AIR POLLUTION AND CLIMATE SERIES

5

Large combustion plants

Revision of the 1988 EC directive

With much air pollution coming from these sources, revision of this directive assumes exceptional importance

The Swedish NGO Secretariat on Acid Rain

The Swedish NGO Secretariat on Acid Rain

The Swedish NGO Secretariat on Acid Rain was formed in 1982 with a board now comprising one representative from each of the following organizations: Friends of the Earth Sweden, the Swedish Anglers' National Association, the Swedish Society for Nature Conservation, the Swedish Youth Association for Environmental Studies and Conservation, and the World Wide Fund for Nature Sweden.

The essential aim of the secretariat is to promote awareness of the problems associated with air pollution, and thus, in part as a result of public pressure, to bring about the required reduction of the emissions of air pollutants. The eventual aim is to have those emissions brought down to levels – the so-called critical loads – that the environment can tolerate without suffering damage.

In furtherance of these aims, the secretariat operates as follows, by

☐ Keeping under observation political trends and scientific developments.

☐ Acting as an information centre, primarily for European environmentalist organizations, but also for the media, authorities, and researchers.

☐ Publishing a magazine, Acid News, which is issued five times a year and is distributed free of charge to some 5000 selected recipients.

☐ Producing and distributing information material.

☐ Supporting environmentalist bodies in other countries by various means, both financial and other, in their work towards common ends.

☐ Acting as coordinator of the international activities, including lobbying, of European environmentalist organizations, as for instance in connection with the meetings of the bodies responsible for international conventions, such as the United Nations Convention on Long Range Transboundary Air Pollution.

☐ Acting as an observer at the proceedings involving international agreements for reducing the emissions of greenhouse gases.

The work of the secretariat is largely directed on the one hand towards eastern Europe, especially Poland, the Baltic States, Russia, and the Czech Republic, and on the other towards members of the European Union, in particular Great Britain. By emitting large amounts of sulphur and nitrogen oxides, all these countries add significantly to acid depositions over Sweden.

As regards the eastern European countries, activity mostly takes the form of supporting and cooperating with the local environmentalist movements. Since 1988, for instance, financial support has been given towards maintaining information centres on energy, transport, and air pollution. All are or will be run by local environmentalist organizations.

AIR POLLUTION AND CLIMATE SERIES

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Large combustion plants

THE EC DIRECTIVE

Comments on the present directive
and proposals for revision

By Fredrik Lundberg and Christer Ågren

THE SWEDISH NGO SECRETARIAT ON ACID RAIN

Previous reports in the series:
No. 1 The Eastern Atmosphere (1993)
No. 2 The "Black" Triangle – a General Reader (1993)
No. 3 Sulphur emissions from large point sources in Europe (1995)
No. 4 To clear the air over Europe (1995)

AIR POLLUTION AND CLIMATE SERIES

Large combustion plants. Revision of the 1988 EC directive

By Fredrik Lundberg and Christer Ågren

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CONTENTS

PREFACE

This year a start was to be made on revising the EU directive of 1988 concerning emissions of air pollutants from large combustion plants. Since 1980 the European emissions of sulphur have, according to official statistics (1), been reduced by 35-40 per cent, while those of nitrogen oxides have remained static.

The effects on the environment that are due, directly or indirectly, to these pollutants are various and include the acidification of soil and water, damage to forests, eutrophying of coastal waters, impairment of the natural diversity of flora and fauna, corroding of the materials in cultural edifices and structures in general, and harm to human health.

Since the mid-1980s scientists have been working on ways to determine the amounts of the various kinds of pollutant that ecosystems can withstand without suffering damage. The outcome has been the so-called critical loads for depositions of the acidifying substances sulphur and nitrogen, and the levels of gaseous pollutants such as ozone, sulphur dioxide, and nitrogen oxides.

The resulting data has formed the basis, in a European context, for what is known as the critical loads approach, which is being applied, especially within the UN ECE Convention on Long Range Transboundary Air Pollution (2) when developing international agreements for the reduction of such pollution. An inherent aim of the critical loads approach it to achieve the necessary reductions as cost-effectively as possible.

According to Article 3 of the 1988 directive, the European Commission was to report in 1994 to the Council of Ministers on "the implementation of the prescribed reductions, accompanied where necessary by proposals for a revision of the reduction targets for existing plants." It was also said that the Commission should, at the latest by July 1995, submit proposals for the revision of the emission limit values for new plants.

In view of the intended revision of the directive, and especially of the need for a much greater reduction of the emissions than has hitherto been envisaged, if the environment is to be saved, we are now publishing this report — in the hope that it will serve to stimulate discussion and help develop sound proposals.

Göteborg, August 1995

Fredrik Samuelsson

Chairman, The Swedish NGO Secretariat on Acid Rain

SUMMARY AND CONCLUSIONS

Depositions of sulphur and nitrogen compounds are having profound effects on the European environment and the various countries' economies. A large part of the pollution emanates from power stations and other plants burning great quantities of fuel. An unprecedented opportunity for tightening the requirements on such installations is now at hand in the forthcoming revision of the original EC directive of 1988.

An unprecedented opportunity for tightening the requirements is now at hand.

Adopted after nearly five years of laborious negotiation, this directive is itself a very much watered-down version of a first proposal. It really consists of two parts, the one aiming at a gradual reduction of emissions from existing (pre-1987) plants, the other prescribing limit values for emissions from new ones.

Emissions of sulphur dioxide from existing plants throughout the then Community were, according to the directive, to be reduced by about 57 per cent by 2003, and those of nitrogen oxides by 30 per cent by 1998, from the 1980 levels.

Emissions of sulphur dioxide from existing plants were to be reduced by about 57 per cent by 2003, and those of nitrogen oxides by 30 per cent.

Needed reductions

In answer to the question of how much pollution the environment can withstand, environmental scientists have developed the concept of critical load. A critical load has been defined as "the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems." Towards the end of the 1980s the critical load had become a widely accepted instrument in international environmental politics, even to being used in the UN ECE Convention on Long Range Transboundary Air Pollution (CLRTAP). It has moreover been stated as a long-term aim of the EC Fifth Environmental Action Programme that there should never be any exceeding of critical loads.

A long-term aim of the EC Fifth Environmental Action Programme is that there should never be any exceeding of critical loads.

A critical load is the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems.

Basing their view on internationally agreed scientific data in respect of critical loads, European environmentalist organizations have unanimously concluded that the emissions of sulphur dioxide and nitrogen oxides will have to be reduced by at least 90 per cent, as from the levels of the early eighties.

It should therefore be clearly stated in the directive that the aim is to cause emissions to be reduced sufficiently to bring down the depositions of sulphur and nitrogen to below the critical loads.

Aim should be to cause emissions to be reduced sufficiently to bring depositions of sulphur and nitrogen to below the critical loads.

Target aims

The necessary 90 per cent reduction refers to all sources of sulphur dioxide and nitrogen oxides. It will principally affect large combustion plants, such as are defined in the directive, because they are the main emitters of sulphur dioxide, as well as being a considerable source of nitrogen oxides.

Emissions of sulphur dioxide and nitrogen oxides will have to be reduced by at least 90 per cent.

Since it may be difficult to bring about a 90-per-cent reduction of the emissions, especially of NO_x, from other main sources such as small boilers, as well as road, sea, and air traffic, within the next 10-15 years, it is all the more urgent that it should be achieved in the case of large combustion plants, both as regards SO_2 and NO_x.

Since it may be difficult to bring about a 90-per-cent reduction of the emissions from other main sources, it will be all the more urgent to achieve it for large combustion plants.

Proposed changes

☐ The emission limit values should be expressed as weight of pollutant per unit of usable energy, grams per gigajoule (g/GJ). This

Limit values should be expressed as weight of pollutant per unit of usable energy.

would provide a better means of comparison between different plants, encourage more efficient use of energy, and allow a better basis for the taxing of emissions.

