenous deposition level B_{8i}/a (in 1000 tonnes of sulphur) in 1980 and 1987.

	NFI	CFI	EFI	KOL	KAR	LEN	EST	B_{80}/a	B_{87}/a
NFI	.2	.017	.01	.046	.012	.0	.0	27	26
CFI	.0	.3	.062	.011	.047	.036	.029	66	59
SFI	.0	.017	.227	.003	.0	.027	.038	38	35
KOL	.0	.017	.0	.286	.023	.009	.0	36	27
KAR	.0	.033	.031	.017	.318	.045	.019	65	50
LEN	.0	.017	.031	.003	.012	.268	.058	57	46
EST	.0	.0	.031	.0	.0	.018	.221	38	32

Source: Tuovinen et al. 1990

As one may expect the largest parameters in the transport coefficient matrix can be found at the diagonal. Note also the decrease in the exogenous deposition level between the years 1980 and 1987.

Table 2 gives information about the total depositions and emissions of sulphur in these seven regions.

Table 2. Annual total depositions Q_{8i}/a (in 1000 tonnes ofsulphur), annual depositions per square meter $Q_{g8i}/m^2/a$ (in grams), annual exogenous deposition per square meter $B_{g8i}/m^2/a$ (in grams) and annual emissions E_{8i}/a (in 1000 tonnes of sulphur).

	Q_{80}/a	Q_{87}/a	$Q_{g80}/m^2/a$	$Q_{g87}/m^2/a$	$B_{g87}/m^2/a$	E_{80}/a	E_{87}/a
NFI	50	46	.51	.47	.26	18	5
CFI	124	98	.72	.57	.34	107	60
SFI	89	66	1.34	1.0	.53	167	97
KOL	156	131	1.12	.94	.19	362	350
KAR	118	95	.67	.53	.28	85	85
LEN	108	88	1.27	1.03	.54	125	112
EST	71	60	1.57	1.33	.71	120	104

Source: Tuovinen et al. 1990

As can be noted the total deposition and also the deposition per square meter varies considerably from region to region. The deposition per square meter is highest in Kola and in southern regions. The high deposition in the southern regions is partly explained by the high exogenous deposition from the other parts of Europe. However, in Kola the deposition is mainly from home sources.

I next turn to perhaps the most simple economic model which can be used in these calculations. Let us assume that the aim of Finland and the Soviet Union is to attain region-specific target deposition levels with minimum possible abatement costs. If these two countries work in cooperation, the aim is to minimize the sum of the abatement costs in Finland and in the nearby regions of the Soviet Union. Formally the aim of cooperative policy is to

$$\underset{E_i}{\text{MIN}} \sum_{i=1}^{7} C_i(E_i)$$

subject to

$$\hat{Q} \geq AE+B,$$

$$E_{min} \leq E \leq E_{max},$$

where $C_i(E_i)$ are the region-specific emission abatement cost functions, E_i are the levels of emissions in these regions, $\hat{Q}$ is the target deposition vector, A is the emission transport matrix and B is the vector for exogenous emissions. In addition, it must be taken into account that there are some region-specific minimum and maximum emission levels.

The cost functions $C_i(E_i)$ are defined as the minimal cost envelope encompassing the entire range of sulphur abatement options for region i in a given time period. The costs can be calculated for various sulphur reduction requirements ranging up to the maximal technologically feasible removal. The HAKOMA project at the Technical Research Centre of Finland has produced such regional cost functions by applying an engineering approach in estimating the direct costs of sulphur reductions in both combustion processes in energy production and non-combustion processes in industries using inputs containing sulphur. The annual costs, measured in million Finnish marks, have been estimated on the basis of expected energy demands for the year 2000, and they include both capital and operating costs. The former have been obtained by assuming that the plants are operated for 25 years and that the annual nominal interest rate is 5 per cent. Two main options to reduce emissions in energy production have been considered in constructing the cost functions. The first is sulphur abatement through in-furnace lime injection and flue gas desulphurization. The second is switching to the use of low sulphur heavy oils in combustion systems. In calculating costs for non-combustion processes industry-specific costs per abated amount of sulphur have been applied. Here we use continuous, convex and piecewise linear cost functions. This means that the optimization problems can be solved by linear programming techniques.

