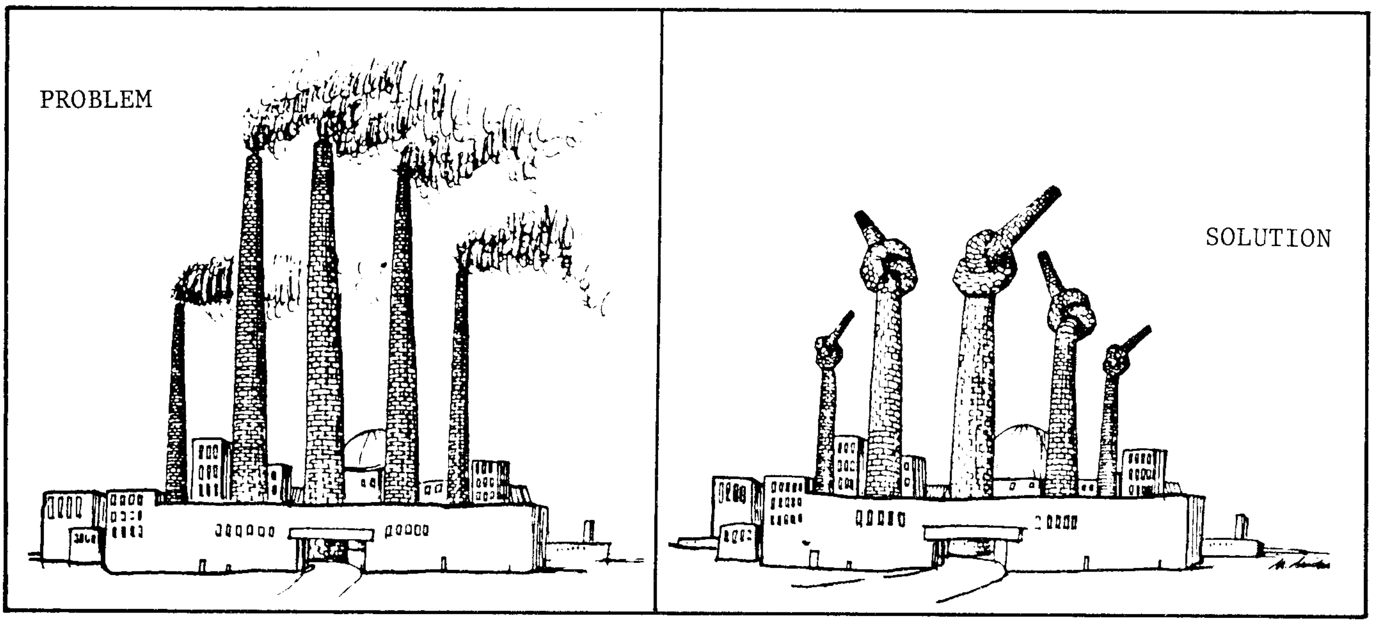
2/83

# Acid News

A Newsletter from the Swedish and Norwegian NGO Secreteriats on Acid Rain.




# THINGS ARE MOVING FORWARD

## Action in West Germany

*In February a major action against acid rain and "Waldsterben" was performed in West Germany. A newly formed action group for environment issues, Robin Wood, carried out a range of activities simultaneously in five major cities, including the occupation of flue-stacks, and the "planting" of dead trees in the middle of town.*

## Norwegian campaign

*In mid March, on the same day as the ECE Convention comes into force, "The Stop Acid Rain Campaign/Norway" will make its official start. The campaign is backed by six organisations concerned with the environment, who have come together to work against acid rain. Our Swedish and the newly formed Norwegian Secretariats will be working together on several projects, including for example the production of "Acid News".*

## Interest awakened in the UK

*An interest in acid rain has now been awakened also among environment organisations in the UK. A joint meeting is planned there at the end of March, with a view to coordinating future work against acid rain.*

*And we naturally look forward with excitement to what will be happening during* ***"Acid rain week"****, 18 – 24 april.*

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# 200,000 Norwegians in acid rain campaign

*The Norwegian environment movement has also grouped in a campaign against acid rain. 16 March – the same day as the E-CE Convention comes into force – will see the official start of* ***"The Stop Acid Rain Campaign/ Norway"****. Six organisations concerned with the environment, with a total membership of some 200,000 have put themselves behind the campaign.*

## Goals

The Norwegian organisations see it as their main task to inform similar organisations and the press in the countries responsible for discharges concerning the effects of acid rain. Not only about the damage being caused to the Norwegian countryside, but also about the extensive environmental damage gradually being discovered in the "discharge countries" themselves. By creating contacts with environmentalists in other countries, the campaign aims at spreading the work of combating acid rain to non-governmental organisations throughout Europe.

## Collaboration

In other words, the work of the Norwegian campaign will closely resemble that of the Swedish Secretariat, and close collaboration is planned over the Scandinavian frontiers.

## Information

The Campaign Secretatiat will be producing a broad selection of acid rain information for distribution to contacts, and to interested persons. Special information brochures from the Norwegian campaign will also be produced.

The six organisations are:

- Nature and Youth/Norway
- The Norwegian Association of Anglers and Hunters
- The Norwegian Forestry Society
- The Norwegian Mountain Touring Association
- The Norwegian Society for Conservation of Nature
- World Wildlife Fund/Norway

"The Stop Acid Rain Campaign/Norway"
c/o The Norwegian Society for Conservation of Nature
P.O.Box 8268, Hammersborg
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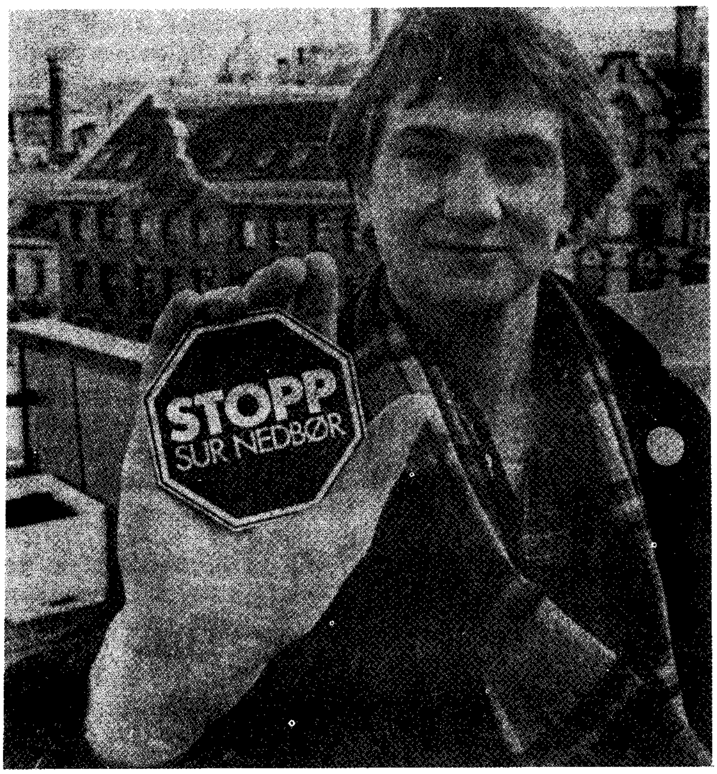



-Stop acid rain, says Trygve Aas Olsen, who works as co-ordinator at the newly started Norwegian secreteriat.

# New book on acid rain

A new "short version" of "Acidification Today and Tomorrow" has now been produced. The new edition is of 48 pages, and its Swedish title is "Försurningen – Ett Gränslöst Miljöhot". (Acidification – a boundless threat to the Environment / Versauerung – eine grenzenlose Bedrohung der Umwelt) It is published by the Swedish Ministry of Agriculture, and will be **available in both German and English**. This book will be sent to all of you who now receive "Acid News" and if you would like further copies you can order them (free of charge) from:

The National Swedish Environment Protection Board
Department of Information
Box 1302
S-171 SOLNA
SWEDEN

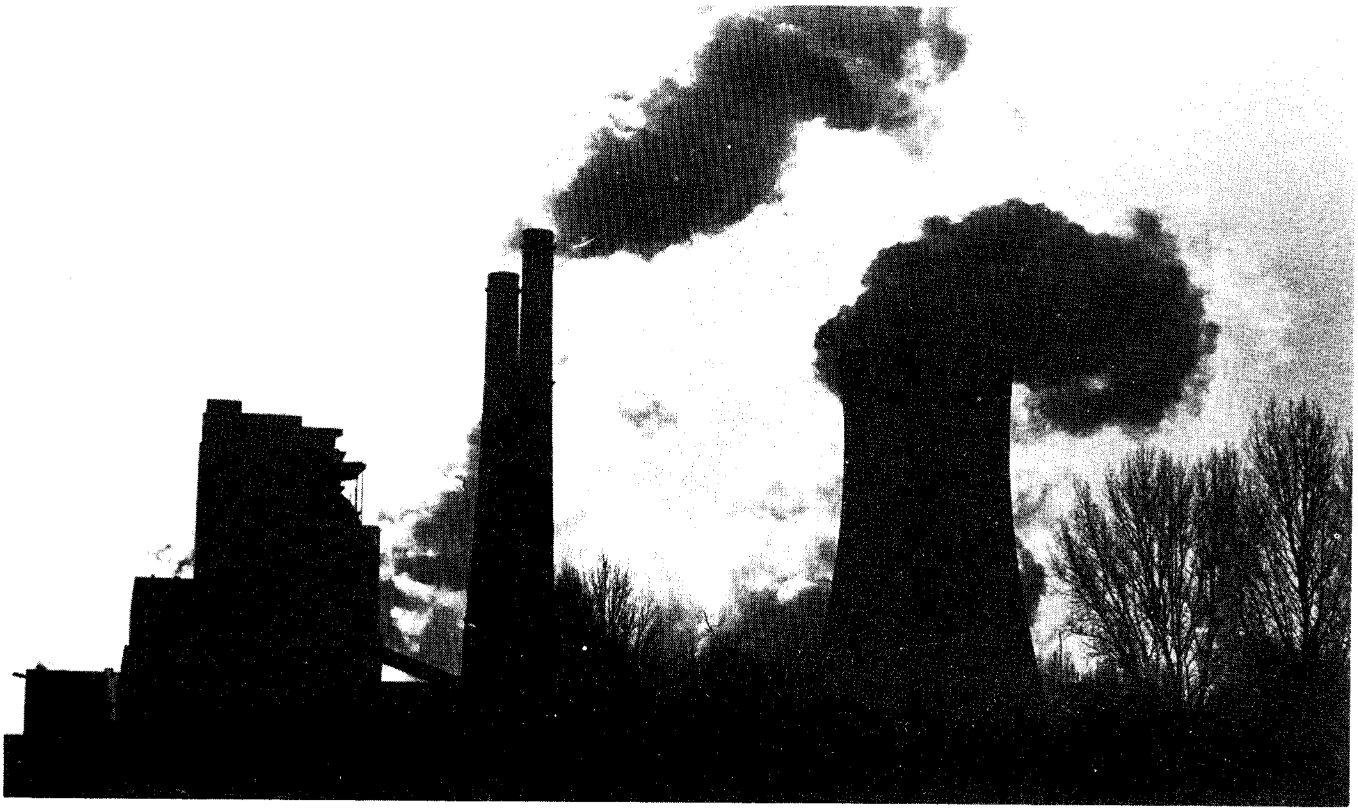
# Acid rain hearing

The Environment Committee of the European Parliament is organising its 1983 hearing on the theme of **long distance air pollution, April 19 – 20 in Brussels.**

A set of experts will be invited (forestry; soil; water) as well as representatives from six (6) organisations who will make a policy statement and be able to take part in the debates.

The six organisations concerned are the EEB, (European Environmental Bureau) UNIPEDE (European Electricty producers) the Central Electricity Generating Board, OECD, the UN Economic Commission for Europe, and UNEP.