Limit values for emissions from new plants will have to be set markedly lower.

☐ The limit values for emissions from new plants must be set markedly lower than they are at present (for specific figures, see page 17). In the case of sulphur, a strict interpretation of best available technology (BAT) would in the first place mean employing energy sources that do not give rise to any emissions of this pollutant at all, such as natural gas. Renewables such as wind, solar and geothermal energy emit practically no pollutants. A second choice would be to employ modern gasification processes, by which 99 per cent of the sulphur can be removed. A third alternative is maximally desulphurized oil or low-sulphur coal in combination with at least a 95-per-cent desulphurization of the flue gases. The emission figure would then be less than a fifth of the directive's present limit value for large coal and oil-fired plants.

As regards nitrogen oxides, the natural gas combined heat-and-power plants are best, followed by combined cycle, power only – assuming, of course, that gas is available or can be made so. Emissions from such plants are 5-10 times lower than the emission limits of the directive. With low-NO_x burners and flue-gas denitrification the emissions from coal and oil-fired plants can be made to be 3-5 times lower than allowed by the present limits.

Emission ceilings for each country should be altered to denote total emissions.

☐ The emission ceilings for each country should be altered to denote *total* emissions, that is, from new plants as well. The ceilings should moreover be lowered, and the timeframe extended, so as to indicate when the 90-per-cent reduction will have to be met.

Need to make emission limit values apply to existing plants as well as new ones.

A combination of command-and-control with economic instruments probably the best solution.

☐ In general, there is an obvious need to make the emission limit values apply to existing plants as well as to new ones, and to use economic instruments, for example by setting a price (tax or charge) on the emission of each unit of pollutant. A combination of command-and-control with economic instruments will probably be the best solution if the reduction targets are to be achieved in a cost-effective manner and within a reasonable time.

Present directive too restricted

Of several ways of cutting back emissions of sulphur dioxide and nitrogen oxides, one would be to **promote greater efficiency in the use of energy.**

There are several ways of cutting back emissions of sulphur dioxide and nitrogen oxides that are not taken up in the directive as it now stands. One would be to promote greater efficiency in the use of energy, both at the plants and in the community in general. It is unlikely that this could be successfully dealt with by pure command-and-control means, but it could well be effectively done by imposing higher taxes on energy and/or emissions, by de-subsidizing the coal industries for example in Germany and Spain, and halting tax reliefs to energy-intensive industry.

Combined energy/CO_2 tax should be introduced as soon as possible.

A combined energy/CO_2 tax should be introduced as soon as possible. Such a tax would also act as an indirect tax on sulphur dioxide and nitrogen oxides, since the worst emitters of carbon dioxide, such as coal-fired power plants, are often big emitters of sulphur dioxide and nitrogen oxides too.

A complementary strategy might first be to identify the worst point sources of emissions of sulphur within the European Union. The next step would be either to make them redundant, for example through demand-side management, or to replace them with non-polluting or less polluting sources of energy, or to retrofit them for limit values in line (or nearly in line) with BAT for new plants.

For formulating effective strategies, a **greater availability of information is needed.**

For formulating effective strategies for the reduction of emissions, there needs however to be a greater availability of information. The European Commission is for instance in possession of information on every major combustion plant in the Union, but so far such data has not been made public.

1. BACKGROUND

In the autumn of 1988, after five years of laborious negotiation, a first EC directive was issued with the aim of cutting back the emissions of sulphur dioxide, nitrogen oxides, and particles from large combustion plants. The reason for the move lay in the damage that was being done to the environment, and could be seen especially in general acidification and dying forests.

Acidification first brought to international attention in 1972.

Acidification was first brought to international attention at the United Nations conference on the environment that was held in Stockholm in 1972. There Sweden, as the host nation, presented a case study (3) on the subject, reporting the acidification of lakes and streams that had recently been noted in the southwestern part of the country, with consequent harm to the fish populations. It also pointed out that the precipitation had been becoming steadily more acid over the whole of Europe, and that a great part of the acidifying airborne sulphur that fell over Scandinavia had its origin in central Europe and Great Britain. All the other countries, except Norway, were however reluctant to believe this.

The attitude of most of the delegates to acidification, and their refusal to believe that it could be due to the migration of pollutants, was evident in regard to Point 21 of the declaration of principle that was adopted by the conference, where it was stated that nations were obliged to ensure that activities in their own territory were not causing damage to the environment elsewhere (4). A principle that seems generally to have remained in abeyance.

Airborne pollution shown later to be a general European problem.

Some years later, in 1977, the OECD published the findings of a three-year research project on transboundary air pollution (5), which showed that airborne sulphur pollutants constituted a general European problem, and that some countries were more affected – received more of the wandering pollution – than others.

These findings, combined with fresh data on the effects of acidification in Scandinavia, led to negotiations starting, on Norway's initiative, for an international convention on transboundary air pollution. The matter was put in the hands of the UN Economic Commission for Europe (ECE), in which all the European countries are involved, as well as the United States and Canada.

Framework convention on transboundary air pollution signed in 1979.

All signed the subsequent UN ECE Convention on Long Range Transboundary Air Pollution, generally known as the ECE Convention, at Geneva in November 1979.

This is a framework convention, under which the signatories, while recognizing that boundary-crossing pollution does create problems, are not in any way bound to take steps or make commitments to reduce emissions. Nevertheless, after having been ratified by twenty-four countries, the convention came into force in the spring of 1983. (2)

Throughout the seventies practically no measures were taken, either by the EC or the member states, to reduce emissions of sulphur and nitrogen oxides. This may have been due to the fact that two of the biggest emitters, West Germany and Great Britain, which were also among the most influential members, were still unconvinced that acidification was a serious matter.

A complete reversal of the West German attitude took place in 1982-83, after some alarming reports of a great increase in forest damage. Measures were quickly taken to reduce emissions of air pollutants – among them being stricter requirements as regards sulphur dioxide and nitrogen oxides from large combustion plants.

About the same time, some of the other member countries, such as the Netherlands and Denmark, had also awoken to the problems of acidification and border-crossing pollutants.

Draft for an EC directive on large combustion plants came late in 1983.

Prompted by the German example, in December 1983 the European Commission presented a draft of a directive for reducing emissions from large combustion plants (that is, plants with a thermal input of more than 50 megawatt). This is what came to be known as the Large Combustion Plant Directive. According to the available statistics, in 1980 about 80 per cent of the sulphur emissions in the EC area, and 40 per cent of the nitrogen oxides, came from such plants.

The aim of the proposed directive was first to reduce emissions from existing plants by 60 per cent for SO_2 and 40 per cent for NO_x, all by 1995 from 1980 levels. Every country was to make the same percentual reductions. It was further proposed to introduce emission limit values for SO_2 and NO_x from new plants, as from 1985, based on the best available technology (BAT). (There were also proposals for particles, which however will not be considered here.)

The proposed limit values were about the same as those that had already been adopted in West Germany in the same year. As calculated by the Commission, the proposed measures would increase the cost of electricity by less than 10 per cent, or about $0.003 per kilowatt-hour. The Commission also noted that the cost of the various kinds of damage arising from emissions of SO_2 and NO_x (which would be eliminated if emissions were reduced) was at least as great as the cost of the proposed measures.

To begin with, the most outspoken resistance to the proposal came from Britain, which was not only the largest emitter in the Community, but also feared the high cost of the measures that would have to be taken. Further resistance came in 1986, after Spain and Portugal had become members, and saw a threat to their plans for economic expansion.

Unanimity required in the Council of Ministers delayed final adoption.

Adoption of the proposed directive would have required a unanimous vote in the Council of Ministers – in other words, the agreement of all the member states. The consequence in this case was a long drawn-out process of negotiation. In the end, after almost five years of discussion and numerous compromise proposals, agreement was reached in the summer of 1988, and a directive,[1] very much watered-down in comparison with the original proposal, was adopted in November of that year.