It must be emphasized that this model includes some severe simplifications. First, the regional unit is too large for accurate approximations. Especially northern Finland should be divided into smaller regional units. Second, deposition targets are exogenously given. They can reflect some kind of "critical deposition" levels in different regions. Another approach attempts to estimate the economic damage of sulphur deposition. Third, the model does not explicitly include the dynamic and accumulating aspects of the acidification problem (see Kaitala et al. 1990a). Together, this means that the figures presented are first order approximations that merely demonstrate the most difficult problems which have to be considered more closely.

Let us consider three kinds of Finnish targets: 1. Assume that Finland attempts to maintain the 1987 deposition levels. 2. Assume that Finland and the Soviet Union abate sulphur according to the 1989 agreement made between Finland and the Soviet Union. 3. Assume that Finland aims to reach a deposition level $0.35 g(S)/m^2/a$ in every region.

To demonstrate the dependence of the Finnish sulphur abatement policy on the Soviet emission levels I will compare the emission charge levels of the case when the countries act in cooperation to the case when the Soviet abatement costs are kept at a zero level.

The results of the computations of the first Finnish target are shown in Table 3. It presents the cost effective allocation of the abatement activities for maintaining the 1987 deposition levels in Finland. Finland is assumed to be able to control her own as well as the Soviet emissions. An obvious thing to note is that the emission charge level is quite different in different regions. The last column demonstrates the level of the total emission charges firms have to pay to the government. When these figures are compared to the emission abatement costs, it follows that when using emission charges in order to attain these deposition levels the abatement costs are only about 8 % of the total environmental expenditures of firms. This makes it understandable why firms usually dislike emission charges and why the government may be forced to compensate this loss to firms in order to make emission charges politically acceptable.

In Case 2 the Finnish objectives are the same but it is assumed that in the Soviet Union no resources are used for abatement. The implication of this is that now Finland must cut emissions more in northern Finland and thus the level of the emission charge must also be higher.

Table 4 shows the computations concerning the 1989 agreement between Finland and the Soviet Union. Both countries agreed to reduce their sulphur emissions by 50 % from the 1980 levels by the end of 1995. Note that it is assumed that the level of the exogenous emissions will decrease by 30 %. Column 1 shows the deposition levels, which are now considerably lower than in the first example. Note also that because the Soviet Union now reduces the emissions in Kola quite substantially, the emission charge in northern Finland is zero. Howerer, because of lower deposition targets the emission charge levels in central and southern Finland are now higher.

If Finland maintains these deposition targets but the Soviet Union does not use any resources for abatement (Case 2) the above picture considerably changes. Even if Finland applied the highest possible emission charge levels (i.e. the level of charges which would reduce the emission levels to minimum levels), the deposition targets in northern Finland cannot be reached.

Finally consider table 5 where Finland attempts to reach a deposition level of $0.35g(S)/m^2/a$. In the first case it is assumed that countries act in cooperation but that the Soviet Union has no deposition targets. This means that Finland attempts to reach her deposition levels by controlling optimally both Finnish and Soviet emissions. The most important result to note is that the sum of the abatement costs in the Soviet Union is quite high, i.e. FIM 1987 millions annually, while the abatement costs in Finland are FIM 1136.52 millions annually. Column 1 shows that only the deposition target of southern Finland is binding while the deposition levels of northern and central Finland are below the targets. Note also that now the total amount of the emission charges is about 50 % of the total environmental costs of polluting firms.

The last experiment considers the case where Finland attempts to reach the above deposition targets while no resources are used for abatement in the Soviet Union. Now Finland cannot reach her deposition targets in southern Finland although the emission levels in central and southern Finland are at the lowest possible levels. In spite of this the level of the emission charge in northern Finland is zero. This is because the deposition level is already lowered by the low emission levels of central and southern Finland.

TABLE 3.

Case 1. Finland attempts to maintain the 1987 deposition levels in cooperation with the Soviet Union.
Assumption: Exogenous emissions equal the 1987 levels.

	Deposition kg/S/m²/a	Emissions E_i 1000 tonnes	Abatement costs millions of FIM	Emission charge P_i FIM/S/kg/a	$E_i \cdot P_i$ millions of FIM/a
Nothern F.	0.47	5.39	0.33	≅2.0	10.79
Central F.	0.57	60.60	41.97	≅5.3	321.20
Southern F.	1.00	96.87	28.66	≅4.9	474.66
Kola	0.94	345.70	4.30	-	-
Karelia	0.54	85.0	0	-	-
Leningrad area	1.03	111.5	0	-	-
Estonia	1.33	103.5	0	-	-

Case 2. Finland attempts to maintain the 1987 deposition level but USSR does not use any resources for abatement.
Assumption: Exogenous emissions equal the 1987 levels.