# Major manifestation against acid rain and tree death in West Germany



It's three in the morning of Monday 21 February. Three passenger cars park in a spinney a few hundred yards away from the coal-fired power station of Frimmersdorf. A group of some ten people climb out. A number of large sacks are unpacked from the boots of the cars. Coutiously the group approaches the fencing that surrounds the power station. A few rapid clips and snips, and an opening has been made. Five people, three women and two men, creep in through the opening in the fence, and move rapidly across to the previously selected chimney stack, which rises up 160 metres in front of them. One after the other they briskly climb the "steps". When the last of them is only some six metres over the ground, a worker comes cycling immediately beneath her. All of them hold their breath. The man cycles on, without noticing a thing. With a common sigh of relief, the five continue their climb towards the first platform, at a height of some 40 metres.

After resting and checking their equipment, they climb on. Achim is having trouble with his shoulder, and remains where he is for the moment. Their next target is the second platform, at a height of 120 metres.

## Slowly climbing

It's a slow process. First attach the snap-hook to the iron rung above, then detach the other snap-hook and heave yourself up half a metre. Over and over again. Achim, who is a chimneysweep in everyday life, and the only member of the party used to heights, goes first. Followed by Axel, Lollo, Eva and finally Catherine. If they should be spotted, it will be Catherine's job to talk and delay things long enough for the others to reach their target.

The support group outside has drawn back to a fringe of trees some 300 yards from the plant. The two groups maintain contact the whole time via walkie-talkies. When the first climber has reached the platform, it is almost 4.30. He starts immediately to haul up the sack with the banderoles, and the sleeping-bags, which they have left at the foot of the stack. A short while later all five (and the sacks) are safely up on the 40-metre platform. So far, everything has gone off perfectly.

Slowly, infinitely slowly it seems to us watching from the group, the four keep climbing. By seven o'clock it is getting light enougt for us to follow heir climb through binoculars. They look so infinitely small, as they crawl at a snail's pace up the giant stack..

## Emissions in West Germany

*Frimmersdorf, a condensate station fired with lignite (brown coal), produces not only electric power, but also a mass of pollutants. Every year its stacks spew out 108,000 tons of sulphur dioxide. And huge volumes of nitrogen oxides, carbon monoxide, soot, heavy metals etc. Only half a mile away is another, similar plant, Neurath, which discharges annually 97,000 tons of sulphur dioxide. These two power stations, plus ten or so others within a short radius from Cologne, operate without any form of flue-gas desulphurisation whatsoever. Of the hundred or so coal-fired power stations in West Germany, only 8 have a fully or partially operative system for desulphurisation.*

*In total, some* ***3.6 million tonnes of*** $SO_2$ *a year are discharged in West Germany, and the power stations account for over half this figure. Discharges of nitrogen oxide amount to over 3 million tonnes, and here the power stations account for roughly one third.*

## "Waldsterben"

*These emissions put an enormous burden on the population, on the* *wildlife, and on the countryside. Here in West Germany attention has been concentrated in the past few years mainly on "three death". **Today at least 500,000 hectares of forest land are affected.** This corresponds to approx. 8% of all Germany's forests. All sorts of trees are affected, but hardest hit are the coniferous trees (silver fir, spruce and pine). It is estimated that 60% of the aggregate stand of silver fir has been damaged. The issue of how best to deal with these problems has become one of the most important in the election campaign for 6 March. Chancellor Helmut Kohl has also proposed a new Bill to limit emissions of sulphur from the major power stations, the "GFVO" (Grossfeuerungsanlagen Verordnung). This bill will be considered by Parliament on 23 February. So this is a good point in time at which to stage an action.*

*Which brings us back to where we started this article (and will soon be continuing) namely at the occupation of the stack in Frimmersdorf.*

## Robin Wood

But first, something about Robin Wood.

This is a newly started "action group for environmental issues". It has about one hundred members, many of whom are former activists in Greenpeace. Robin Wood is a member of **the BBU** (Bundesverband Burgerinitiativen Umweltschutz), which has long been an established environment organisation in West Germany. It is Robin Wood that has initiated and planned this manifestation against acid rain, of which "our" stack occupation is part. This action took place in five major German cities simultaneously, on 21 February.

- In Berlin, a stack was occupied at another power station. Three people climbed up and hung out a 30 m long banderole. At the same time hundreds of balloons were released. These carried picture postcards with a message aimed at East Germany, telling it to reduce its sulphur discharges.
- In Hamburg six people hid as early as on Sunday in the bell-tower of the St. Michaelskirche, where they spent the night. In the morning they hung out a 400 m large banderole, with the text "Stoppt den Sauren Regen".
- In Kiel a dead forest, consisting of some forty or so trees, was planted in the city's pedestrian street.
- In Bremen a large dead tree was placed in the centre of the square in front of the City Hall. A young man seated himself on a thick branch some 3 m above the ground, sawed the branch off and fell! A symbolic action... There was singing and music in the square, and a note demanding reduced discharges of sulphur was submitted to the mayor.
- An in Cologne, the occupation of the stack, to which we shall soon be returning...

Leaflets were distributed in all these cities, and Scandinavians were taking part to underline the international importance of this problems.

## Back to Frimmersdorf

Eight o'clock in the morning. The first TV teams arrive. So far no one at the power station seems to have observed what is happening.

By the nine o'clock they are all, except Achim, up on the second platform, at a height of 120 m. There's a strong wind up there. Otherwise the weather is perfect, the sun is shining and the temperature around zero. Had it not been for the enormous volumes of steam generated by the cooling tower, and the waste gases from the stacks at Frimmersdorf and Neurath, the sky would have been utterly cloudless.

Shortly after nine those on the stack report that they have been discovered. One of the workes (?) tried to make his way up, but Achim effectively barred the way. A group of the participants who had so far been observing the course of events from outside took the TV team, journalists and photographers with them, and went up to the main entrance. They informed the plant management by telephone that their stack had been occupied and why. At roughly the same time the four on the stack went to work intensively to get up their 20 m long banderole with the text "Stoppt den Sauren Regen". This was a tough job in the strong wind.

## Pressconference

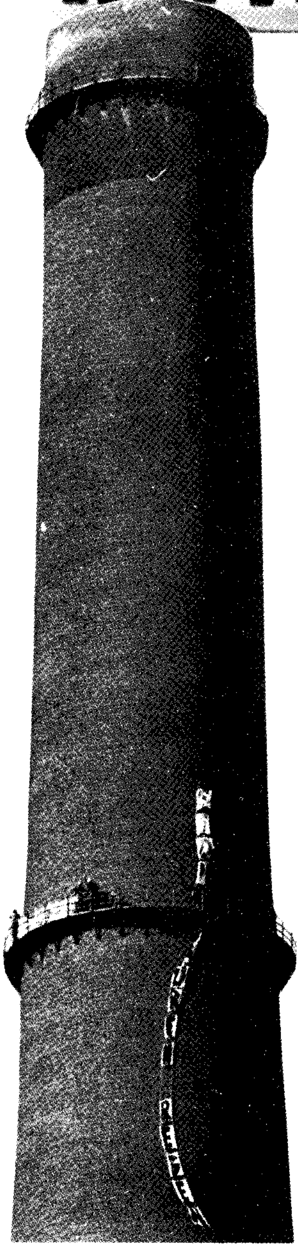
Meanwhile a few of us had driven at top speed to Bonn, where a press conference had been announced by telex for 11 a.m. A couple of minutes late, we rushed in breathlessly to meet some twenty interested journalists. After just over half an hour's questioning the conference was dealt with, and we returned to Frimmersdorf, curious to know what had happened during our absence.

## "Stoppt den Suren Regen!"

The first thing we saw was the banderole, at a height of 120 m. The action had succeeded! There were crowds of illegally parked cars and buses along the road, which passes just outside the power station. Curious onlookers wondered what was happening. Those with radios in their cars explained, and leaflets were distributed.

The entire mass media gang was now inside the power station. From the balcony in the tower beside the stack they were in the "dress circle", and able to take pictures of the occupiers and their banderole without difficulty.

Around three in the afternoon, the occupiers climbed down. They were met, to their surprise, by consistently friendly faces among both the management and the policy! They were invited to coffee, at the same time as their names and personal data were demanded. Then they were able quite simply to walk out to meet their awaiting friends, and the TV team.

One of the occupiers ventured to ask whether they would be charged. The response was a (scornful) smile, and the comment: "To give you still more publicity? That would make you happy, wouldn't it?" So we'll just have to see what happens... On the other hand they are likely to have to pay the "costs" of taking down the banderole, since they left it behind them, proudly fluttering in the wind.

## Coverage of massmedia

That evening we followed the occupation (and the other actions) over and over again on television. All the news programmes (I reckon we saw some seven or eight) had the action as one of their main items. The action was also reported in the majority of the daily papers, usually on the front page, on Tuesday morning.

On Tuesday morning we met for another press conference in Bonn. Participants from all five actions had now arrived, and they were pleased to answer the questions put by the journalists.

The entire action went off perfectly. With the possible exception of Hamburg, where a priest called in the police, who of cource swiftly picked down 4 of the 6 people who had hung out the banderole (two got away!). But when the priest subsequently found out why the action had been performed, he announced his wish to join Robin Wood, and said he would try to hold a mass on the theme of Tree Death!

Coverage of the action by the mass media was practically 100%, and not very many Germans can have avoided learning at least something about acid raid.

## And afterwards:

The new Bill restricting discharges of sulphur was approved by Parliament on Wednesday. With the help of the new Act it is estimated that it will be possible to reduce sulphur discharges by approx. 30% by 1995. This is a little bit along the road, but the new Act been severely criticised by the environment organisations, including during the action. It is considered that discharges must be reduced to a much greater extent, and that they must be reduced much faster. The BBU in its book "Saurer Regen" (see the previous issue of "Acid News") has put forward a development plan for sulphur discharges, in which it is demonstrated that if it is decided immediately that all the major power stations should be fitted with desulphurisation units as quickly as possible (within three years), then discharges could be cut to half what are today. This at a cost of approx. DM 6 billion, or DM 2 billion a year.

Who knows if there will be any German forests left to save by 1995.

*Christer Ågren*

Grüße aus dem Wald

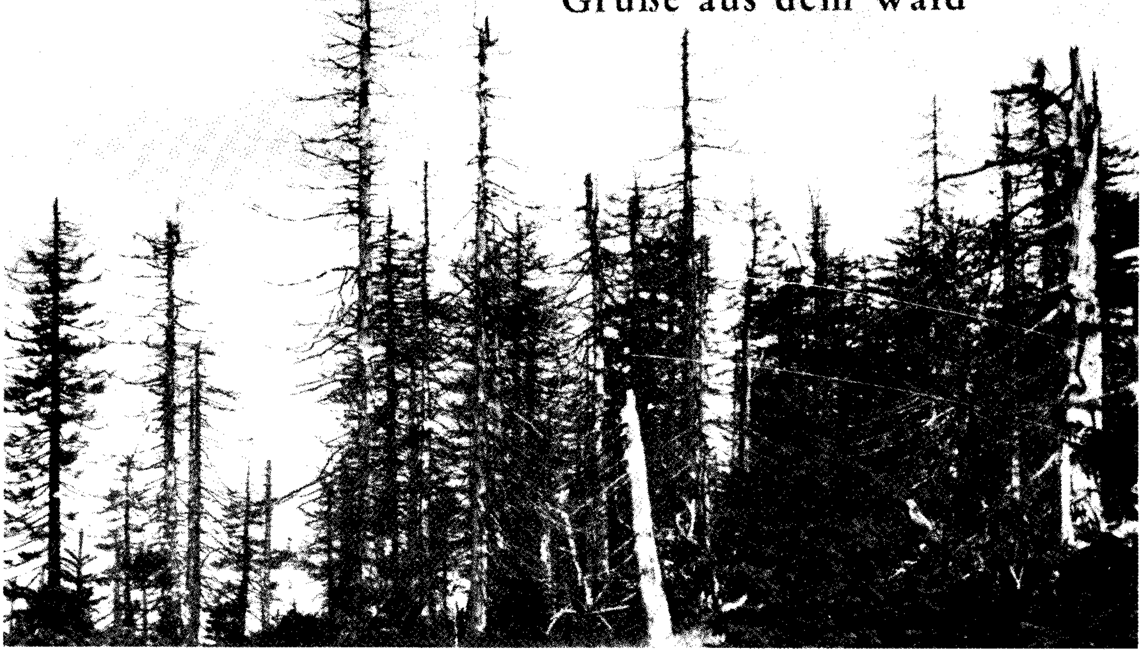


PHOTO: Herbert Wolf

# The Effects of Changing Patterns of Energy Use On Sulfur Emissions and Depositions in Europe

BY NH HIGHTON AND MJ CHADWICK

From AMBIO, Volume XI
Number 6, 1982

*European coal consumption may increase by as much as 50 percent in the next two decades, and in the absence of control measures sulfur depositions might increase by about one third as a result, from 57 million metric tons in 1982 to 74 million metric tons in 2002. Emissions are widely dispersed in Europe, and no single nation can hope to protect ecologically sensitive areas without a co-ordinated abatement program for the entire region.*

It is generally agreed that coal will be more important in meeting European energy requirements during the next two decades that it has been during the last two. Virtually all recent studies concerned with forecasting patterns of energy consumption predict either higher levels of coal usage, or assign an increased proportion of total energy consumption to coal, or both (1–10). One study (4) cites a number of advantages coal enjoys: new developments allow it to be burned more efficiently and with less environmental impact; the technology for converting coal to gaseous or liquid fuels is constantly improving; and coal offers by now familiar opportunities for co-generation of steam and electricity. And the incentives for increased use of coal resulting from its low cost in comparison with oil are likely to persist.