One reason for the directive finally becoming adopted is believed to have been that Britain, in view of the coming privatization of its power industry, needed to be rid of uncertainty as to future rules. The Germans, who had started it all, wanted to ensure that there would at least be a directive, even if it was not as good as they had hoped. Spain managed to obtain exemption from some of the minimum requirements for new plants, while Portugal, Ireland, and Greece got off relatively lightly as regards reductions from existing ones.

The directive really consists of two parts, one covering a gradual reduction of emissions from existing installations, the other emission limit values for new plants.

The intended reductions were less than in the original proposal.

In the case of the former, emission ceilings are set for each country, and further defined as the intended percentual reduction from 1980 levels (see Tables 1 and 2). Emissions of SO_2 from existing plants in the whole Community are (according to the directive) to be reduced from 14.4 to 6.1 million tons, or by 57 per cent, between 1980 and 2003. Nitrogen oxides should be reduced by 30 per cent, from 3.7 to 2.6 million tons by 1998 (also from 1980). Under the Commission's original proposal the emissions of SO_2 and NO_x would have been

[1] Council Directive of 24 November 1988 on the limitation of emissions of certain pollutants into the air from large combustion plants (88/609/EEC).

reduced by 60 and 40 per cent respectively, and moreover already by 1995.

It says in the directive that the member countries shall, at the latest by July 1, 1990, "draw up appropriate programmes for the progressive reduction of total annual emissions from existing plants. The programmes shall set out the timetables and the implementing procedures." In July 1993 the Commission issued a report on the monitoring of the application of Community law in 1992 (COM/93/320). From this it appeared that several member countries still had not notified programs to reduce pollution, as required by the directive.

For new plants (those that had been granted construction licences after July 1, 1987) the directive sets emission limit values. For units burning solid or liquid fuels, the SO_2 limits are set on a rising scale, depending on boiler capacity. The requirements is not especially onerous – in fact they do no more than reflect the technological level of the early eighties. In practice this means that flue-gas desulphurization – which can reduce emissions by more than 90 per cent – will only be needed for the largest plants, while smaller ones could meet the requirements simply by using medium or low-sulphur fuel.

All that is needed to meet the requirements for nitrogen oxides is a so-called low-NO_x burner, which makes for a reduction of about 30 per cent. And that when flue-gas denitrification, which can reduce nitrogen-oxide emissions by more than 85 per cent, was already well established technology by the middle of the eighties. There are, too, a large number of so-called derogations.[1]

[1] Derogate v. To deviate from a standard or expectation. Hence derogation. (American Heritage Dictionary.) Here it means exemption from some requirement of the directive.

2. THE PRESENT DIRECTIVE

The preamble starts with a reference to paragraph 130S of the Treaty of Rome, which means that this is a so-called minimum directive – enabling any country, if it so desires, to impose stricter requirements than those laid down in the directive. Up to the time of the establishment of the European Union, directives of this kind always had to be adopted by unanimous vote of the Council of Ministers.

There is also a reminder that the Community is a Party to the Convention on Long Range Transboundary Air Pollution.

Reference is further made to a directive of 1984,[1] stating that the Commission "shall, if necessary, fix emission limits for new plants based on the best available technology not entailing excessive costs" (BATNEEC) and taking into account the nature, quantities, and harmfulness of the emissions concerned. In another paragraph of that directive, member states are enjoined to gradually adapt existing plants to the best available technology (BAT).

Urgent to have limit values for new plants as well as to reduce emissions from existing ones.

It is emphasized that the damage being done to the environment makes it urgent to bring about a gradual and staged reduction of the total emissions of sulphur dioxide and nitrogen oxides from existing plants, and to set emission limit values for those pollutants, and also for dust, from new ones. (Here "gradual" reduction is understood to differ with the size of the plant, and "staged" to take place over a period of time.)

It is further stated that the emission limit values laid down in the directive for new plants "will need to be reviewed in the light of technological developments and the evolution of environmental requirements."

The temporary exemptions granted to Spain as regards emission limits for sulphur from new plants are explained by the need to allow the country respite for growth in the fields of energy and its manufacturing industry.

ARTICLE 1

The directive shall apply to plants with a rated thermal input of 50 megawatt or more.

At the time of adoption in 1988, however, no agreement had been reached on emission limit values for new plants of 50-100 MW_{th}. (Later, in January 1993, the Commission made a proposal for rectifying this, and in December 1994 the Council of Ministers voted an addition to the directive, setting the value at 2000 mg SO_2/m^3 for new plants within this range of thermal capacity.)

ARTICLE 2

Here are various definitions and exceptions, it being stated that limit values are expressed in milligrams per cubic metre, with allowance given for excess air.

The types of plants not covered by the directive are also listed, These are:

☐ Plants in which the products of combustion are used for direct heating, drying, or any other treatment of objects or materials.
☐ Post-combustion plants.
☐ Facilities for regeneration of catalytic cracking catalysts.
☐ Facilities for the conversion of hydrogen sulphide into sulphur.
☐ Reactors used in the chemical industry.
☐ Coke battery furnaces.
☐ Cowper stoves.

Plants powered by diesel, petrol, and gas engines or by gas turbines are also excluded, irrespective of the fuel used.

[1] Council Directive 84/360/EEC on the combating of air pollutants from industrial plants.

New plants are those for which the original construction or operating licence was granted on or after July 1, 1987, and existing ones those which were licenced before that date.

ARTICLE 3

Member states were to draw up programs for reducing their total annual emissions from existing plants at the latest by July 1, 1990. Timetables and implementing procedures were to be shown.

The Commission should, moreover, on the basis of information from member states, report to the Council of Ministers on the implementation of the directive, including where necessary proposals for a revision of the Phase 3 reduction targets (for 2003) and/or date for sulphur dioxide, and of the Phase 2 targets (for 1998) and/or the date for nitrogen oxides. Decisions must be by unanimous vote of the Council.

ARTICLE 4

Member states must see that the emission limits set forth in Annexes III to VII for new plants are respected. Then, "before 1 July 1995, and in the light of the state of technology and environmental requirements, the Commission shall submit proposals for the revision of the limit values applicable, and the Council shall decide upon such proposals by unanimity." Member countries may in any case impose stricter requirements and include other pollutants than those mentioned in the directive.

For the emission limit values for sulphur dioxide and nitrogen oxides, see Tables 3 and 4.

ARTICLE 5

Derogations as regards emission limits for:

☐ New plants with a thermal input of more than 400 MW, and operating less than 2200 hours a year, may release 800 mg/m^3 of sulphur or twice as much as other plants.

☐ New plants burning indigenous solid fuel, where the emission limit value for sulphur dioxide set for such plants cannot be met without using excessively expensive technology. They must however achieve a certain rate of desulphurization.

☐ As a special case, Spain will be allowed to authorize new large combustion plants (more than 500 MW_{th}), for commissioning before the end of 2005, that will emit twice as much sulphur as is generally permitted in the Community, even if they burn imported solid fuels. If they use indigenous solid fuels, at least 60-per-cent desulphurization is required.

ARTICLE 6

Emissions from plants burning indigenous lignite may be allowed to exceed the limit values after consultation with the Commission.

ARTICLE 7

If, for unforeseen reasons, the emission limit value for nitrogen oxides is not being complied with in any particular case, the national authority must require the operator of the plant to take all appropriate measures, and immediately inform the Commission.

ARTICLE 8

In case of failure of the abatement equipment, the national authority must require the operator either to reduce or stop operation until the fault has been corrected. Non-compliance may on the other hand be permitted for a limited period if there should be an interruption in the supply of fuels such as low-sulphur coal or gas.

ARTICLE 9

Describes the procedure for determining the emission limit values for plants that are burning two or more fuels simultaneously. Refineries using residues in their own operations may be allowed a higher limit value than other types of plant.

ARTICLE 10

Waste gases must be discharged from chimneys that are high enough to safeguard health and the environment.