	Deposition kg/S/m²/a	Emissions E_i 1000 tonnes	Abatement costs millions of FIM	Emission charge P_i FIM/S/kg/a	$E_i \cdot P_i$ millions of FIM/a
Nothern F.	0.47	4.42	12.37	≅16.0	70.72
Central F.	0.57	60.60	42.74	≅5.3	321.20
Southern F.	1.00	96.87	28.88	≅ 4.9	474.65
Kola	0.95	350.00	0.00	-	-
Karelia	0.54	85.0	0	-	-
Leningrad area	1.03	111.5	0	-	-
Estonia	1.33	103.5	0	-	-

TABLE 4.

Case 1. Finland and the USSR reduce emissions optimally to reach the deposition levels of the 1989 agreement.
Assumption: Exogenous emissions decrease 30 % from 1987 levels.

	Deposition $kg/S/m^2/a$	Emissions E_i 1000 tonnes	Abatement costs millions of FIM	Emission charge P_i FIM/S/kg/a	$E_i \cdot P_i$ millions of FIM/a
Nothern F.	0.31	7.21	0.00	≅ 0.00	0.00
Central F.	0.41	53.52	79.22	≅ 5.50	294.37
Southern F.	0.73	83.57	95.62	≅ 5.11	427.05
Kola	0.52	181.00	169.00	-	-
Karelia	0.34	42.51	199.96	-	-
Leningrad area	0.67	62.60	361.21	-	-
Estonia	0.87	59.50	88.00	-	-

Case 2. Finland attempts to reach the deposition levels of the 1989 agreement but USSR does not use resources for abatement.
Assumption: Exogenous emissions decrease 30 % from 1987 levels.

	Deposition $kg/S/m^2/a$	Emissions E_i 1000 tonnes	Abatement costs millions of FIM	Emission charge P_i FIM/S/kg/a	$E_i \cdot P_i$ millions of FIM/a
Northern F.	0.37	1.95	55.30	≅ 22.1	43.00
Central F.	0.37	19.01	514.90	≅ 22.1	421.49
Southern F.	0.61	3.04	681.67	≅ 22.1	730.24
Kola	0.88	350.00	0.00	-	-
Karelia	0.43	85.00	0.00	-	-
Leningrad area	0.84	111.5	0.00	-	-
Estonia	1.07	103.5	0.00	-	-

TABLE 5.

Case 1. Finland attempts to reach 0.35g/S/m²/a by controlling her own emissions and the Soviet emissions.
Assumptions: USSR has no deposition targets, exogenous emissions decrease 60 % from 1987 levels.

	Deposition kg/S/m²/a	Emissions E_i 1000 tonnes	Abatement costs millions of FIM	Emission charge P_i FIM/S/kg/a	$E_i \cdot P_i$ millions of FIM/a
Northern F.	0.18	7.21	0.00	≅ 0.0	0.00
Central F.	0.25	21.96	454.85	≅ 20.0	439.20
Southern F.	0.35	33.04	681.67	≅ 22.0	726.88
Kola	-	98.00	252.00	-	-
Karelia	-	85.00	0.00	-	-
Leningrad area	-	22.00	1090.00	-	-
Estonia	-	11.00	645.00	-	-

Case 2. Finland attempts to reach 0.35g/S/m²/a by controlling ONLY her own emissions.
Assumptions: USSR has no deposition targets, emissions in Europe decrease 60 % from 1987 levels.