In Europe, the future contribution of coal is expected to be as a substitute for oil in generating electricity and in the co-generation of electricity and heat; as a replacement for oil for industrial purposes, particularly where the smaller fluidized bed combustion units can be installed; and, in some European countries where coal is not regarded as the likely substitute for oil in generating stations, as the feedstock for conversion plants producing gas and oil. Because of these developments, it is possible that annual coal consumption in Europe (including the USSR) may increase by about 600 million metric tons by the year 2000, an increase of about 50 percent.

The major questions surrounding this substitution of coal for oil concern how quickly and to what extent it will occur, and the probable effects on the environment. The purpose of this paper is to sketch the general shifts in the patterns of energy use which have already occurred, and to describe what might occur in the next two decades. No attempt has been made to do this by considering what might be most desirable from the environmental point of view; instead our approach has been to follow what seems to be the likely progression of fuel use, and then attempt to predict what this pattern of energy consumption will mean in terms of sulfur emissions and depositions in Europe, in the absence of significant new emission control measures. Finally, we have gone on to consider the available sulfur control technologies and to highlight the need for the establishment of strategies which provide the most effective and economic way of meeting environmental objectives. It is important to note that different policies and strategies will be required in different parts of Europe, because of different patterns of energy use and other economic factors, and that it is unrealistic to envisage a single program that would be effective everywhere. For example, in some countries it may be possible to increase the use of low-sulfur fuels; in other countries it may be more appropriate to employ emission control technologies.

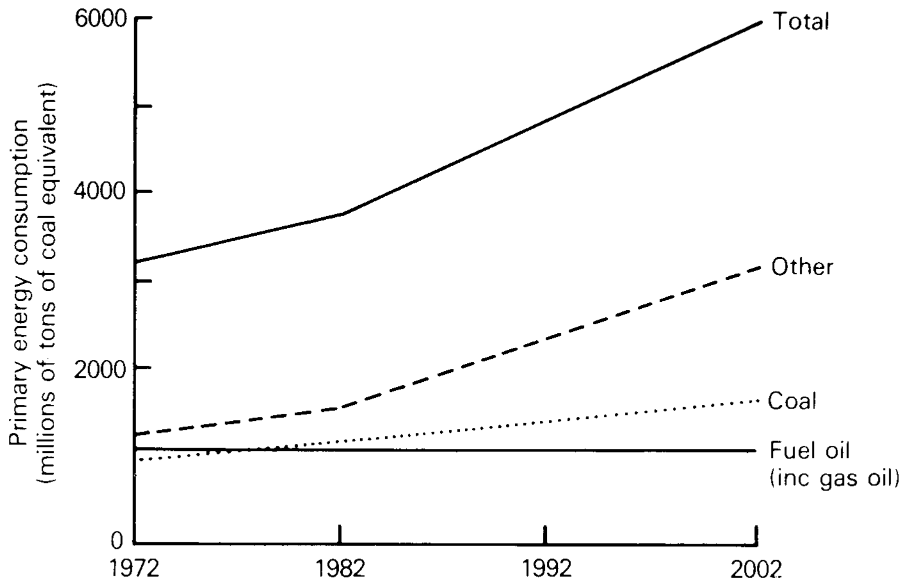
## COAL AND OIL USE IN EUROPE

Coal was the fuel of the first Industrial Revolution, and it was on coal that nations built their industrial power during the nineteenth and early twentieth centuries. As early as 1860 Great Britain was producing over 80 million tons of pit-coal, and by 1913 Great Britain, Germany, France and the USA together produced almost 90 percent of the coal extracted in the whole world; this production accounted for virtually all of the world's commercial energy supply (11). But by the end of the second World War this situation had changed considerably; coal's share of the world's commercial energy consumption was 61 percent in 1950, 51 percent in 1960, and about 35 percent in 1970. Solid fuels now account for no more than 30 percent of the total world energy supply, and only 21 percent in Western Europe (12).

Oil reached its largest share of total energy use, both in Europe and the world as a whole, in the early 1970's (13, 14); since then, its share of total energy consumption has been declining, largely because of major price increases. This shift in the pattern of energy use can be expected to continue as the adjustment to this change in energy prices proceeds. In addition, since 1970 the world has consumed more oil than has been found, which means that global oil stocks are now declining. This trend is likely to continue, despite reduced consumption and the increased incentives to exploration provided by high energy prices. The current fall in oil prices is not generally expected to continue beyond the middle of the 1980s. Because of these factors it is unlikely that oil will ever again have so large a share of total energy consumption as it enjoyed in the early part of the last decade.

Coal is the most likely candidate to replace oil, for a number of reasons. It is unlikely that "alternative" energy sources —solar, wind, and wave power, *etc*—will be able to provide a significant portion of Europe's energy requirements before the end of this century. The other alternative, nuclear power, has not developed as planned (4), and coal-fired generating stations are the most probable method of covering the shortfall. (This trend is already noticeable in European power stations, where coal use increased by 40 percent from 1975 to 1979 (11) while electricity production increased by about 20 percent). There are ample reserves of coal and they are widely distributed (8), and prices will remain competitive with oil. Production, transportation and utilization methods are well-known for coal, and no new technology is required. Finally, the environmental problems are fairly clearly defined, and capable of solution.

**Figure 1. European energy consumption by source, 1972–2002. (Sources in text).**




Sources: see text.

Figure 1 shows actual and projected energy consumption in Europe and the Soviet Union (described hereafter as "the Region" for brevity) from 1972 to 2002, by coal, fuel oil (including gas oil) and "other," a classification that includes natural gas, nuclear, hydropower, wood, petrol and other light petroleum products. The trends for the individual countries included in the composite projections in Figure 1 are shown in Table 1. It should be noted that the relative importance of oil is expected to decrease in all countries; the relative increase in coal utilization will be most marked in Western Europe, while the consumption of natural gas is expected to increase considerably in the Soviet Union over the next two decades.

These estimates of energy consumption

**Table 1. Consumption of commercial sources of primary energy in the Region: 1972, 1982, 1992 and 2002.** (In millions of tons of coal equivalent).

| | 1972 | | | | 1982 | | | | 1992 | | | | 2002 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coal | Fuel oil[1] | Other[2] | Total | Coal | Fuel oil[1] | Other[2] | Total | Coal | Fuel oil[1] | Other[2] | Total | Coal | Fuel oil[1] | Other[2] | Total |
| **Austria** | 5 | 12 | 12 | 29 | 5 | 14 | 13 | 32 | 9 | 19 | 16 | 44 | 13 | 15 | 25 | 53 |
| **Belgium** | 16 | 29 | 21 | 66 | 15 | 25 | 25 | 65 | 18 | 28 | 31 | 77 | 21 | 32 | 37 | 90 |
| **Bulgaria** | 16 | 8 | 6 | 30 | 18 | 15 | 13 | 46 | 28 | 23 | 23 | 74 | 39 | 29 | 34 | 102 |
| **Czechoslovakia** | 56 | 14 | 24 | 94 | 63 | 19 | 34 | 116 | 71 | 21 | 46 | 138 | 79 | 22 | 59 | 160 |
| **Denmark** | 2 | 24 | 2 | 28 | 6 | 17 | 7 | 30 | 11 | 16 | 8 | 35 | 16 | 14 | 9 | 39 |
| **FRG** | 124 | 143 | 102 | 369 | 113 | 126 | 147 | 386 | 148 | 98 | 196 | 442 | 182 | 70 | 246 | 498 |
| **Finland** | 3 | 15 | 4 | 22 | 5 | 15 | 5 | 25 | 9 | 12 | 6 | 27 | 14 | 8 | 6 | 28 |
| **France** | 50 | 112 | 66 | 228 | 46 | 100 | 93 | 239 | 53 | 68 | 156 | 277 | 60 | 36 | 219 | 315 |
| **GDR** | 80 | 14 | 12 | 106 | 81 | 17 | 26 | 124 | 86 | 17 | 33 | 136 | 90 | 17 | 41 | 148 |
| **Greece** | 2 | 8 | 5 | 15 | 5 | 12 | 3 | 20 | 10 | 16 | 9 | 35 | 15 | 19 | 16 | 50 |
| **Hungary** | 13 | 8 | 7 | 28 | 12 | 12 | 14 | 38 | 14 | 13 | 18 | 45 | 16 | 14 | 23 | 53 |
| **Ireland** | 3 | 5 | 4 | 12 | 2 | 5 | 6 | 13 | 4 | 8 | 11 | 23 | 5 | 12 | 16 | 33 |
| **Italy** | 11 | 99 | 70 | 180 | 13 | 92 | 84 | 189 | 18 | 89 | 133 | 240 | 23 | 85 | 183 | 291 |
| **Luxembourg** | 3 | 2 | 2 | 7 | 2 | 2 | 1 | 5 | 3 | 2 | 1 | 6 | 3 | 2 | 1 | 6 |
| **Netherlands** | 4 | 22 | 49 | 75 | 5 | 22 | 54 | 81 | 8 | 25 | 66 | 99 | 12 | 27 | 78 | 117 |
| **Norway** | 1 | 8 | 15 | 24 | 1 | 8 | 16 | 25 | 2 | 9 | 20 | 31 | 2 | 10 | 26 | 38 |
| **Poland** | 110 | 8 | 25 | 143 | 161 | 14 | 26 | 201 | 180 | 14 | 40 | 234 | 199 | 14 | 54 | 267 |
| **Portugal** | 1 | 3 | 2 | 6 | 1 | 5 | 3 | 9 | 2 | 7 | 6 | 15 | 3 | 10 | 8 | 21 |
| **Rumania** | 12 | 10 | 40 | 62 | 18 | 17 | 54 | 89 | 25 | 21 | 77 | 123 | 32 | 25 | 101 | 158 |
| **Spain** | 14 | 32 | 22 | 68 | 20 | 46 | 28 | 94 | 35 | 52 | 61 | 148 | 50 | 58 | 94 | 202 |
| **Sweden** | 2 | 36 | 12 | 50 | 2 | 29 | 21 | 52 | 7 | 23 | 24 | 54 | 13 | 15 | 28 | 56 |
| **Switzerland** | 1 | 15 | 7 | 23 | 0 | 14 | 9 | 23 | 1 | 16 | 12 | 29 | 1 | 19 | 15 | 35 |
| **Turkey** | 6 | 14 | 9 | 31 | 7 | 17 | 11 | 35 | 14 | 49 | 42 | 105 | 22 | 80 | 72 | 174 |
| **USSR** | 287 | 253 | 597 | 1137 | 403 | 330 | 759 | 1492 | 485 | 371 | 1180 | 2036 | 568 | 411 | 1602 | 2581 |
| **UK** | 118 | 110 | 125 | 353 | 116 | 48 | 140 | 304 | 132 | 51 | 148 | 331 | 149 | 53 | 157 | 359 |
| **Yugoslavia** | 17 | 10 | 8 | 35 | 20 | 15 | 12 | 47 | 37 | 19 | 22 | 78 | 54 | 22 | 33 | 109 |
| **Total** | **957** | **1033** | **1248** | **3219** | **1140** | **1036** | **1604** | **3780** | **1410** | **1087** | **2385** | **4882** | **1681** | **1119** | **3183** | **5983** |

[1] Includes gas oil. [2] Includes nuclear, hydro, wood, natural gas, petrol and other light petroleum products.