ARTICLE 11

When capacity is extended by at least 50 MW, the emission limit value for the new part is to be fixed in relation to the thermal capacity of the whole plant.

ARTICLE 12 If a proposed new plant is likely to have a significant effect on the environment in another member country, consultations and exchanges of information must take place.

ARTICLE 13 Measuring methods shall conform to the best industrial technology, and information concerning their performance shall be forwarded to the Commission.

ARTICLE 14 Member states must ensure that information is forthcoming in regard to measuring results and whatever else is needed for assessing compliance with the directive.

ARTICLE 15 With continuous measuring, none of the calendar monthly mean values may exceed the emission limit values, and for all the 48-hour mean values 97 per cent of the sulphur dioxide emissions, and 95 per cent of NO_x, must fall under 110 per cent of the emission limit values. With discontinuous measuring, none of the results may exceed the limit values.

ARTICLE 16 At the latest by December 31, 1990, member states were to send in reports on emissions and intentions as regards existing plants, and indicate when further reports were to be expected.

The reports should provide an overall view of:

- All plants covered by the directive.
- Emissions of SO_2 and NO_x, expressed in tons per annum and as concentrations of these substances in the waste gases.
- The measures taken or envisaged for reducing emissions, and changes in fuel.
- Changes made or envisaged in the method of operation.
- Plants either to be closed down or already closed down.
- The emission limit values in any program there might be for existing plants.

The Commission was to make regular comparisons of the national programs in order to ensure harmonization within the Community. It should also ensure that implementation was producing the intended result as regards the overall reduction of emissions, and if necessary propose remedies.

ARTICLE 17 Members must have made the necessary arrangements for compliance with the directive at the latest by June 30, 1990.

ANNEX I Successive columns show the emissions of sulphur dioxide from large combustion plants as they were thought to be in 1980, the agreed ceilings for each country in 1993, 1998, and 2003, and the percentual reduction that these were intended to have brought about by the end of each of these years, as compared with their 1980 levels. (Table 1.) The figures take no account of emissions from new plants.

According to an official source, the figures for 1980 are mixed, being in part "political" and in part "correct." Although in most cases there is little difference between the two, it seems that some countries, such as Greece, Portugal, Ireland, and Spain, had at first greatly underestimated their emissions for 1980 – as had also, though to a lesser extent, Italy and Denmark.

The supposed reductions for Greece after adjustment must also be wrong. They would mean that the country's emissions of sulphur dioxide from existing LCPs amounted to 580,000 tons, whereas the country's total emissions in 1980 were, as reported to the UN ECE, only 400,000 tons. Also in the case of Portugal the adjusted figures would mean that the emissions from LCPs would be more than the country's total.

ANNEX II Figures for nitrogen-oxide emissions are set out in the same way as those for sulphur dioxide, except that here there are only two phases, for 1993 and 1998. Discrepancies, similar to the above, can also be seen here as regards Greece and Portugal.

The graph shows the emission limit value for new plants burning solid fuels to be 400 mg SO_2/m^3 if the plants are larger than 500 MW_{th}, but rising for smaller plants up to 2000 mg/m^3 for a 100 MW unit. This last figure would be for a plant, more or less, burning coal with a sulphur content of 1 per cent, but without flue-gas desulphurization or similar. (Fig. 1.) ANNEX III

Graph for new plants burning liquid fuel (actually oil). Here again the emission limit value for plants greater than 500 MW_{th} is 400 mg/m^3. For plants between 50 and 300 MW_{th} the limit is 1700 milligrams, descending from 1700 to 400 mg/m^3 for plants between 300 and 500 MW. (Fig. 2.) ANNEX IV

Emission limit values for SO_2 from new gas-fired plants: 35 mg/m^3 for gaseous fuels in general, 5 mg/m^3 for liquified gas, 800 mg/m^3 for refinery, coke-oven, and blast-furnace gas. ANNEX V

Nitrogen-oxide limits for all types of fuel. For solid fuels in general the limit is set at 650 mg/m^3, but plants burning solid fuel such as hard coal, with a volatile component of less than 10 per cent, can emit up to 1300 mg/m^3, as compared with 450 mg for oil and 350 mg for gas. ANNEX VI

Emission limit values for dust for new plants and all types of fuel. ANNEX VII

Rates of desulphurization for new plants burning indigenous fuel with a high sulphur content (Article 5). The desulphurization rate of 90 per cent is required of plants greater than 500 MW_{th}, but only 40 per cent for those up to 175 MW_{th}, with rates on a sliding scale for those inbetween. For a 300 MW plant it will thus be 60 per cent. (Fig. 3.) ANNEX VIII

Prescribes the method for measuring emissions. ANNEX IX

3. BEST AVAILABLE TECHNOLOGY

In expressing the limit values for emissions of sulphur dioxide and nitrogen oxides as milligrams of pollutant per cubic metre of air (mg/m^3), the makers of the directive have been bound more by the methods of measurement than the effects on the environment. But the effects, in the form of acidification, eutrophication, etc., are determined by the total amounts deposited, not by the local concentrations in the air around the chimneys. High local concentrations do indeed give rise to environmental problems, such as effects on health, but it has not been the primary aim of the directive to address that kind of problem.

The present ways of setting limit values are not the best.

Setting the limit values in grams per gigajoule (g/GJ) of useful energy[1] would, besides providing a better means of comparison between different plants, promote energy efficiency and give a better basis for taxing emissions. (The values may be also given in milligrams per megajoule, mg/MJ, which is the same thing.)

For example: A coal-fired power plant with sulphur emissions of 35 g/GJ per energy input and a net fuel-to-electricity efficiency of 40 per cent has about 87 g/GJ of output. If efficiency is raised to 50 per cent, emission per output falls to 70 g/GJ. A combined heat-and-power plant with an efficiency of 85 per cent (for electricity plus useful heat) the same emission per energy input figure will give an output value of 41.2 g/GJ.

Specific proposals for new emission limit values will be found in Section 5, page 17.

Sulphur dioxide

During combustion the sulphur in the fuel is converted to sulphur dioxide, which is emitted with the flue gases. Emissions can be reduced either by burning less sulphur-bearing fuel (by reducing energy use or switching fuel), by reducing the sulphur content of the fuel, or cleaning the flue gases.

Flue-gas desulphurization (FGD) is the most usual cleaning method. With 90 per cent sulphur removal and fuel with a sulphur content of 5 per cent, the emissions will correspond to those from using a fuel with 0.5 per cent sulphur and no desulphurization. Another, but less effective method of desulphurization is to feed an absorbent, such as limestone, into the furnace, so that some of the sulphur becomes taken up by the limestone during combustion. (The ash, being alkaline, can also absorb a small amount of sulphur. When burning hard coal, about 5 per cent of the sulphur is so absorbed; with lignite it is about 30 per cent.)

Most of the emissions come from plants covered by the directive.

Most of the sulphur emitted in the European Union comes from plants covered by the directive, and most of them are power stations. A great number of these power plants have a thermal capacity of more than 500 megawatt, and so have to meet the strictest requirements.

Other big sources are boiler plants producing hot water for district heating and industrial use. These vary greatly in size and in their use of different types of fuel. Since they are mostly operated during the winter half-year, some of them will be able to take advantage of the exemption under Article 5, concerning plants that are in use for at most 2200 hours a year, and thus are permitted to emit 800 mg SO_2/m^3. The higher limits are thus of great practical importance for them.

[1] I.e. energy output in the form of electricity, steam for district heating, etc.

A limit value of 400 mg SO_2/m^3 for coal corresponds to 70 grams of sulphur per gigajoule (g S/GJ) of energy input. That would assume burning coal with a sulphur content of 0.2 per cent and no desulphurization, and such coal is practically unavailable. The limit value could therefore only be attained through the use of flue-gas cleaning.

A limit value of 2000 mg SO_2/m^3 for coal corresponds to 350 g S/GJ of energy input. That would mean coal with 1-per-cent sulphur content, which is generally available.