	Deposition kg/S/m²/a	Emissions E_i 1000 tonnes	Abatement costs millions of FIM	Emission charge P_i FIM/S/kg/a	$E_i \cdot P_i$ millions of FIM/a
Northern F.	0.30	7.21	0.00	≅ 0.00	0.00
Central F.	0.27	19.07	512.74	≅ 22.0	419.58
Southern F.	0.45	33.04	681.67	≅ 22.0	726.88
Kola	-	350.00	0.00	-	-
Karelia	-	85.00	0.00	-	-
Leningrad area	-	111.5	0.00	-	-
Estonia	-	103.5	0.00	-	-

4 CONCLUSIONS

Economic instruments are an established part of environmental policy both in Europe and in the United States. While emission charges are applied in Europe, the United States applies emission trading. Both emission trading and emission charges may cause distributional effects which are much higher than those of the ordinary command-and-control method. This is reflected in the European emission charges applications in the very low levels of charges and in the U.S. emission trading program in grandfathering. In spite of these income distribution problems there are several reasons to believe that the use of the economic instruments will increase in the future. One reason for this is that some of the most serious pollution problems like acid rain, global warming and ozone depletion are cases for which the economic instruments are most suitable. However, these methods are painful to apply because of the following reasons: 1. Environmental goals must be strictly specified. 2. The decision maker is forced to compare environmental benefits and pollution damages to ordinary material welfare. 3. Economic instruments change the distribution of income in the society. 4. The patterns of production and consumption may change.

If emission charges are applied to the sulphur abatement problem in Finland we face the following problems: 1. Sulphur deposition is not uniform in different parts of Finland. In order to calculate the right level of emission charges in different regions, the right size of regions must be specified. 2. The optimal sulphur abatement policy and the level of emission charges in Finland depend heavily on the sulphur emissions of the Soviet Union. Thus it is necessary to know the future trend of the Soviet emissions before the emission charge levels can be calculated. 3. Because the total level of emission charges are at least as high as the level of abatement costs, industry may strongly oppose the application of charges. To make charges politically acceptable some kind of compensation policy may be necessary.

REFERENCES

Hahn, R.W. (1989), "Economic prescriptions for environmental problems: how the patient followed the doctor's orders", Journal of economic perspectives, Vol. 3, no.2.

Kaitala, V., Pohjola, M., and Tahvonen, O. (1990), An economic analysis of transboundary air pollution between Finland and the Soviet Union, Discussion papers no. 335, ETLA - Research Institute of the Finnish Economy.

Kaitala, V., Pohjola, M., and Tahvonen, O. (1990b), Transboundary air pollution and soil acidification: A dynamic analysis of an acid rain game between Finland and the USSR, Discussion papers no. 344, ETLA - Research Institute of the Finnish Economy.

Kaitala, V., Pohjola, M., and Tahvonen, O. (1991a), Transboundary air pollution between Finland and the USSR - A dynamic acid rain game, in R.P. Hämäläinen and H. Ehtamo (eds.), Dynamic Games in Economic Analysis, Lecture Notes in Control and Information Sciences, (to appear).

Kaitala, V., Pohjola, M., and Tahvonen, O. (1991b), A Finnish-Soviet acid rain game: "club solutions", noncooperative equilibria and cost efficiency, Discussion papers no.358, ETLA - Research Institute of the Finnish Economy.

Kauppi, P., Anttila, P., Karjalainen-Balk, L., Kenttämies, K., Kämäri, J., and Savolainen, I. (1990), Happamoituminen Suomessa, HAPRON loppuraportti, Ympäristöministeriö, series A 89.

OECD (1989), Economic Instruments for Environmental Protection, Paris.

Tietenberg, T.H. (1990), "Economic instruments for environmental regulation", Oxford Review of Economic Policy, Vol. 6, No.1.

Tuovinen, J.-P., Kangas, L., and Nordlund, G. (1990), Model calculations of sulphur and nitrogen depositions in Finland, in Kauppi, P., Anttila, P., and Kenttämies, K. (eds.), Acidification in Finland. Finnish Acidification Research Programme HAPRO 1985-1990, Springer-Verlag, Berlin, pp. 167-197.

Weitzman, M. (1974), Prices vs. quantities, Review of Economic Studies 41, pp. 477-491.

ENVIRONMENTAL CHARGES FROM THE POINT OF VIEW OF INDUSTRY

Tellervo Kylä-Harakka-Ruonala

1 INTRODUCTION

Environmental charges and other economic instruments used as tools of environmental policy are generally considered from the macroeconomic point of view. Very seldom are they discussed or evaluated in connection with the special features of various industrial sectors, not to mention the microeconomic point of view of individual firms. These aspects should not be overlooked, however, because it is the firms themselves that represent the real economic world, and it is the activities of these individual firms that form the concrete targets of environmental charges and other economic tools of environmental policy.