Sources: see text.

**Table 3. Current emissions and depositions of $SO_2$ by country.** (Thousands of metric tons per annum)

| Receivers \ Emitters | Austria | Belgium | Bulgaria | Czechoslovakia | Denmark | FRG | Finland | France | GDR | Greece* | Hungary | Ireland* | Italy | Luxembourg* | Netherlands | Norway | Poland | Portugal* | Rumania | Spain | Sweden | Switzerland | Turkey | USSR* | UK | Yugoslavia* | Unidentified + other areas | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 151 | 9 | – | 92 | – | 66 | – | 39 | 54 | – | 33 | – | 96 | – | 5 | – | 23 | – | – | 6 | – | 7 | – | – | 18 | 19 | 72 | **690** |
| Belgium | – | 198 | – | – | – | 50 | – | 55 | 5 | – | – | – | – | – | 10 | – | – | – | – | – | – | – | – | – | 41 | – | 21 | **380** |
| Bulgaria | – | – | 270 | 21 | – | 9 | – | 4 | 14 | 10 | 29 | – | 14 | – | – | – | 13 | – | 98 | – | – | – | 6 | 79 | 5 | 25 | 70 | **667** |
| Czechoslovakia | 64 | 30 | 4 | 1266 | 6 | 223 | – | 88 | 438 | – | 157 | – | 67 | – | 18 | – | 170 | – | 41 | 13 | – | 5 | – | 89 | 73 | 29 | 218 | **2999** |
| Denmark | – | – | – | 8 | 109 | 23 | – | 6 | 28 | – | – | – | – | – | – | – | 7 | – | – | – | – | – | – | – | 25 | – | 26 | **232** |
| FRG | 23 | 110 | – | 126 | 12 | 1160 | – | 211 | 265 | – | 14 | – | 41 | 7 | 57 | – | 32 | – | – | 19 | – | 14 | – | 18 | 165 | 8 | 192 | **2474** |
| Finland | – | 6 | – | 22 | 8 | 31 | 260 | 10 | 43 | – | 7 | – | 4 | – | 5 | 6 | 27 | – | 6 | – | 37 | – | – | 270 | 32 | 2 | 132 | **908** |
| France | – | 97 | – | 21 | – | 203 | – | 1232 | 45 | – | – | 11 | 70 | 6 | 30 | – | 7 | – | – | 201 | – | 18 | – | – | 226 | 3 | 398 | **2568** |
| GDR | – | 25 | – | 146 | 8 | 176 | – | 41 | 1117 | – | 10 | – | 6 | – | 16 | – | 41 | – | – | – | – | – | – | 18 | 51 | 3 | 62 | **1720** |
| Greece | – | – | 60 | 90 | 12 | 6 | – | 6 | 7 | 137 | 12 | – | 24 | – | – | – | 4 | – | 23 | 6 | – | – | 9 | 24 | – | 15 | 84 | **519** |
| Hungary | 25 | – | – | 120 | – | 27 | – | 14 | 40 | – | 448 | – | 46 | – | – | – | 37 | – | 45 | – | – | – | – | 24 | 7 | 42 | 48 | **923** |
| Ireland | – | – | – | – | – | – | – | 4 | – | – | – | 96 | – | – | – | – | – | – | – | – | – | – | – | – | 28 | – | 62 | **190** |
| Italy | 17 | 6 | – | 32 | – | 46 | – | 104 | 24 | – | 25 | – | 1357 | – | – | – | 10 | – | 8 | 52 | – | 16 | – | 13 | 20 | 36 | 223 | **1989** |
| Luxembourg | – | – | – | – | – | 4 | – | 6 | – | – | – | – | – | 4 | – | – | – | – | – | – | – | – | – | – | – | – | – | **14** |
| Netherlands | – | 47 | – | 5 | – | 93 | – | 29 | 13 | – | – | – | – | – | 99 | – | – | – | – | – | – | – | – | – | 62 | – | 26 | **374** |
| Norway | – | 12 | – | 21 | 16 | 41 | 7 | 21 | 50 | – | 5 | – | – | – | 7 | 61 | 18 | – | – | – | 26 | – | – | 50 | 92 | 1 | 178 | **606** |
| Poland | 20 | 21 | 5 | 356 | 22 | 165 | – | 51 | 478 | – | 99 | – | 31 | – | 17 | – | 1012 | – | 37 | 6 | 10 | – | – | 215 | 73 | 22 | 185 | **2825** |
| Portugal | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 72 | – | 52 | – | – | – | – | – | – | 70 | **194** |
| Rumania | 10 | – | 53 | 97 | – | 33 | – | 14 | 58 | 6 | 164 | – | 46 | – | – | – | 68 | – | 822 | – | – | – | 9 | 301 | 13 | 64 | 144 | **1902** |
| Spain | – | 6 | – | – | – | 41 | – | 74 | 9 | – | – | – | 4 | – | 7 | – | – | 35 | – | 1121 | – | – | – | – | 34 | – | 266 | **1597** |
| Sweden | – | 15 | – | 47 | 44 | 72 | 34 | 29 | 95 | – | 12 | – | 7 | – | 12 | 24 | 55 | – | 8 | – | 218 | – | – | 152 | 80 | 4 | 271 | **1179** |
| Switzerland | – | – | – | 5 | – | 27 | – | 45 | 7 | – | – | – | 81 | – | – | – | – | – | – | 6 | – | 32 | – | – | 11 | 2 | 41 | **257** |
| Turkey | – | – | 49 | 13 | – | 10 | – | 6 | 13 | 29 | 16 | – | 22 | – | – | – | 9 | – | 35 | 9 | – | – | 360 | 107 | – | 12 | 190 | **880** |
| USSR | 41 | 53 | 122 | 496 | 69 | 393 | 168 | 131 | 636 | 32 | 367 | 11 | 161 | 4 | 57 | 15 | 691 | – | 587 | 31 | 100 | 7 | 92 | 22674 | 236 | 115 | 264 | **27553*** |
| UK | – | 20 | – | 11 | – | 43 | – | 53 | 24 | – | – | 36 | 4 | – | 12 | – | 4 | – | – | 11 | – | – | – | – | 1545 | – | 173 | **1936** |
| Yugoslavia | 41 | 6 | 57 | 99 | – | 46 | – | 39 | 56 | 9 | 166 | – | 224 | – | 5 | – | 37 | – | 74 | 20 | – | – | – | 50 | 15 | 308 | 209 | **1461*** |
| Other areas | 38 | 149 | 150 | 276 | 144 | 522 | 101 | 578 | 481 | 117 | 156 | 106 | 765 | 9 | 133 | 34 | 235 | 33 | 216 | 537 | 119 | 21 | 174 | 1416 | 1398 | 120 | 281 | **8309** |
| **Total** | **430** | **810** | **770** | **3370** | **450** | **3510** | **570** | **2890** | **4000** | **340** | **1720** | **260** | **3070** | **30** | **490** | **140** | **2500** | **140** | **2000** | **2090** | **510** | **120** | **650** | **25500** | **4250** | **830** | **3906** | **65346** |

* Cases which are not within the estimates given in reference 20. However the proportions of emissions deposited in each country are the same.

Sources: see text.

are subject to a number of uncertainties, particularly in the breakdown between individual fuels in each country. The projections beyond 1982 in Figure 1 are in line with ECE estimates (14) and assume a slower rate of growth than during the postwar period, following prolonged recession and a reduction in energy consumption per unit of Gross National Product (13, 14). However, it should be noted that the relationship between economic growth and energy consumption is difficult to predict, since it depends on technical developments in industry, transport, and other energy-consuming sectors of the economy. Table 1 is based on ECE estimates, as well as other sources (10, 15, 16). The projections for coal consumption broadly correspond to the "high scenario" of IIASA (17) for the period to the year 2000, and to the "low" case produced by WOCOL (8). These projections are considerably higher than the IIASA "low scenario," which depends on the pursuit of vigorous energy conservation policies which we consider unlikely. The inherent difficulties involved in making projections are underlined by the fact that in all countries forecasts of economic growth and energy use are continually revised in the light of new events.

## EMISSIONS OF SULFUR OXIDES

Table 2 shows estimated emissions of $SO_x$ in the Region for 1972 and 1982, and projections for 1992 and 2002, by country. Where available, emission data for individual countries have been used (18); otherwise emissions have been calculated from the past and probable future sulfur content of coal and oil used in each country (15, 19), and on the basis of the projections of future energy use given in Table 1.

A number of observations are immediately obvious. First, there has been no reduction in total emissions from 1972 to 1982, although a number of nations—Austria, Belgium, Denmark, West Germany, France, Ireland, Italy, the Netherlands, Norway, Poland, Sweden, Switzerland and the UK—have reduced their emissions to a greater or lesser extent, due to shifts in energy sources, economic recession, or specific emission control measures. Second, in the absence of significant new emission controls, total emissions in the Region may increase by about one third over the next two decades as a result of increased coal use—despite the growth of other energy sources which do not result in significant sulfur emissions.

Such projections of sulfur emissions are becoming important—if not in detail, certainly in principle—in discussions of European energy options. But a great deal of controversy still surrounds a related, and perhaps more important question: where are sulfur emissions finally deposited?

## DEPOSITIONS OF $SO_X$: 1982 and 2002

Sulfur oxides may be transported over long distances before wet or dry deposition takes place. Depositions in any one country therefore depend on the overall pattern of emissions over the whole Region, and on the manner in which long-range transport of $SO_x$ occurs.

The relationship between emissions and depositions is complex, and depends on meteorological variables. Models have been developed and tested which enable predictions of $SO_x$ depositions to be made (20). However these are subject to considerable uncertainties, and are said to be accurate within a factor of two. The emissions and the pattern of depositions shown in Table 3 are generally within the range of the estimates given in EMEP (20). They provide an indication of the contribution of emissions in one country to depositions in another, based on meteorological conditions prevailing in 1979 and 1980.

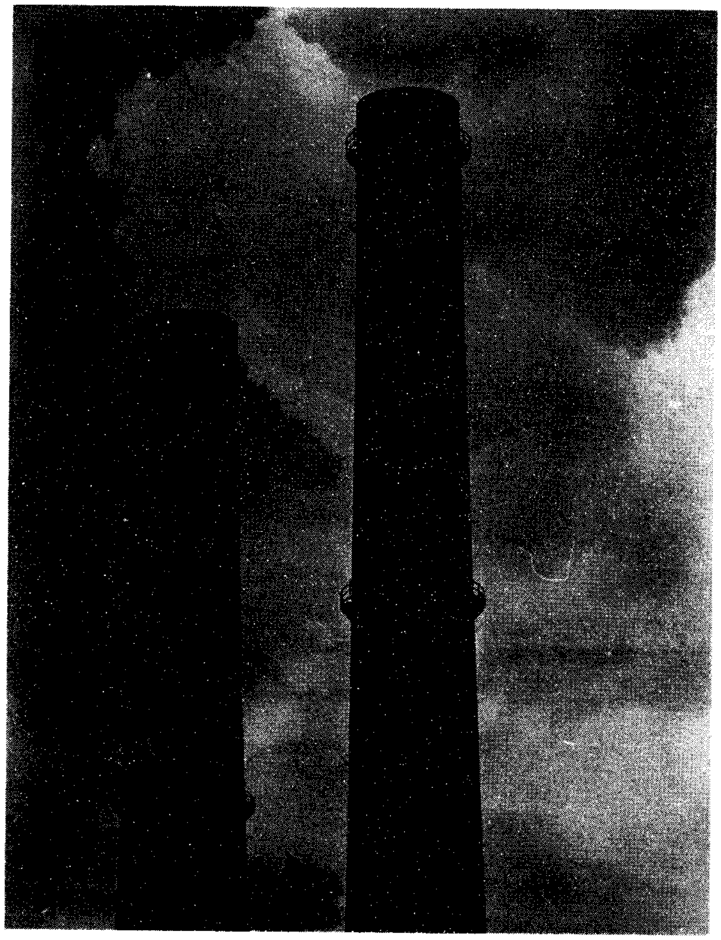
Table 4 shows estimated depositions in 2002, incorporating the expected changes in the pattern of energy consumption and $SO_x$ emissions, and assuming the same factors controlling patterns of deposition. Depositions due to unidentified sources are assumed to remain constant.