A limit value of 400 mg SO_2/m^3 for oil corresponds to 56 mg S/GJ, or oil with a sulphur content of 0.2 per cent.

A limit value of 1700 mg SO_2/m^3 for oil corresponds to 240 g S/GJ, or oil with a sulphur content of 1 per cent, in other words a medium-sulphur oil.

Limit values for gas, in this case process gas used in coking plants and oil refineries, can be recalculated as follows: 5 mg SO_2/m^3 corresponds to 1 g S/GJ, 35 mg SO_2/m^3 to 5 g S/GJ, and 800 mg SO_2/m^3 for low-calorific gas to about 150-300 g S/GJ.

Some heavy oils can be used without desulphurization.

Nowadays no large oil-fired base-load boilers are being built, but only boilers for peak and back-up loads, which in accordance with Article 5 can emit 800 mg SO_2/m^3, even if they are very large. New boilers can therefore be commissioned for firing with oil of 0.5 per cent sulphur content. The emission limit value of 1700 mg SO_2/m^3 means that in practice certain kinds of heavy oils can be used, without any desulphurization.

Since they contain relatively small amounts of sulphur, bio-fuels are not included in the directive.

It is often possible to meet the requirements for coal-fired plants of 50-300 MW_{th} without flue-gas cleaning by burning low-sulphur coal. This cannot always be done however if local supplies have to be relied upon, but as imports of coal to the Union have now greatly increased, there is a greater choice if plants can get their coal from a port.

Best Available Technology of all would be to use fuels that give no emissions.

Strictly interpreted, the Best Available Technology (BAT) for sulphur would in the first place be to use energy sources, such as natural gas, that give rise to no emissions of sulphur. Some renewables, such as wind, solar, and geothermal energy, cause practically no pollution of the air either. Large-scale biomass burning is also relatively benign. The next best would be to employ modern technology, such as gasification of the fuel, by which 99 per cent of the sulphur can now be removed. Thirdly, to use maximally desulphurized oil or low-sulphur coal in combination with at least 95-per-cent desulphurization – which would result in approximately 10 g S/GJ, or less than a fifth of the emission limit value of the directive for large coal or oil-fired combustion plants. (The value should however be expressed, as previously suggested, as the maximum permissible emission in milligrams per megajoule of useful energy.)

Fuels with the lowest sulphur content, such as extremely low-sulphur fuel oils, could well be used in small boilers without any flue-gas cleaning, while fuels with medium or high sulphur content should, unless they are gasified, be burnt in plants with the best flue-gas cleaning technology. Oil with 2 per cent sulphur and 98 per cent cleaning results, for example, in about 10 g S/GJ of useful energy for space heating or combined heat-and-power production.

Nitrogen oxides

Easier to deal with emissions from stationary sources than from traffic.

The directive only covers a lesser part of the emissions of nitrogen oxides, road traffic being the main source. Gradually stricter requirements for cars and heavy commercial vehicles are expected however to have led, towards the end of the nineties, to reduced emissions from traffic, and thus to increase the relative proportion from stationary sources. It is also easier to deal quickly with emissions from stationary sources, since it is easier to apply measures to existing power plants than to existing cars and trucks.

For technical reasons connected with the measuring method, the emissions of nitrogen oxides are calculated as the total amounts of nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as NO_2. Emissions of nitrous oxide (N_2O) are not included, nor are those of ammonia (NH_3) which may arise as a result of certain methods for flue-gas denitrification. The emissions of these two gases may thus increase. Nitrous oxide is a greenhouse gas that also contributes to the thinning of the ozone layer, ammonia is both acidifying and eutrophying. Emission limit values ought therefore to be set for both of these gases, or else the present limit values for NO_x should be extended to express "total fixed nitrogen."

Nitrous oxide and ammonia emissions may increase, need limit values.

It is not possible to find as simple a measure for nitrogen oxides as for sulphur. Conversion to grams of NO_x per gigajoule of energy input gives these limit values:

- Solid fuels in general: 650 mg/m^3 = 228 g/GJ
- Hard coal: 1300 mg/m^3 = 455 g/GJ
- Oil: 450 mg/m^3 = 126 g/GJ
- Gas: 350 mg/m^3 = 95 g/GJ

According to an OECD report from 1992, a typical coal-fired power plant, with no arrangements for curbing emissions, lets out 438 g NO_x/GJ_{input}, whereas in another, with low-NO_x burners and equipped for denitrification (selective catalytic reduction, SCR), emissions can be reduced by at least 85 per cent, giving 66 g NO_x/GJ_{input}, or less than a third of what the directive allows.

Emissions from oil-fired power plants can already be greatly reduced.

Power plants fired with oil but with no flue-gas cleaning emit between 200 and 400 g NO_x/GJ_{input}, of which half could be eliminated by using low-NO_x burners. Add to that SCR, and the emissions can be reduced by more than 85 per cent.

Conventional gas-fired power plants with no cleaning arrangements emit around 165-290 g NO_x/GJ_{input}, which can be reduced by 70 per cent, down to 50 g NO_x/GJ_{input}, by using water injection. Equally great reductions can be attained with low-NO_x burners combined with catalytic cleaning.

As a result of the rapid strides that have been taking place in the development of the technology for gas-fired power plants, much lower figures can be obtained with modern installations. The combined-cycle plant (gas turbine plus steam turbine) that ABB put on the market in 1993, with a record efficiency of 58.5 per cent, is specified for emissions of less than 25 ppm, corresponding to 14 g NO_x/GJ_{input}, without either SCR or water injection.

The best available technology for reducing nitrogen oxides may be said to be a gas-fired combined-cycle plant, and the plants built since the adoption of the directive in 1988 have in fact been mostly of this type. This assumes however that either natural gas or liquid gas (LPG) is available, or can be made available. If other fuels have to be used, both low-NO_x burners and denitrification are essential.

Energy efficiency

In the above the emission limit values inserted for comparison have been expressed in grams per GJ of energy (fuel) input. More interesting however would be to give amounts per unit of useful energy, either as electricity or usable heat, since the total of emissions depends on the total of coal, oil, or gas that is burnt. An important way of reducing emissions is therefore to improve efficiency. Greater efficiency can be obtained at the production stage, as well as in the distribution and use of energy, but here only production will be considered.

An important way to reduce emissions would be to improve efficiency.

Far from 100 per cent of the energy content of the fuel becomes converted into electricity or usable heat. The generators in power plants are usually equipped with condenser turbines, which operate on the principle that the rotor is driven by high-pressure steam at one end and a pressure drop at the other. The pressure drop is achieved by cooling with water, which condenses the steam to drops of water. Most of the energy "vanishes" into the cooling water, which becomes warmed up by about 10 degrees. Between 60 and 70 per cent is thus wasted on the production of a useless by-product in the form of lukewarm water. Only 30-40 per cent of the fuel's energy content goes to producing useful energy.

There are several ways of improving energy efficiency.

Modern gas-fired power plants have gas turbines as well as condenser turbines. A gas turbine operates on the same principle as a jet engine. With a combined cycle (steam turbine plus gas turbine) the waste-heat losses can be brought down to less than 45 per cent. Efficiency thus increases to 50-58 per cent. The best gas combined-cycle plants emit less than 25 g NO_x/GJ of useful energy, which is one-fortieth of the amount allowed by the directive for new coal-fired power plants.

Energy efficiency can be further improved in several ways, one of which is by combining heat and power production. Less electricity is then produced per input unit of energy, but the hot water is of a sufficiently high temperature for use in district heating. Another way is to use industrial back pressure, where the surplus steam (as for instance from drying processes) goes to generating electricity.

A third way is to produce heat directly for space heating, which can be done with 80-95 per cent efficiency. If this replaces electricity in domestic and industrial use, twice as much useful energy will be obtained per unit of energy input. In other words, provided all the other factors are constant, only half as much fuel will be needed to meet a given demand for heat.