One cannot deny the significance of economic theory as a starting point for discussions on the possibilities of influencing societal development. At the same time, however, one must give due consideration to the broader framework of life. The real world, as opposed to the ideal world of economic theory, places numerous preconditions on any proper system of environmental guidance. Among the most important conditions are the realities established by other sciences, such as the natural or behavioural sciences. Consequently, the development of technologies based on the natural sciences does not always follow hypothetical economic curves. And actual human behaviour may differ widely from what is assumed to be rational economic behaviour.

The above aspects are illustrated in the following, starting with the general prerequisites for the reasonable use of environmental charges.

2 PREREQUISITES FOR REASONABLE ENVIRONMENTAL CHARGES

It is commonly asserted that environmental charges should provide **guidance and incentive**, in other words, that they should not be set for the purpose of raising revenues. This requires that the charges be aimed at real environmental problems and that they be effective in directing the behaviour of firms, or other targets, to the desired environmental goals.

Another basic prerequisite, one which is related to the first, is that environmental charges have to be **avoidable** - and not a necessary evil. This is evident if one considers the financial resources needed for environmental protection investments or for production as a whole. It is reasonable to assume that any extra charge will be covered out of these sources, thus ultimately weakening the capacity of firms to implement pollution control measures or to fulfil their other responsibilities.

It should also be remembered that the financial resources of firms are not reserved for specific purposes. Instead, when extra costs arise, e.g. in the form of environmental charges, firms have to weigh their production costs as a whole and make the necessary rearrangements.

It is thus highly questionable whether one can promote technological development by means of extra charges. On the contrary, it is obvious that the introduction of extra charges will result in a depletion of the resources needed for such development.

Thirdly, environmental charges should be **cost-effective**. In theory, economic instruments are generally cost-effective because they are assumed to lead firms, or other targets, to reduce their emissions at those sites where it is most economical to do so. This argument derives from a macroeconomic view on the scale of an entire country or an even larger economic unit. Environmental charges may indeed be cost-effective if firms are not prevented from acting in a cost-effective manner, i.e. that their freedom not be restricted by excessive regulations or standards.

From the point of view of individual firms, and through their intermediary also from the standpoint of the entire society, environmental charges should also be cost-effective in a **microeconomic** sense. To satisfy this requirement, the costs of environmental protection must be met by the firm in a way that achieves the greatest possible decrease in environmental pollution. This can happen if resources for environmental protection are allocated for the most effective investments and for the development of new environmental technologies – and not for extra charges having no positive effect on the environment.

The fourth prerequisite is that environmental charges must be **feasible** in the sense of not being overly complex and not requiring large administrative costs or excessive bureaucracy. In addition, the use of environmental charges must also be based on a clear set of rules and procedures.

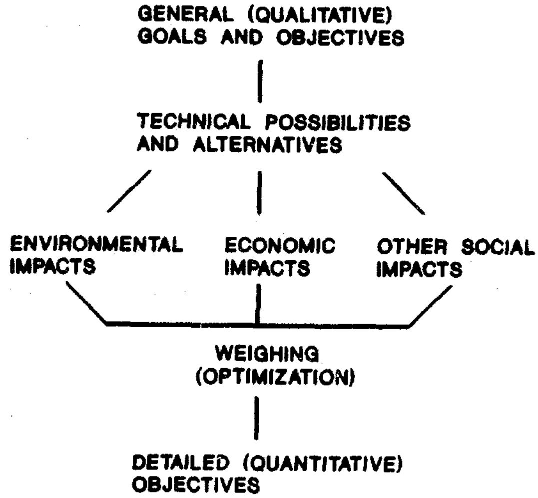
3 PREREQUISITES FOR FORMULATING REASONABLE ENVIRONMENTAL CHARGES

3.1 Clear environmental objectives

If environmental charges are to fulfil the above prerequisites, then they must be formulated on a sound basis. The first prerequisite for a sound planning procedure, and a very significant one, is that clear environmental objectives be defined.

One way to define environmental objectives would be to simply pull them out of a hat. It should be obvious, however, that such an approach would demonstrate nothing but disrespect for the environment and unconcern for the cost-effectiveness of environmental measures. The logical alternative is to introduce thorough planning of adequate objectives. A general scheme of the planning and decision-making procedure for environmental protection is shown in Figure1.

Figure 1. Elements of decision-making for environmental protection.