With the exception of France, Belgium and Luxembourg, a significant increase in depositions of $SO_2$ is indicated, rising in Europe as a whole from 57 million metric tons in 1982 to about 74 million metric tons in 2002. It should be noted that countries which take measures to reduce their own sulfur emissions may not achieve the full benefit of that action because of depositions from other countries. In Sweden, for example, our estimates indicate that a considerable reduction in their emissions is not likely to lead to a reduction in total depositions in Sweden by 2002. Table 5 summarizes the likely change in both emissions and depositions of $SO_x$ in each country of the Region.

## EMISSION CONTROL METHODS AND STRATEGIES

To this point we have discussed the likely changes in sulfur emissions over the next two decades in the absence of new abatement policies. However there are a number of strategies which could be used to reduce these emissions and depositions. The options include more efficient use of energy, and consequently lower fuel use; shifts toward the use of cleaner fuels, including the use of coal with a naturally low sulfur content; fuel de-sulfurization, (*ie* coal cleaning procedures to reduce sulfur content); and control of sulfur emissions during or after combustion, usually through flue gas desulfurization (FGD), coal-limestone combustion methods (including fluidized bed combustion and limestone-coal pelleting) and, in the longer term, coal gasification and liquefaction procedures.

Not all of these methods will be appropriate to all countries in the Region. The availability and cost of low-sulfur coal, the costs of coal cleaning, the installation costs of FGD equipment, the level of technological expertise and even geographical location will all affect the choice of abatement policies. It should be noted that from a regional viewpoint, an efficient strategy for reducing depositions on ecologically-sensitive areas may not involve all countries reducing their emissions in the same proportion. For example, a country with no indigenous coal supplies might opt for imports of low-sulfur coal. But if that fuel is in limited supply and the country is situated "down-wind," a more efficient regional strategy might be to leave the sup-



**The imbalance in the international "trade" in $SO_2$ underlines the obstacles in the path of a coordinated, region-wide abatement policy. There are 26 countries in the Region, and 11 of them—Czechoslovakia, West Germany, France, East Germany, Hungary, Italy, Rumania, Spain, the UK, Poland and the USSR—are responsible for almost 85 percent of total $SO_2$ emissions. All except the USSR and Poland are net exporters of $SO_2$. For these nations, the inducements to join a regional abatement program are reduced, since for them the costs are proportionally higher and the benefits proportionally lower. Yet no abatement program could be successful without their participation.**

**Table 4. Estimated emissions and depositions of $SO_2$ by country in 2002.** (Thousands of metric tons per annum)

| Receivers (rows) / Emitters (columns) | Austria | Belgium | Bulgaria | Czechoslovakia | Denmark | FRG | Finland | France | GDR | Greece | Hungary | Ireland | Italy | Luxembourg | Netherlands | Norway | Poland | Portugal | Rumania | Spain | Sweden | Switzerland | Turkey | USSR | UK | Yugoslavia | Unidentified + other areas | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 253 | 10 | – | 114 | – | 74 | – | 21 | 59 | – | 42 | – | 105 | – | 6 | – | 28 | – | – | 11 | – | 11 | – | – | 22 | 44 | 72 | **872** |
| Belgium | – | 213 | – | – | – | 56 | – | 30 | 5 | – | – | – | – | – | 13 | – | – | – | – | – | – | – | – | – | 51 | – | 21 | **389** |
| Bulgaria | – | – | 561 | 26 | – | 10 | – | 2 | 15 | 22 | 37 | – | 15 | – | – | – | 16 | – | 164 | – | – | – | 18 | 107 | 6 | 58 | 70 | **1127** |
| Czechoslovakia | 107 | 32 | 8 | 1570 | 8 | 250 | – | 48 | 482 | – | 198 | – | 73 | – | 23 | – | 209 | – | 69 | 23 | – | 8 | – | 121 | 90 | 67 | 218 | **3604** |
| Denmark | – | – | – | 10 | 140 | 26 | – | 3 | 31 | – | – | – | – | – | – | – | 9 | – | – | – | – | – | – | – | 31 | – | 26 | **276** |
| FRG | 39 | 118 | – | 156 | 15 | 1299 | – | 115 | 291 | – | 18 | – | 45 | 9 | 73 | – | 39 | – | – | 34 | – | 21 | – | 24 | 204 | 18 | 192 | **2710** |
| Finland | – | 6 | – | 27 | 10 | 35 | 287 | 5 | 47 | – | 9 | – | 4 | – | 6 | 8 | 33 | – | 10 | – | 26 | – | – | 366 | 40 | 5 | 132 | **1056** |
| France | – | 104 | – | 26 | – | 227 | – | 674 | 49 | – | – | 27 | 76 | 8 | 39 | – | 9 | – | – | 359 | – | 27 | – | – | 280 | 7 | 398 | **2310** |
| GDR | – | 27 | – | 181 | 10 | 197 | – | 22 | 1229 | – | 13 | – | 7 | – | 21 | – | 50 | – | – | – | – | – | – | 24 | 63 | 7 | 62 | **1913** |
| Greece | – | – | 125 | 112 | 15 | 7 | – | 3 | 8 | 298 | 15 | – | 26 | – | – | – | 5 | – | 39 | 11 | – | – | 27 | 33 | – | 35 | 84 | **843** |
| Hungary | 42 | – | – | 149 | – | 30 | – | 8 | 44 | – | 565 | – | 50 | – | – | – | 45 | – | 75 | – | – | – | – | 33 | 9 | 97 | 48 | **1195** |
| Ireland | – | – | – | – | – | – | – | 2 | – | – | – | 236 | – | – | – | – | – | – | – | – | – | – | – | – | 35 | – | 62 | **335** |
| Italy | 28 | 6 | – | 40 | – | 52 | – | 57 | 26 | – | 32 | – | 1481 | – | – | – | 12 | – | 13 | 93 | – | 24 | – | 18 | 25 | 83 | 223 | **2213** |
| Luxembourg | – | – | – | – | – | 4 | – | 3 | – | – | – | – | – | 5 | – | – | – | – | – | – | – | – | – | – | – | – | – | **12** |
| Netherlands | – | 50 | – | 6 | – | 104 | – | 16 | 14 | – | – | – | – | – | 127 | – | – | – | – | – | – | – | – | – | 77 | – | 26 | **420** |
| Norway | – | 13 | – | 26 | 21 | 46 | 8 | 11 | 55 | – | 6 | – | – | – | 9 | 78 | 22 | – | – | – | 18 | – | – | 68 | 114 | 2 | 178 | **675** |
| Poland | 33 | 23 | 10 | 442 | 28 | 185 | – | 28 | 526 | – | 125 | – | 34 | – | 22 | – | 1243 | – | 62 | 11 | 7 | – | – | 292 | 90 | 51 | 185 | **3397** |
| Portugal | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 133 | – | 93 | – | – | – | – | – | – | 70 | **296** |
| Rumania | 17 | – | 110 | 120 | – | 37 | – | 8 | 64 | 13 | 207 | – | 50 | – | – | – | 84 | – | 1377 | – | – | – | 27 | 408 | 16 | 147 | 144 | **2829** |
| Spain | – | 6 | – | – | – | 46 | – | 40 | 10 | – | – | – | 4 | – | 9 | – | – | 65 | – | 2001 | – | – | – | – | 42 | – | 266 | **2489** |
| Sweden | – | 16 | – | 58 | 57 | 81 | 38 | 16 | 104 | – | 15 | – | 8 | – | 15 | 31 | 67 | – | 13 | – | 154 | – | – | 206 | 99 | 9 | 271 | **1258** |
| Switzerland | – | – | – | 6 | – | 30 | – | 25 | 8 | – | – | – | 88 | – | – | – | – | – | – | 11 | – | 48 | – | – | 14 | 5 | 41 | **276** |
| Turkey | – | – | 102 | 16 | – | 11 | – | 3 | 14 | 63 | 20 | – | 24 | – | – | – | 11 | – | 59 | 16 | – | – | 1091 | 145 | – | 28 | 190 | **1793** |
| USSR | 69 | 57 | 254 | 615 | 89 | 440 | 186 | 72 | 700 | 70 | 463 | 27 | 176 | 5 | 73 | 19 | 849 | – | 983 | 55 | 71 | 10 | 279 | 30766 | 292 | 265 | 264 | **37149** |
| UK | – | 21 | – | 14 | – | 48 | – | 29 | 26 | – | – | 89 | 4 | – | 15 | – | 5 | – | – | 20 | – | – | – | – | 1912 | – | 173 | **2356** |
| Yugoslavia | 69 | 6 | 118 | 123 | – | 52 | – | 21 | 62 | 20 | 209 | – | 244 | – | 6 | – | 45 | – | 124 | 36 | – | – | – | 68 | 19 | 709 | 209 | **2140** |
| Other areas | 63 | 162 | 312 | 343 | 187 | 583 | 111 | 318 | 531 | 254 | 196 | 261 | 836 | 13 | 173 | 44 | 289 | 62 | 362 | 956 | 84 | 31 | 528 | 1921 | 1729 | 273 | 281 | **10903** |
| **Total** | **720** | **870** | **1600** | **4180** | **580** | **3930** | **630** | **1580** | **4400** | **740** | **2170** | **640** | **3350** | **40** | **630** | **180** | **3070** | **260** | **3350** | **3730** | **360** | **180** | **1970** | **34600** | **5260** | **1910** | **3906** | **84836** |

plies of low-sulfur fuel for "up-wind" countries whose emissions would otherwise be widely distributed.

Countries with abundant coal deposits, mainly of high sulfur content, will be more likely to opt for fuel cleaning, or for emission control measures after combustion. These choices will depend on a number of economic and technical factors. Political, social, and even ethical considerations will also affect the final choice of abatement policies. What does seem clear, however, is that it is unlikely that any blanket strategy would provide a rational means of reaching the environmental objective of reduced sulfur depositions on ecologically sensitive areas.

The economic aspects of sulfur abatement policies for individual nations have been worked out in some detail (21) and the implications of those considerations for the UK are discussed on page 336 of this issue (22). In general, that discussion shows that in the UK an efficient strategy for reducing present $SO_2$ emissions by about one third would involve some reduction in electricity consumption, inclusion of FGD on all new coal-fired generating capacity, including that under construction, and retrofitting such equipment on large power plants, and the use of fuel oil desulfurization at oil refineries. The cost would be about £350 million annually, or about two percent of total annual expenditure on energy by final users.