Inefficient plants emit a disproportionate amount of pollution.

Among the installations covered by the directive it is precisely the notably inefficient power plants that are responsible for a disproportionate amount of the pollution.

In the directive, however, no regard is taken to energy efficiency even to the extent of favouring combined heat-and-power (CHP) and district heating at the expense of condensing power.

There is a great variation in efficiency on the consumer side (in space heating, household appliances, refrigeration, lighting, ventilation, etc.). This is also an aspect that is ignored in the directive, despite the fact that it offers great practical possibilities, both for utilities and the community, to reduce emissions at a relatively low cost.

There will often be a direct environmental and financial gain if a power company for instance chooses to promote energy-saving industrial processes, energy-saving lighting, windows, refrigerators, etc., instead of investing in a new generating unit.

4. REVISING THE DIRECTIVE

A revision of the directive in 1995 is provided for in the original document – mainly because even in 1988 it was evident that neither the reduction targets for existing plants nor the emission limit values for new plants would suffice to protect the environment.

The Commission had to put forward a directive that was in gross and acknowledged contravention of the Polluter Pays Principle because at that time nothing better was deemed politically possible. Since the decision had to be taken unanimously, any country could block it. The directive that was eventually adopted after more than four years of negotiations included some derogations and a large number of compromises.

Scientific evidence accepted, but costs of reduction a problem.

At the time of drafting, the consequences of continued high emission levels may to some extent have been underestimated. But by the second half of the 1980s the cause-effect relationships between emissions of sulphur and nitrogen oxides and their environmental effects, such as acidification, forest damage, and eutrophication, were widely acknowledged, and the basic scientific evidence was accepted by all governments. The big problem was however the likely costs of the measures needed to reduce emissions.

Although it is a part of the negotiating process to exaggerate the costs for any given emission reduction, it would nevertheless have been undeniably very expensive, for example, to retrofit all major coal-fired power stations for flue-gas desulphurization (FGD) and selective catalytic reduction (SCR), which was thought to be the best solution in the mid 1980s when the directive was conceived.

Cost-effectiveness must clearly enter any politically viable program for reducing emissions. The question of what is sufficient or adequate needs therefore to be addressed with more precision.

Since the mid-1980s environmental scientists have attacked this problem by developing the concept of critical loads – an approach that soon became widely accepted in international environmental politics, being introduced for example in the 1988 NO_x Protocol to the UN ECE Convention on Long Range Transboundary Air Pollution (CLRTAP).

In 1986 an international scientific workshop (6) on critical loads for sulphur and nitrogen coined the following definition: "The highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems."

Harmful effects inevitable if the critical loads are exceeded.

For example, the critical load for acid deposition on forest soils equals the quantity of acid that can be absorbed by the soil without causing harmful effects on the ecosystems. Different types of soils have a varying sensitivity to depositions of acid. Unforeseen harmful effects may still occur at deposition levels below the defined critical loads, but it is nevertheless irrefutable that there will be harmful effects to ecosystems if the critical loads are being exceeded. Scientifically based and internationally agreed methods have been available for some time for determining and mapping critical loads for acidity and sulphur.

Under the auspices of the UN ECE Convention, Europe-wide maps have been made of the critical loads for sulphur (7). These were used in the negotiations leading up to the new sulphur protocol to the Convention, signed in June 1994. (8)

Similar maps showing critical loads for nitrogen are at present being developed, and some preliminary ones already exist. Since nitrogen compounds do not only contribute to acidification, but also cause eutrophication and play a major role in the formation of tropospheric ozone, the production of critical-load maps for nitrogen is less straightforward than it is for sulphur.

A parallel to critical loads is critical levels of air pollutants in their gaseous form. There are scientifically derived and internationally agreed critical levels for sulphur dioxide, nitrogen oxides, ammonia, and tropospheric ozone.

On the basis of such internationally agreed scientific data on critical loads and levels, European environmentalist organizations have concluded that the emissions of sulphur dioxide and nitrogen oxides will have to be reduced by at least 90 per cent, relative to the emission levels of the early 1980s (9). While regarding these as minimum demands, environmentalists do not necessarily maintain that every country or region must achieve equal reductions. Whereas even greater reductions will be necessary in areas with very high emissions, in some others they might be lower.

Emissions will have to be reduced by at least 90 per cent

As it is also becoming known with increasing precision where the pollutants are being deposited, and what the costs will be for reducing emissions in various European countries, it is now possible, in the effort to reduce emissions, to establish priorities.

Some countries, such as Germany, Austria, Sweden, and the Netherlands, have already come a long way towards achieving the needed reductions in SO_2 emissions. But harmful effects will continue as long as the critical loads are being exceeded. Even if an overall SO_2 reduction of 80 per cent should be achieved, the critical values for sensitive forest soils and surface waters may still be exceeded by a factor of two or more. Furthermore, the NO_x emissions have decreased at best by a few percentage points in some countries and even increased in others.

In the EC Fifth Environmental Action Programme, *Towards Sustainability,* adopted in 1993, the stated long-term objective is that there should be no exceeding ever of critical loads and levels. But there are no plans or proposals as to how or by when this aim is to be achieved.

There is a wide chasm between what is needed and the present political intentions of the Commission and the member states.

Wide chasm between what is needed and present political intentions.

Revision of the LCP directive cannot alone change this. The main sources of acidifying and eutrophying nitrogen are transportation (nitrogen oxides) and agriculture (ammonia, both from manure and fertilizers), although the combustion plants covered by the directive are also of importance in this respect.

As for sulphur, the large combustion plants are the main source, together with fuel oils containing sulphur.

Even so, the whole approach of the directive leaves much to be desired. It is, in effect, a watered-down version of the German Ordinance on Large Combustion Plants, adopted already in 1983. For a rich country, during an economic boom, with an acquiescent population and a first-class bureaucracy, it was possible to attack the problem in a typical command-and-control manner. By such methods, an impressively rapid reduction of emissions could be achieved, at a cost the public was ready to pay.

In poorer countries, with a less efficient administrative apparatus and a less committed electorate, and during periods of recession, this approach cannot be copied, especially if the intention is to achieve a still more radical reduction.

Where the directive misses out is in dynamic perspective. There are several options for cutting the emissions of SO_2 and NO_x from LCPs that are not addressed. Here are some examples:

Increased energy efficiency, both at plant and community levels, will result in a reduction of emissions. It is not likely that this would be effectively dealt with by pure command-and-control means, but it

Increasing energy efficiency through use of economic incentives.

could be effectively promoted by higher taxes or charges on energy and/or on emissions, by de-subsidizing for example the German and Spanish coal industries, and by halting tax reliefs for energy-intensive industries. It may be simplistic to claim that a rapid improvement in energy efficiency could be achieved by market instruments alone, but they are an indispensable part of any effective program to this end.

Alternating the use of plants would be one way of minimizing emissions.

Another way of cutting emissions would be if there were two power plants, both running at a base load of about 5000 hours a year, but one with twice as high emissions as the other. If the less polluting plant were to be run for 6000 hours and the more polluting one for 4000 hours, there would be a significant reduction of emissions. Another version of this alternative might be to import or export more electricity, so as to maximally utilize the least-cost low-polluting plants. Clearly such methods are feasible for individual member states as a means of fulfilling their commitments for existing plants, but the actual national emission ceilings show that such a dynamic view should not be taken for granted. Because it seems more difficult to cut emissions than it actually is, governments are unwilling to set ambitious targets.

...as would be to use plants with zero-sulphur emissions.

A third possibility is to use plants with much lower emissions than are required. An example is combined-cycle natural-gas power plants, which emit no SO_2, and much lower levels of NO_x than any other kind of fossil-fueled power plant. Such potential "extra" cuts in emissions are not encouraged by the directive in its present form.

The early retirement or mothballing of highly polluting plants also an option.