In Finland, as in most countries, environmental planning begins with general, qualitative goals and objectives. These goals are formulated on the basis of our knowledge of the environmental impacts and risks caused by polluting activities. In order to arrive at more detailed and more precisely quantified objectives, there are certain steps that must be taken. Firstly, different technical alternatives must be surveyed, including those currently in use or under development, as well as those that are interesting and promising enough to be developed in the future.

Once the different technical alternatives are established, we need to assess the practical implications of selecting one alternative or another. These include environmental impacts on the one hand, and economic and social impacts on the other. Weighing these different impacts or consequences against each other, the decision-maker should then be able to choose the most suitable alternative.

Weighing the environmental consequences of alternative anti-pollution measures is a kind of optimization procedure in which the costs and benefits, or advantages and disadvantages, of different options are compared. Rarely can such calculations be based entirely on monetary values, since it is very difficult to set a price on environmental benefits.

Furthermore, it is often difficult to quantitively assess environmental impacts even in their own physical or ecological terms. However, ecological modelling has recently made great advances, thus facilitating quantitative predictions of environmental effects. Further difficulties are encountered when expanding our view to areas other than direct or primary environmental effects. For it is also necessary to take into account the indirect effects of our solutions to environmental problems. After all, even environmental measures, such as the construction and operation of wastewater treatment plants or the collection and recycling of waste material, require energy and raw materials and generate environmental pollution.

Decisions regarding the suitability of different environmental measures are commonly based on a less precise weighing of different impacts against each other, while at the same time implicitly assigning some kind of monetary terms to the impacts under consideration. Such a procedure is bound to reflect the values of the decision-maker. If the costs of pollution control measures and the degree of emissions reduction are the only factors being considered, the costs needed to achieve the set objectives directly reflect the monetary value of the decrease in emissions. In practice, however, the optimization procedure also involves other criteria and consequences.

3.2 Adequate preparations

Once the environmental objectives have been determined, it is time to consider the tools and instruments most suitable for obtaining them. It is often asked whether economic instruments are substitutes or complements to other instruments of environmental policy. One could say that they are **substitutes** in the sense that they should not overlap other policy instruments. On the other hand, they are **complements** because they may be directed at targets not affected by other instruments.

When considering the imposition of environmental charges, the most relevant task is to determine the correct focus, scale, and timing of the charges so that efforts are directed to the desired environmental objectives.

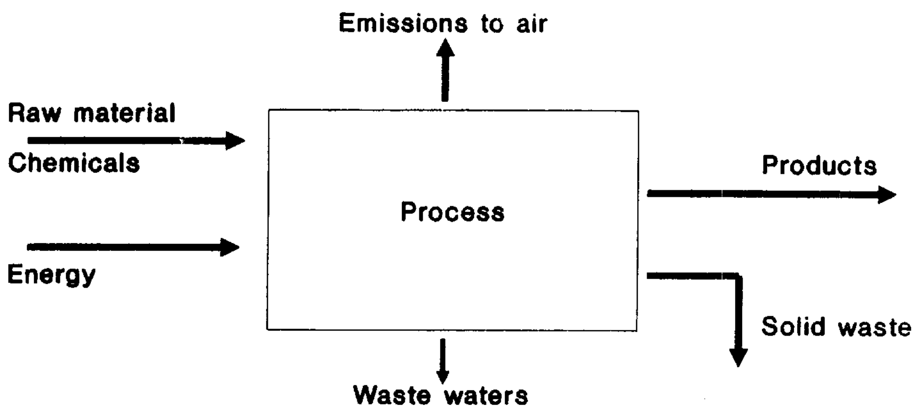
The problem of **focusing** the charges is partly a question of whether product/input charges or emission charges should be used. Keeping in mind that charges should lead to improvements in the state of the environment, and in the most cost-effective way, one might conclude that **emission charges** would be the most suitable type of charges in industry. Such a conclusion is based on the fact that the state of the environment depends rather directly on the quality and quantity of emissions, whereas the dependence between process inputs and emissions is not constant, but varies according to, e.g., the pollution control measures adopted.

Another point to consider is that by regulating the quality and quantity of emissions, one simultaneously affects industry's choice of process techniques and treatment methods as well as of raw materials and additives. The reason for this lies with the material balances that have to be valid at any one time in the system considered. A simplified scheme of the material flows of a production process is shown in Figure 2.

The advantage of emission charges over input charges is that they allow firms to make their own decisions on technical measures, thus encouraging them to seek and develop the most effective solutions.