**Table 2. Emission of sulfur dioxide in the Region: 1972, 1982, 1992 and 2002 (in millions of metric tons).**

| | 1972 | 1982 | 1992 | 2002 |
|---|---|---|---|---|
| **Austria** | 0.70 | 0.43 | 0.57 | 0.72 |
| **Belgium** | 1.14 | 0.81 | 0.84 | 0.87 |
| **Bulgaria** | 0.68 | 0.77 | 1.18 | 1.60 |
| **Czechoslovakia** | 2.91 | 3.37 | 3.78 | 4.18 |
| **Denmark** | 0.62 | 0.45 | 0.51 | 0.58 |
| **FRG** | 3.91 | 3.51 | 3.72 | 3.93 |
| **Finland** | 0.55 | 0.57 | 0.60 | 0.63 |
| **France** | 3.22 | 2.89 | 2.24 | 1.58 |
| **GDR** | 4.00 | 4.00 | 4.20 | 4.40 |
| **Greece** | 0.20 | 0.34 | 0.54 | 0.74 |
| **Hungary** | 1.50 | 1.72 | 1.94 | 2.17 |
| **Ireland** | 0.33 | 0.26 | 0.45 | 0.64 |
| **Italy** | 3.17 | 3.07 | 3.21 | 3.35 |
| **Luxembourg** | 0.05 | 0.03 | 0.04 | 0.04 |
| **Netherlands** | 0.78 | 0.49 | 0.50 | 0.63 |
| **Norway** | 0.18 | 0.14 | 0.14 | 0.18 |
| **Poland** | 3.00 | 2.50 | 2.78 | 3.07 |
| **Portugal** | 0.11 | 0.14 | 0.20 | 0.26 |
| **Rumania** | 0.85 | 2.00 | 2.67 | 3.35 |
| **Spain** | 1.30 | 2.09 | 2.91 | 3.73 |
| **Sweden** | 0.83 | 0.51 | 0.33 | 0.36 |
| **Switzerland** | 0.15 | 0.12 | 0.14 | 0.18 |
| **Turkey** | 0.60 | 0.65 | 1.31 | 1.97 |
| **USSR** | 23.50 | 25.50 | 30.05 | 34.60 |
| **UK** | 5.61 | 4.25 | 4.75 | 5.26 |
| **Yugoslavia** | 0.65 | 0.83 | 1.37 | 1.91 |
| **Total** | **60.54** | **61.44** | **70.97** | **80.93** |

Sources: see text.

**Table 5. Changes in emissions and depositions of sulfur oxides 1982–2002**

| | percent change in emissions: 1982–2002 | percent change in depositions: 1982–2002 |
|---|---|---|
| Austria | 67 | 26 |
| Belgium | 7 | 2 |
| Bulgaria | 108 | 69 |
| Czechoslovakia | 24 | 20 |
| Denmark | 29 | 19 |
| FRG | 12 | 10 |
| Finland | 11 | 16 |
| France | −45 | −10 |
| GDR | 10 | 11 |
| Greece | 118 | 62 |
| Hungary | 26 | 29 |
| Ireland | 146 | 76 |
| Italy | 9 | 12 |
| Luxembourg | 33 | −14 |
| Netherlands | 29 | 12 |
| Norway | 29 | 11 |
| Poland | 23 | 20 |
| Portugal | 86 | 53 |
| Rumania | 67 | 49 |
| Spain | 78 | 56 |
| Sweden | −29 | 7 |
| Switzerland | 50 | 7 |
| Turkey | 203 | 104 |
| USSR | 36 | 35 |
| UK | 24 | 22 |
| Yugoslavia | 130 | 46 |

## FUTURE PROSPECTS

The projections we have presented here, which are derived from official estimates, do not suggest extreme increases in sulfur emissions for the Region as a whole over the course of the next two decades. This is no basis for complacency, however, and should not obscure the fact that in some countries there are likely to be large increases in sulfur emissions and depositions. Nor should it be taken to suggest that the overall increases will have only insignificant effects. Indeed, we see the scale of the predicted increases in emissions and depositions as underlining the need for concerted, collective action for the development and implementation of control strategies for the Region as a whole. As a matter of priority this will require the development of effective sulfur control strategies for each country. Some steps have already been taken in the direction of collective action for parts of the Region (see p 371) but it is clear that effective control of sulfur depositions can only be achieved through co-operative efforts involving the entire Region. It also seems clear that nations can not singly hope to control sulfur depositions in their territories without the assistance of their neighbors, and in the absence of Region-wide sulfur abatement programs.

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# Controlling the Emission of Sulfur Compounds in the United Kingdom: Is It Worth the Cost?

Smokestacks in the United Kingdom have emitted between 5 and 6 million metric tons of sulfur each year since 1955, which makes the UK the largest source of sulfur emissions in Western Europe. Most of these emissions come from the combustion of coal, especially that used to generate electricity in coal-fired power stations, which burn about 70 percent of the coal consumed in the UK. And it is coal that on average contains half again as much sulfur (1.5 percent) as that burned by industrial consumers. As a result, while there has been a slight reduction in total sulfur emissions in the UK over the past decade—due to a general economic recession and increasing use of sulfur-free natural gas (which now supplies 20 percent of the UK's primary energy consumption) rather than to any abatement program; in fact the UK makes no effort to limit aggregate emissions—the amount attributable to coal-fired power stations has increased (Figure 1).

By using established desulfurization techniques and by emphasizing the use of "cleaner" fuels, these emissions could be reduced by as much as one-third by the end of this century. But a reduction on that scale would cost about £400 million per year, or about 2.5 percent of consumer expenditure on energy. Since the UK is a net exporter of sulfur (Table 1), much of the benefit would be felt in other countries, although there would also be advantages to the UK. However, it is extremely difficult to assign economic values to the environmental benefits arising from a reduction in $SO_x$ emissions, which makes arguments for the implementation of the necessary measures less concrete, and thus less convincing.

In the absence of measures specifically aimed at abatement, emissions of $SO_x$ over the next two decades will depend on the rate of growth of the economy and developments in UK energy policy, including the nuclear power program. The sulfur content of fuels can be expected to remain constant. The projection for the year 2000 shown in Figure 2 (case A) represents the result of consumption paths for electricity, coal, oil and gas which are estimated to be most economic in the absence of any requirement for $SO_x$ abatement (1). The average rate of growth of Gross Domestic Product

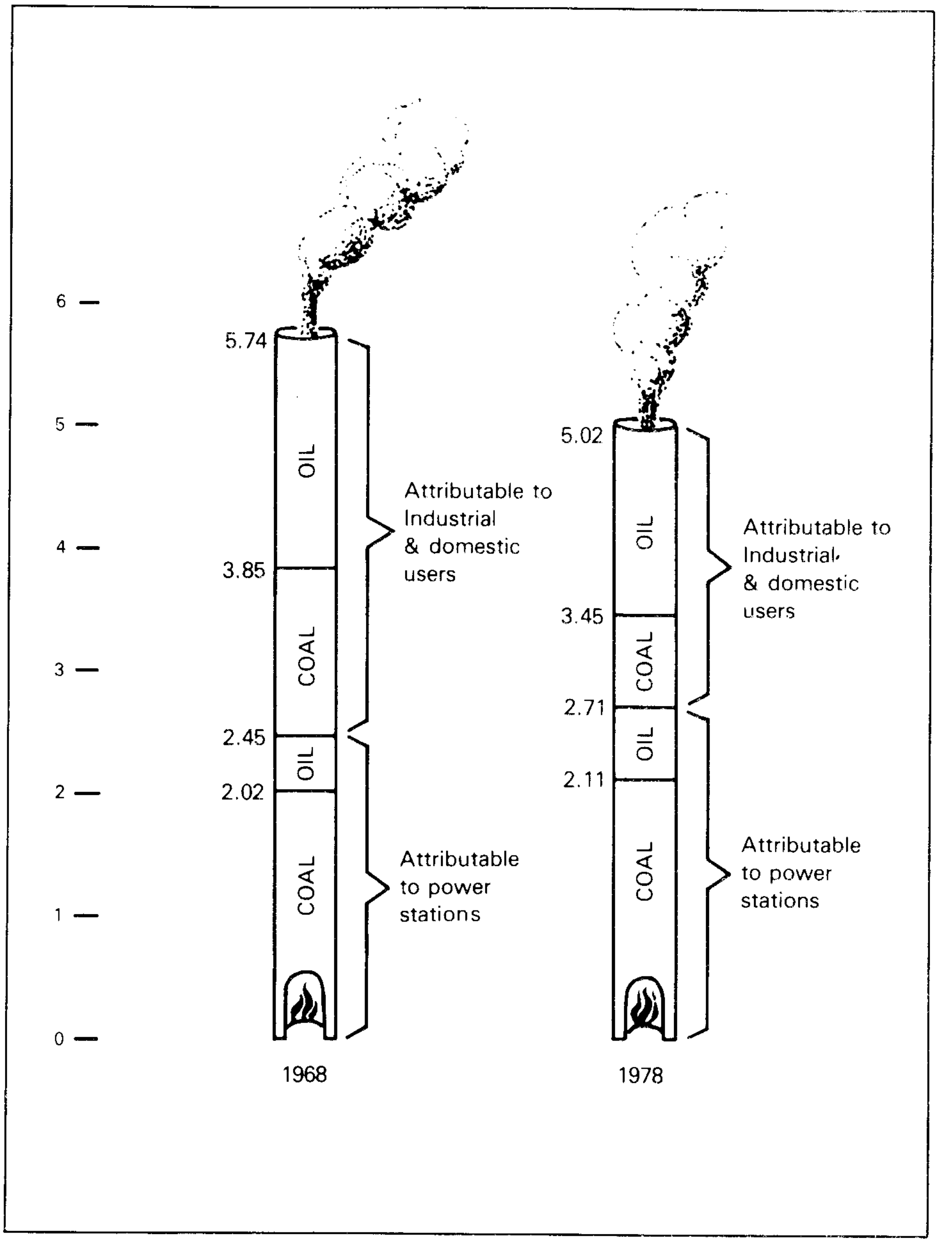



**Figure 1. $SO_x$ emissions in the UK 1968–1978 (in millions of metric tons). Note that there was a substantial increase in the use of natural gas during this period.**

**Table 1. Budget for dry plus wet depositions of sulfur based on estimates by the OECD for 1974. Accurate to within ±50 percent. Units are $10^5$ metric tons.**

| Receivers: / Emitters: | FRG, N, D | F, Sw, B | N | S | Fi | UK, Ir | Other[1] | Total |
|---|---|---|---|---|---|---|---|---|
| West Germany, Netherlands, Denmark (FRG, N, D) | 16 | 4 | 0 | 0 | 0 | 3 | 5 | **28** |
| France, Switzerland, Belgium (F, Sw, B) | 3 | 17 | 0 | 0 | 0 | 3 | 6 | **29** |
| Norway (N) | 0 | 0 | 1 | 0 | 0 | 1 | 2 | **4** |
| Sweden (S) | 1 | 0 | 0 | 2 | 0 | 1 | 4 | **8** |
| Finland (Fi) | 0 | 1 | 0 | 1 | 2 | 0 | 4 | **8** |
| UK. Ireland (UK, Ir) | 3 | 1 | 0 | 0 | 0 | 16 | 2 | **22** |
| Other[1] | 10 | 5 | 0 | 1 | 1 | 12 | – | **29** |
| **Total** | **33** | **28** | **1** | **4** | **3** | **36** | **23** | **128** |

[1] Includes Italy, Czechoslovakia, German Democratic Republic, Poland and other areas.
Source: Reference 7.

(GDP) up to the year 2000 is assumed to be 2 percent per annum. $SO_x$ emissions by the turn of the century would then be 5.4 million metric tons (2).

Three additional projections of $SO_x$ emissions are shown in Figure 2 for the year 2000 (cases B, C, and D). These could be met, at increasing cost for successive reductions, by combining various options in different ways. Case B could be met most efficiently (in economic terms) by desulfurizing a proportion of power station coal and by reducing oil and coal consumption in industry by a small amount. In 2000, $SO_x$ emissions would be reduced by seven percent at a cost of £45 million per annum. Case C could be met most efficiently by combining coal separation with desulfurization of combustion gases on a limited number of coal-fired power stations, as well as by reducing electricity production by five percent. $SO_x$ emissions would be reduced by 13 percent at a cost of about £90 million per annum.

A reduction of 37 percent in $SO_x$ emissions (case D) could be achieved by reducing electricity production by more than 10 percent, by installing combustion gas desulfurization equipment on large power stations, and through fuel oil desulfurization at refineries. The cost would be about £400 million per annum and the impact on the electricity industry would be significant compared with other important factors—about the same as the effect of decreasing the rate of economic growth from three percent to two percent per annum. These cost estimates are necessarily subject to a degree of uncertainty; in all cases it is assumed that the nuclear power program would be unaffected by requirements to reduce $SO_x$ emissions.