A fourth option would be the early retirement, some years ahead of schedule, of highly polluting plants. The marginal cost for the emission reductions achieved in this way may be lower than it is for many other measures, especially in a situation of excess capacity. But according to the directive this has to be ordered by the government – which is usually not easy. The fact that many power stations are publicly owned does not seem to help; every organization strives at least to maintain its staff and budget and if possible to expand, irrespective of ownership.

Mothballing can in some cases be an alternative to decommissioning. An old and dirty coal-fired power station may have a value for reasons of security of supply, for example in case of extreme weather conditions, interruption of natural gas supply, etc.

Need for most cost-effective measures and incentives for improvement

A first-things-first approach must include finding the most cost-effective measures and giving a continuous incentive for improvements. This works better the more are the variables that enter the equation.

For example, the reduction in the emissions of SO_2 and NO_x, which could be achieved by retrofitting an existing plant, might be attained by closing down that plant (see early retirement, above), and instead spending the money that would have been needed for the retrofit on energy savings through demand-side management. The secondary benefits, such as reductions in emissions of CO_2 and other pollutants, would be likely to make such measures even more cost-effective.

Discussion

To attack one problem at a time is not a very efficient way of doing things, and it is even less cost-effective. For a given amount of money the reduction in pollution resulting from a piecemeal approach is much less than from a more integrated one. This is in principle recognized by the Commission, and DG XI officers also describe the coming revised LCP directive as probably the last non-integrated directive of its kind.

It would be facile to criticize the Commission for not employing a fully integrated approach, which is admittedly an extremely complicated administrative undertaking, and apt to raise very serious political obstacles. It is after all better to do something than to wait for perfection. Nevertheless some move towards integrating control of the emissions of SO_2, NO_x, VOCs and CO_2 from large combustion plants would be welcome.

Better to do something now than to wait for perfection.

One realistic way to achieve emission reductions within a reasonable time is through the use of economic instruments. For some years the Commission has persistently fought for a community-wide combined energy/CO_2 tax, and by the autumn of 1993 it had changed emphasis by stressing the "double dividend" – not only will the tax cut emissions, but it will, if the revenues are used to lower taxes on payrolls, also create more jobs.

If this line of argument is accepted, an energy/CO_2 tax could pave the way for more taxes of the "green" type. The Commission has also insisted on reducing coal subsidies, which as a by-product would cut emissions of CO_2, SO_2, NO_x, and VOCs, if any of the indigenous coal were replaced by natural gas, renewables, and/or energy efficiency rather than by imported coal.

In view of all the shortcomings of the existing LCP directive, its revision is a highly important matter. Commission officials have indicated that for new plants, the limit values will be lowered by a factor 2 for SO_2 and a factor 2-3 for NO_x. The latter figure will in practice force the application of selective catalytic reduction at new base-load plants – which is only reasonable, since SCR is about the best available technology for coal-fired power plants, whereas combined-cycle gas-powered plants can achieve lower NO_x emission values even without SCR, for example by using water injection, steam injection, or dry low-NO_x.

Revision of the directive is a highly important matter.

On the other hand, if reduction of SO_2 emission limits by a factor of 2 means just halving all the figures in Annex IV, it would by no means reflect the best available technology (see Section 3 on emission limit values).

The most important part of the directive concerns existing (pre-1987) plants. So far, the Commission has however been extremely reticent about revealing what it is heading for, which presently makes the drama somewhat like Hamlet without the principal character.

5. PROPOSALS FOR REVISION

Decision should be by qualified majority vote, not unanimity.

According to the text of the present directive, its revision would have to be adopted unanimously by the Council of Ministers. After the coming into force of the Maastricht treaty late 1993, there seems however to be some uncertainty as to whether the revised LCP directive should be adopted by unanimous or by qualified majority vote (QMV). Although the qualified majority vote system may be wanting in democratic accountability, if ever there was a case for supranational decisions rather than international, this is it. In most cases the local acid fallout emanates mostly from other countries. Conversely, a large part of most countries' emissions is exported to others. The problem is very much an international one.

According to the Maastricht treaty, whenever it is a matter of the environment QMV is to be the rule and unanimity the exception. An escape clause says among other things that QMV shall not apply if there should be a regulation, directive, or decision "significantly affecting a member state's choice between different energy sources and the general structure of its energy supply." It may well be argued that the LCP directive does not do so, since it would be possible to retrofit all of the existing plants, or at least most of them, to comply with the emission limit values for new plants.

Obviously it is vital for the environment, both in this specific case and as a precedent, that QMV should apply when deciding on the revision of the LCP directive.

Needed reductions

It should be clearly stated that the aim of the directive is to cause the emissions of sulphur and nitrogen oxides to be reduced sufficiently to bring depositions and concentrations down to figures that are below the critical loads and levels.

In order to achieve the objective – of stopping the deterioration of the environment – the European emissions of both SO_2 and NO_x will have to be cut by at least 90 per cent, from 1980, the base year.

Being the main emitters, LCPs will have to do most of the reducing.

The goal of a 90 per cent reduction applies to all sources of SO_2 and NO_x. Since they are the main emitters of SO_2, and an important source of NO_x, a substantial part of the reduction will have to come from large combustion plants, as defined in the directive.

It will probably be difficult at least in the case of some of the other main sources of these pollutants (such as small boilers, and road, sea, and air traffic), to achieve a 90 per cent reduction, especially of NO_x, within the next 10-15 years. The LCPs can, and should therefore do their part by bringing about a full reduction of 90 per cent, both for SO_2 and NO_x. There can be no doubt that this would be technically achievable through the simple replacement of old plants by modern ones. The problem is that this would take too long, since very few plants are retired and replaced each year.

Here is another of the weak points of the present LCP directive. It is inadequate for achieving the necessary reduction of emissions within an acceptable period of time. Even if the emission limit values for the new, post-1987, plants, the only ones directly covered by the directive, were set at zero, it would still take something like 30-40 years to attain the needed reductions, due the fact that the expected life of a combustion plant is about 30-50 years. But the average new plant is not of course a zero-emitter, and the total capacity (number and size) of LCPs is growing.

Combine BAT-standards with economic instruments

There is thus an obvious need either to extend the emission limit values to existing LCPs, or to introduce the use of economic instruments, or a combination of both. The first would mean extending the command-and-control approach in the directive to include existing plants (which could also be done by using the proposed Integrated Pollution Control Directive) so that all plants would be given time-limited operating licenses, with individual emission-limit values. The second alternative is to internalize costs, by setting a price (tax or charge) on the emission of each unit of pollutant.

Extend command-and-control, as well as economc instruments to include existing plants.

A combination of command-and-control with economic instruments would probably be the best way forward if the targets for emission reductions are to be achieved in a cost-effective manner and within a reasonable time.

New plants

That said, the emission limit values for new plants are still of importance. The following simplifications and changes are proposed:

1. The emission limit values should be expressed as grams of SO_2 and NO_x per unit (GJ) of useful energy. That would be neutral as regards fuel, and favour efficiency. It would put the heaviest demands on electricity-only production, which would be reasonable as there are many ways to avoid emissions from new power plants.

2. The emission limit values should be the same for all sizes of boilers (above the threshold size of 50 MW_{th} already set in the directive).

3. The emission limit values for plants ordered when the revised directive is in force should differ from those for upgraded plants built in the period 1987-1995. In the revised directive, this would necessitate three rather than two categories for large combustion plants: pre-1987, post-1995 and a middle category. The emission limit values to be set for the post-1995 plants should reflect the most up-to-date BAT practices.

Three categories for LCPS as regards emission limit values.

4. As numerical values the following are suggested: emission limit values of 12 grams of sulphur per gigajoule of useful energy (g S/GJ_{output}) for sulphur dioxide for all new (post-1995) large combustion plants, and 40 g NO_x/GJ_{output} for nitrogen oxides. For plants licensed between 1987 and 1995, the emission limit values could be set twice as high.