Environmental objectives are usually expressed in terms of the emission levels of certain pollutants, which again are related to certain variables in the state of the environment. The basic idea of emission charges is, of course, that they should be levied on these specific pollutants. A general charge on wastewater, flue gas or solid waste would not make much sense because such charges would fail to take into account the quality or harmfulness of the

Figure 2. Material flows of a production process.



emissions or wastes in question. In contrast, the objectives, and thus the charges, should focus on the most significant pollutants and those that are controllable and without causing harmful side effects, such as increases in other pollutants.

Determining the **correct scale** of environmental charges is perhaps the most difficult task at hand. In order to succeed, one should know the relationship between the amount of the charge and the firm's response to it. Studies on this issue are needed. Otherwise, efforts to determine the correct scale of environmental charges will be based on trial and error, which is a most irrational and wasteful approach.

An optimal charge would induce a firm to decrease its emissions to the level fully corresponding with the set objectives. If the charge is too low, it will not function as an incentive and will only remain an extra charge. If the charge is too high, the excess becomes an additional penalty. The latter situation is likely to arise when charges are levied against the total sum of emissions with the zero level as the base, or according to an emission goal that is unattainable even with the best available techniques.

The concept 'best available techniques' is used here to refer to the reasonable measures needed to achieve the desired environmental objectives. Just as numerous elements form the basis for decisions regarding environmental objectives (Figure 1), so the best available techniques also vary with time and site according to the state of the available technology, our knowledge of environmental impacts, economic conditions, and social values.

The third task in formulating environmental charges is to determine their correct **timing**. A general prerequisite for correct timing is that charges should not come into force until after firms have been allowed sufficient time to achieve the set objectives. The amount of time necessary can vary from one firm to another, and the predetermined schedule of the charges should vary correspondingly. If the charge is imposed too early, it first becomes merely an extra cost - as opposed to an incentive - because there is no real possibility of reducing emissions at that moment.

Objectives change with time as a consequence of increased knowledge, technological development and new human values. This means that the basis of and criteria for environmental charges also change with time. Such change must be taken into account and the charges revised accordingly. A certain amount of stability and predictability are desirable, of course. This is especially important because changes in production techniques, and the vast investments involved, are understood to be the key to a cleaner environment. Such changes require at least several years, sometimes even more than ten years.

Because of the dynamics of the basic criteria for implementing environmental charges, it might be useful to set a charge that would fluctuate automatically in accordance with changing conditions. Due to a lack of information, however, this is impossible in practice. Instead, charges should be set for a certain frame of time and checked periodically.

3.3 Applications of environmental charges

Potential applications of environmental charges include areas where clear environmental objectives already exist or are under preparation, but have not yet been fixed by regulations. Such areas can be found in the air pollution control sector, particularly in the curbing of acidification caused by sulphur dioxide and nitrogen oxide emissions.
The question of climatic change is another area that has inspired a great deal of discussion over environmental charges. But since the objectives to be pursued in regard to this environmental problem are still under consideration, the time is not yet ripe for decisions as to the appropriate policy instruments. Another restrictive aspect is that climatic change is a global problem that

cannot be solved without worldwide cooperation and coordination. This pertains both to objectives and policy instruments.

Special difficulties arise when global systems are concerned. The first question is how to distribute the obligations and charges in an equitable way. Another difficulty is posed by the practical aspects of administering and monitoring the system.

Besides environmental charges, emission trading has been suggested as a possible means of solving worldwide environmental problems. However, this policy instrument shares many of the drawbacks of environmental charges. Perhaps the most significant unsolved question is how to distribute the emission permits among various countries or regions when introducing such a system of trading. Another question is how to reduce total emissions once such trading has begun.

The above difficulties indicate that both charges and emission trading are likely to require strong supervision and control by a central authority. In a world made up of sovereign states, this approach is not possible as such, and success depends on the effectiveness of international conventions.

4 CONCLUSIONS

From the point of view of industry and individual firms, it is most important that environmental charges act as an incentive and are not imposed for the purpose of raising revenues.

Another prerequisite is that the cost-effectiveness of the charges be considered from the point of view of individual firms as well as from the macroeconomic perspective.

Thirdly, the use of charges must be coordinated internationally. This is essential if we are to avoid market distortion. Another reason for international cooperation is that many environmental problems are global, or at least regional, in nature.

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