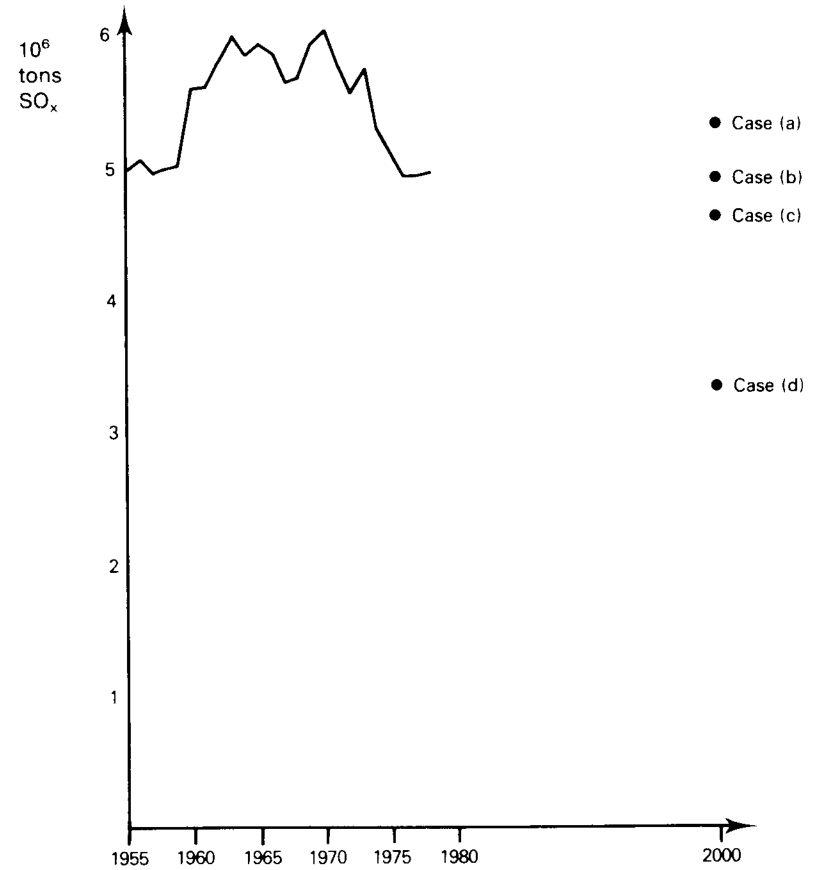
## THE COSTS OF REDUCING EMISSIONS

A coal-fired power station of 2000 MW emits about 130 000 metric tons of $SO_x$ per annum and it is the transport of these emissions over long distances that is the main concern, although the extent to which this occurs is uncertain. It should be noted that the estimates in Table 1 are subject to a very high degree of uncertainty (±50 percent); furthermore considerable variation can occur in the pattern of depositions from one year to another with changes in wind and precipitation. Nevertheless, these emissions could be substantially reduced at source with well established technology, in particular flue gas desulfurization (FGD) and desulfurization of oil and coal before combustion (3).

FGD involves forcing the combustion gases of coal or oil through an appropriate solution or slurry; on average, 80 percent of $SO_x$ emissions can be eliminated by this method. Since FGD entails high fixed capital costs, it would be most efficient to use it on the largest sources, that is 2000 MW power stations. If $SO_x$ control were required for power stations in the UK, electricity authorities would favor regenerable processes which recover sulfur or sulfuric acid and minimize waste disposal requirements. The estimated capital cost for including this type of FGD process on a new coal-fuel power station is £135 million; the estimated operating cost is 0.2 pence/kWh (4). This represents 10 to 20 percent of the total costs of constructing and operating a power station. Capital costs of FGD would be increased by approximately 20 percent if retrofitting were required on an existing installation. FGD could also be included on oil-fired power stations. Capital and operating costs would be lower than for coal-fired stations, but oil-fired power stations are generally operated less intensively (because of relative fuel costs) so $SO_x$ abatement costs per ton removed would not be substantially different.

A constraint on the use of FGD would be the possible rate of construction. Installation of the necessary equipment at one large plant per year has been suggested as feasible; at that rate, only half of all conventional generating capacity would be fitted with FGD by the year 2000. Much of the remainder would be smaller power stations, for which abatement costs would be greater.

**Figure 2. $SO_x$ emissions in the UK, 1955–1978, and projections for the year 2000 assuming an average rate of economic growth of 2 per cent per annum. Case (A) would result from an estimated "ideal" pattern of energy consumption. Cases (B), (C) and (D) show the effect of three alternative abatement policies. Desulfurization costs would be approximately £45 million, £90 million and £400 million per annum respectively (1979 prices).**




Sources: "Digest of Environmental Statistics" H.M.S.O. London 1979 and reference 1.

## DESULFURIZATION OF COAL AND OIL

An alternative to FGD is coal desulfurization. There are many methods of physically washing coal which are mainly designed to remove dirt and to give a constant calorific content. At least half of power station coal is normally processed in this way. Extension of these practices could remove about 15 percent of sulfur. The abatement potential is therefore limited, but the cost would be low. The construction of new facilities for coal processing would involve considerable extra expense and would be more costly, in relation to the amount of $SO_x$ removed, than FGD.

With less elaborate extensions of coal processing it would be possible to separate coal into high and low sulfur streams but with no actual sulfur removal. Since the capital cost of FGD is insensitive to the sulfur content of fuel burned, and since the cost of this separation is low, a combination of techniques could be an economically efficient method of $SO_x$ control. The lower sulfur product would then be burned in conventional installations, possibly blended with other coal, and the high sulfur product would be burned in large power stations specially equipped with FGD. Estimated abatement costs per ton of $SO_x$ removed are lower than for FGD alone. However, the abatement potential with this combination would still be comparatively low, since only a limited amount of high sulfur coal would be obtained from these separation techniques.

Although the technology is proven, the desulfurization of fuel oil at refineries is not standard practice. Depending on the precise technique employed, up to 80 percent of the sulfur content can be removed at a cost, in terms of $SO_x$ abatement, which is comparable with standard FGD. However, not all crude oils can be treated, and the possible impact on total UK emissions would be less dramatic than policies directed towards coal.

The introduction of new combustion techniques like fluidized bed combustion in industry could also lead to some further reduction in $SO_x$ emissions, but this is a less well known technology and could apply only to new sources. There are also doubts whether technical developments would make fluidized bed combustion economic for large 2000 MW power stations. The projections shown in Figure 2 therefore take no account of this effect.

To some extent electricity, coal, gas and oil can be substituted for one another, as can energy-saving capital equipment. Limiting consumption of the more polluting fuels is therefore feasible, but involves economic costs. In practice, adjustments in the pattern of energy consumption could be brought about by revisions in energy pricing, so that consumers would in effect pay an implicit cost of environmental damage, in addition to the other costs of supplying energy.

## WHAT ARE THE BENEFITS?

In conventional economic terms, reductions are worthwhile if the marginal benefits exceed the marginal costs of abatement. The problem lies in the assessment of these benefits. In the three abatement policies discussed above, marginal abatement costs rise from £200 to £400 per metric ton of $SO_x$ removed. This may be compared with the benefits of abatement, which are tentatively estimated to lie in the range £80 to £800 per metric ton of $SO_x$ in OECD Europe (5). These estimates are intended to reflect the economic value of agricultural crop damage, corrosion of materials, acidification of waters and health effects. However the range of uncertainty is so wide that the comparison with abatement cost gives no indication whether the *net* economic costs of abatement would be positive or negative.

Estimates of the economic benefits of $SO_x$ abatement are subject to severe practical and methodological difficulties, and could involve uncertainties which become obscured in summarized data. On the other hand, even though it is inconceivable, perhaps even in theoretical terms, that cost-benefit analysis can identify an optimal degree of environmental protection, the approach can act as a vehicle in spreading discussion. It should not be forgotten in such an assessment that some of the effects of $SO_x$ emission may be irreversible; thus there is an economic benefit in reducing emissions simply in order to keep options open for the future.

## CONCLUSION

By 2000, emissions of $SO_x$ in the UK could be reduced by approximately one third, and the costs of doing this are predictable: £400 million per annum, or about 2.5 percent of consumer expenditure on energy (6). In addition, alterations in the composition of energy consumption would be required which would significantly affect long term planning in the electricity industry. These adjustments could be brought about by changes in the structure of energy pricing which, in turn, could contribute towards the financing of FGD and fuel desulfurization.

On the basis of the estimates shown in Table 1, depositions in West European countries other than the UK would be reduced by about 4 percent. Depositions in Norway and Sweden might be reduced by 6 percent. However, this would depend on future $SO_x$ emissions outside the UK. Finally, while the UK is known to be a major emitter of sulfur compounds and the implications of reducing these emissions are possible to assess, the economic benefits remain uncertain. Whatever the degree of control advocated, a value is implicitly placed on this aspect of environmental protection (8).

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***Visiting Research Fellow***
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### References and Notes

1. N H Highton, *Pollution control technology and adjustments in UK energy consumption: Trade-offs in meeting environmental objectives* (University of York, 1982).
2. UK Department of Energy projections made in 1979 (*Energy Projections 1979*, HMSO, London), based on the same economic growth assumptions, indicate slightly higher aggregate energy consumption than that underlying case A in Figure 2, but would imply lower emissions of $SO_x$ in 2000 (4.6 million metric tons). This is because the official projections differ in the following ways: first, a considerable increase in gas consumption was projected, instead of an assumed stable level equal to that of the late 1970's; second, a decline in oil consumption was projected instead of an assumed stable level; third, it is assumed in all the projections shown in Figure 2 that the nuclear power program will not develop after 1990 as fast as had been envisaged in 1979. This would imply increased coal use for electricity generation. Other developments in UK energy policy would have different implications for $SO_x$ emissions. However, unless the current economic recession persists almost indefinitely no great reduction in $SO_x$ emissions can be expected by the end of the century in the absence of measures specifically aimed at $SO_x$ abatement.
3. N H Highton, M G Webb, *Energy Policy* (March 1980).
4. April 1979 prices, see N H Highton and M G Webb, *The Journal of Industrial Economics* (September 1981).
5. *The costs and benefits of sulphur dioxide control. A methodological study* (OECD, Paris, 1982).
6. Estimated expenditure on energy by final users in the United Kingdom was $17 billion in 1978. Se *Digest of UK Energy Statistics* (HMSO, London, 1981).
7. *The OECD program on long range transport of air pollutants; Measurements and findings*, Second Edition (OECD, Paris, 1979).
8. The author is a Research Fellow at the University of York, Y01 5DD, England.

From AMBIO, Volume XI
Number 6, 1982

# Acid Rain in the Swiss Alps

Switzerland, a land long fabled for its forest and alpine lakes, famous as Wilhelm Tell himself, is believed to be a victim of acid rain.

Alarmed by the threat of acidification, Switzerland is collaborating with other governments and scientists to develop a strategy to limit the damage. But despite its excellent forest protection laws, Switzerland has not yet found a solution.

During the 19th century tons of snow and debris roared down the Swiss mountainsides, wiping out unsuspecting settlements, roads and railway lines, in a rising tide of man-made natural disasters.

The cost in terms of human life and money became intolerably high. Floods and landslides claimed numerous victims, destroying many buildings and fields. Investigations underlined the reason – the reckless and uncontrolled clear felling and cutting of forest over many years, resulting in severe environmental damage.

In order to prevent new disasters, the Federal government passed its first forest protection law in 1876. By 1902, a ban on clear-felling of trees was put into effect throughout the country.

Today approximately, 27% of Switzerland remains forested (23% is covered by alps and glaciers) and that portion is strictly protected. Seventy-three percent of Switzerland's forests are owned by local communities and federal and cantonal governments, while the remaining 275, though privately owned, is subject to nearly the same regulations as the public forest.

All Swiss forests are maintained on a sustained yield basis, which means that the amount of wood cut must not exceed the annual growth. Annually, one to three percent of the total volyme of trees is cut. Since a small percentage is taken, replanting is usually not necessary, as the trees mostly regenerate themselves.

Swiss mountain villages are traditionally built below large patches of protective forests, with each community maintaining its own forester, who is a member of the Swiss forester reserve. In the case of avalanches or strong storms, the village forester helps nature to sustain her yield by arranging for community members of other hired workers to assist him in planting saplings.

## Trees pay taxes

In some Swiss villages the wealth of the forests partially or fully covers the costs of community upkeep, including the salary of the game warden, mayor and custodian.

By owning the surrounding woods, these villages are able to hire a forester to manage the planting and harvesting of trees. The forestry programme, which harks back over a 100 years, enables the inhabitants to reside in their village without paying local taxes. The church, school, community office, meeting centre and roads are all financed by the efficiency of forest management.

Up until enforcement of the Swiss Federal Forestry Law, the Swiss cleared virgin forests in many regions to obtain wood and farmland. Bit by bit they have replaced the major portion of the remaining forests with species foreign to the region. This has led, in some cases, to the development of monocultures, especially of fast-growing spruce.

When an area is heavily wooded with spruce, the soil tends to become acidic. Other disadvantages of lowland spruce forests is their susceptibility to disease and wind damage.

Scientists have concluded that the roots and stems of the trees have been progressively weakened by the acidification of the soil, thus reducing their ability to weather storms. A new phenomenon has also been recorded, the tendency of spruce trees to snow-break, a process in which the tops of the trees simply snap off.

## Acid rain

Alarmed by the threat of acid rain, which the Swiss Interior Minister claims affects Switzerland more than any other nation in Europe, the Swiss government is collaborating with governments and scientists to develop strategies and methods to control emissions of sulphur and nitrogen oxides.

Switzerland also recently adopted the strictest rules in Europe on automobile pollution. Starting in the spring of next year, all new cars must conform to a stringent set of exhaust standards.

A research station on acid rain has been set up not far from Switzerland's famed school of forestry engineering at the University of Zurich. Recent findings indicate that 78% of Switzerland's acid rain is imported, and that there is extensive damage to forests, groundwater, rivers and mountain lakes throughout the country.

According to Dr Jurg Bucher, Head of the Department of Forest Protection for the Swiss Federal Institute of Forestry Research, Switzerland is collaborating closely with Gottingen University in West Germany, whose spokesman Bernard Uhlrich warned that the Black Forest may be dying as a result of acid precipitation (See WWF News, No.16).

He added that Switzerland was not duplicating the efforts of German research, but was concentrating its study on changes in the ozone layer as well as the effects of the emissions of industrial plants, automobiles and agricultural pollutants.

"You can't just count trees in a forest," says Dr Bucher, "It's also very important to determine the health of individual trees."

Concequently, the Institute is preparing a Swiss National Forest Inventory, which will begin in 1983 and take three years to complete. The entire country will be systematically surveyed every five to ten years with aerial photographs, topographical maps and terrestrial observation.

"It took over a century to build a programme of sound forest management in Switzerland. It would be a great economic and aesthetic loss to helplessly stand by and watch its demise," noted Dr Maurice de Coulon, Director of the Swiss Federal Forestry Office.

*By Elizabeth Kemf*

From WWF-News
No 20,nov/dec-82

# USA Acid Rain Research

The Reagan Administration's commitment to acid rain research, already under question, has come under a new cloud. Last month when the president named to the panel overseeing federal acid rain research three new members, all three turned out to have close ties to the utility industry.

Earlier last month, the Administration provoked protests from environmetal groups and several members of Congress when the Office of Management and Budget (OMB) directed the Environmental Protection Agency (EPA) to cut funding for the development of an acid rain model from $650,000 to $150,000. The model, to be used in assessing the effects of utility emissions control strategies on sulphur and nitrogen emission, was to have been ready for use next year. According to EPA, it will now be completed in 1986, by which time a similar model for industrial sources will also be completed.

The OMB action was considered unusual in that it effects already appropriated and being spent – and that it deals with a very detailed internal policy decision. OMB could not actually order a cut; what it did was to direct EPA to "reprogramme" $500,000 from the utility model to the industrial model. But according to the Natural Resources Defense Council, EPA sources say that at most $200,000 of the reprogrammed funds could actually be used this year on the industrial model.

Environmental groups had been eager for EPA to complete work on the utility model, which will be available for public use. Groups such as NRDC have been spending large sums on hiring consultants to run model predictions for policy analyses.

The appointments of the three new members to the Acid Precipitation Task Force has added fuel to the fire. The task force, which is made up of representatives of the 13 federal agencies involved in the 10-year research effort plus four outside members, oversees all aspects of the Federal Government's research programme on acid rain.

The new task force members, who are not subject to Senate confirmation are: Ralph Perhac, director of environmental assessment at the Electric Power Research Institute (the electric utilities' research organization); James Mahoney, vicepreci-dent of Environmental Research and Technology, a consulting firm that has many contracts with industry and the government, and Professor John McKetta, of the University of Texas at Austin, who has frequently served as an expert withness for the utility industry.

*Stephen Budiansky*

*From Nature, Vol 301, No. 5897, 1983.*

# The ECE Convention

The ECE Convention on Long-Range, Transboundary Air Pollution.

Signed in Geneva 13 November 1979 by 35 signatories. Comes into force 16 March 1983, after ratification by 24 signatories.

* Belgium
* Bulgaria
* Denmark
* EC
* Finland
* France
Greece
* Ireland
Iceland
* Italy
Yugoslavia
* Canada
Lichtenstein
* Luxembourg
* Netherlands
* Norway
Poland
* Portugal
Romania
San Marino
Switzerland
* Soviet Union
Spain
* United Kingdom
* Sweden
Czechoslovakia
* German Democratic Republic
* Federal Republic of Germany
Turkey
* Ukraine
* Hungary
* USA
* Vatican City
* White Russia
* Austria

# US action against film on acid rain

*The american justice department has decided that three canadian-produced films on acid rain and atomic warfare shall be registered as political propaganda, and accompanied by "Corrections" from the American government.*

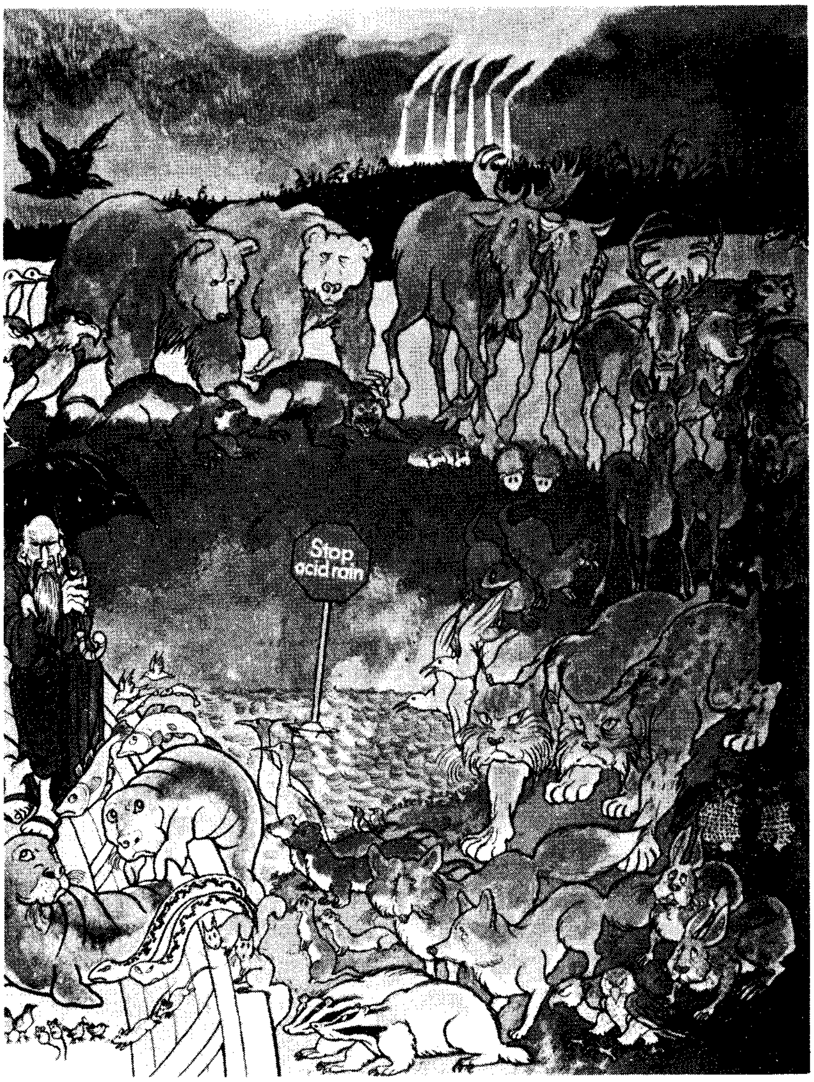
This decision, which was taken at the end of February, has led to violent reactions, both from Canada and from Civil Rights and political groups. The government in Ottowa, in a formal letter to the US State Department, has requested that the decision be reconsidered.

The Justice Department has also requested distributors in the USA to compile lists of the organisations ordering these films for screening, and to send them to the authorities.

This event occurs at a somewhat painful moment for the US administration – only a few days after Foreign Secretary George Shultz put forward a plan which envisages spending 85 million dollars on propaganda abroad. A plan presented with the following words: "Don't be afraid of democracy, don't be afraid of holding the torch (of liberty) high in the air".

One of the films, "If you love his planet", has been nominated for an Oscar in the short film class, and one of the films about acid rain, Acid Rain" Requiem or recovery", won first prize in a competition in the USA last year.


Cartoon: Haitzinger




## "Noah's Ark" poster

The Secretariat is just now producing a poster, "Noah's Ark". At the foot of the poster will be a text demanding measures to stop acid rain. It is to be printed in English, German and Swedish, and the text runs:

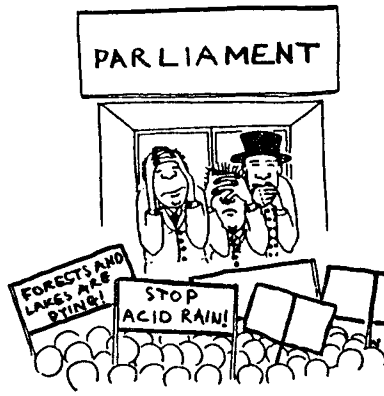
### Stop acid rain!

The acidification of rain, soil, and water is today one of the world's most serious environmental problems. If it is allowed to continue, we shall soon have to build a new Noah's Ark. Which is why we must – quickly! –

- **Reduce the wastage of energy and raw materials**
  The more efficiently we use energy, the less oil and coal we need to combust.
- **Reduce the sulphur contents in oil and coal**
  It is possible to use fuels with a naturally low sulphur content, or to desulphurise fuels before burning them.
- **Clean the flue gases**
  All major oil-fired and coal-fired plants should desulphurise their flue gases.
- **Invest in renewable sources of energy**
  Oil and coal must be replaced by more environment-postive, renewable sources of energy, such as solar heat, wind power, and heat pumps...
- **Expand public transport services**
  Car exhaust fumes account for a high proportion of the discharge of acidifying nitrogen oxides.
- **Comply with the ECE Convention**
  An international Convention exists by which countries undertake to reduce their discharges of long-range, transboundary air pollutants.
  We must ensure that every country complies with that Convention.

It is intended that this poster should be ready by the end of April, and it can be ordered from the Secretariat free of charge.

# INTERNATIONAL ACID RAIN WEEK; 18-24 APRIL 1983




The International Youth Federation for Environmental Studies and Conservation (IYF) is proclaiming this week an International Acid Rain Week. The idea is that as many organisations and local groups as possible should devote themselves to Acid Rain issues at that time.

## Some tips on activities

* Start "Stop acid rain!" **working groups**, preferably in cooperation with other organisations
* Write **articles** for newspapers, and **letters** to editors
* Distribute **leaflets** with information
* Arrange **lectures** with slides and/or films for the general public
* Organise **public panels and debates**
* Write **letters and postcards** to politicians
* Spread lapel **buttons and stickers** (see "Acid News 5/82)
* Perform your **own investigations** concerning the drinking water, forests and lakes
* Draw up a **local "sulphur budget"** for the municipal authority
* Hold **exhibitions**
* Arrange **"theme days" on acid rain** in the schools.

You can get furthur tips for future activities by reading about the action in West Germany, and the article "Acid Rain caravan ("Acid News" 1/83).

Footnote. The IYF spans some 50 youth organisations concerned with nature conservancy and the environment, throughout the world.