The SO_2 limit value of 12 g S/GJ_{output} corresponds to about 5 g S/GJ_{input} for power stations (with 45 per cent efficiency) and 11 g S/GJ_{input} for district heating and combined heat-and-power plants (CHPs) with 90 per cent efficiency. The last figure in turn corresponds to 60-80 mg SO_2/m^3, depending on the fuel used. When using high or medium-sulphur fuels, the attainment of such emission levels would require either highly efficient sulphur removal (95 or more per cent), for example through flue-gas desulphurization, or gasification of the fuel prior to combustion.

The NO_x limit value of 40 g NO_x/GJ_{output} corresponds to about 18 g NO_x/GJ_{input} for power stations, or 36g NO_x/GJ_{input} for district heating or CHP plants (assuming the same efficiencies as above). The last figure corresponds to 100-130 mg NO_x/m^3, also depending on the fuel. This emission limit value could be attained for example by combined-cycle natural-gas power stations, or plants using gasification (IGCC), or others equipped both with low-NO_x burners and selective catalytic reduction.

5. New reserve and peak power plants could be given less stringent targets, since they emit lesser amounts of pollutant per year, and the cost for pollution control is disproportionally high per ton of SO_2 and NO_x so removed. There is however no case for permitting any

Limit values both to bring about reductions and provide incentives for improving technology.

combustion without some form of desulphurization other than with extremely low-sulphur fuels. The emission limit values for reserve and peak power plants should be set so as to attain the twin goals of providing cost-effective emission reductions, and an incentive for improving technology. The limits could be made to be the maximum allowed annual emissions of SO_2 and NO_x, expressed as tons per year. If annual limits are exceeded, there should be both fines and a requirement to cut emissions still further in the following year.

6. Fines should be prescribed for exceeding limits. All cases where this occurs should be made public by the Commission.

7. There should be no general exemptions, only individual (plant by plant) derogations allowed by the Commission. Applications and all correspondence concerning such derogations should also be made public by the Commission.

8. It should be stated that a revision must be undertaken so as to give new values from 1999. This could be done within the framework of the directive for Integrated Pollution Control.

Existing plants

National emission ceilings for existing plants the most important item.

The most important part for revision concerns the national emission ceilings for existing plants, because it is from them that most of the emissions come. It would make little sense here in this report to give alternative quantitative recommendations for each of the twelve nations. The ceilings should however be reformulated so as to signify *total* LCP emissions, i.e. including emissions from new plants. To retain the present artificial partition between old and new plants would be to conserve the misconception that there are a) old problematic plants and b) clean new plants. As mentioned earlier, from the point of view of environmental protection the most relevant parameters are the total SO_2 and NOx emissions, irrespective of how they are distributed among old and new, small or big plants.

Better with pollutants stated per amount of useful energy.

In the EU region there are, however, some spectacular point sources of SO_2 emissions. (10) To clean them up or eliminate them will not by itself solve the overall problem, but it might well result in remarkable environmental improvement, since it is likely that those same plants are also top offenders as regards several other pollutants. This becomes even clearer if pollutants are stated per amount of useful energy, and if emissions of CO_2 are also taken into account. One strategy might be for example to identify the hundred worst point sources of sulphur emissions in the Union – calling them, say, cases of worst available technology (WAT). The next step would be either to:

□ make them unnecessary, for example through demand-side management; or

□ replace them with non-polluting plants or plants using much less polluting sources of energy (such as bioenergy, natural gas, LPG, or coal/oil gasification); or

□ retrofit them to achieve emission limit values in line (or nearly in line) with BAT for new combustion plants.

The worst offenders should in many cases be closed down.

Such a scheme would be likely to pay off nicely for the environment as well as by promoting European competitiveness in cutting-edge technology. Some of the worst plants are to be found in poor regions of the poorer member states. Subsequently, the measures adopted should be aided by some kinds of EU or national subsidies. In many cases, however, the plants in question should simply be closed down, because the environmental destruction they give rise to is unacceptable, and short-term measures for reducing emissions might not be economically justifiable.

A first prerequisite for a "WAT-strategy" is however an *increased freedom of information*. The Commission has collected information on every major combustion plant in the EU, with emission data and efficiency (i.e. how much of the energy in the fuel is transformed into useable energy). But at present such data are being kept secret.

Related issues

Apart from the revision of the directive, there are also other matters of importance as regards the future emissions of sulphur and nitrogen oxides.

The proposed combined energy/CO_2 tax should be introduced as soon as possible. Although this proposal seems so far to have failed at EU level, at least some member states are likely to introduce such a tax, and the issue will inevitably re-emerge on the EU agenda. Any such tax – whether applied nationally or on an EU scale – will also act as an indirect SO_2 and NO_x tax, because often the worst CO_2 emitters, such as coal-fired power plants, are also high emitters of SO_2 and NO_x. Furthermore, once an energy/CO_2 tax has been adopted, it should pave the way for other eco-taxes.

Energy/CO_2 tax should be introduced as soon as possible.

The proposed energy/CO_2 tax is assumed to be "revenue neutral," meaning that other taxes should be lowered, so as to keep the tax burden constant. There are several reasons for this, one being that so much money is involved, over so long a time, that earmarking the revenues (say, for environmental purposes) would be inpractical.

Revenues from taxes on SO_2 and NO_x emissions are not, however, a direct parallel. They should not necessarily be fully revenue neutral, as the tax base would in any case become rapidly eroded as emissions decrease. High SO_2 and NO_x taxes will induce rapid reductions, and thus rapidly falling revenues.

A phase-out of subsidies to the coal, aluminium, and steel industries would also be likely to have a significant effect in reducing emissions. Old steel, and especially coking operations, emit great quantities of pollutants. They and the coal mines also consume large amounts of energy, often from old coal-fired power stations. A phase-out of subsidies is moreover favoured by the Commission.

Phase-out of subsidies would also result in reduced emissions.

The electricity sector is riddled with market distortions. Proposals for liberalizing it have so far failed, but are likely to re-emerge. When and how the power and gas markets are reformed will greatly affect the emissions of sulphur and nitrogen oxides.

Other important measures would be to impose stricter limits on the sulphur content of gas oils (light fuel oils and diesel), and to introduce limits on the sulphur content of heavy fuel oils, including bunker oils used in ships.

Stricter limits on sulphur content of fuel oils.

Such proposals have been vented – for example in the so-called French Memorandum – but so far the development of new and improved EU directives has been painfully slow.

Much needed, too, is a Demand Side Management/Integrated Resources Planning Directive. This should oblige electricity utilities to look into the possibilities of saving electricity as an alternative to building new power plants and power lines, and to supply such a service to their customers.

Stricter energy conservation standards for buildings and domestic appliances could achieve huge long-term savings in energy, and thus cut emissions. The high ambitions for specific energy-efficiency targets with which the SAVE program started have since been shamefully watered down under the banner of subsidiarity.

A carefully thought-over policy for influencing the countries of Central and Eastern Europe (CEE) to reduce their emissions is also essential. It should include conditions for imports of energy-intensive goods (coal, aluminium, copper, ammonia, etc.) and assistance programs. The conditions for opening up trade should include stricter targets and timetables for reduction of the emissions of NO_x and SO_2. But the most effective way to exert influence is by example. It would be a big mistake if the EU were to continue to allow subsidies for

Essential to influence eastern countries, too, to reduce emissions.

exports of energy-intensive agricultural products, coal mining and steel production, etc., while condemning the CEE countries for doing the same.

If, on the other hand the EU were to start serious action for reducing the chief air pollutants by using economic instruments as a complement to regulatory measures, it might be possible to include the CEE countries, either one by one or as a group in such a regime. This might later be extended through the introduction of tradeable emission permits. If the western Europeans show that they can fight down a hundred-year tradition of electricity oligopolies and over-supply, it might drive home the message to their eastern neighbours. If the westerners were to take responsibility for developing schemes and technologies for conserving energy, it would enable the East to leapfrog 40 years of technological development.

To attain the ecologically necessary reductions of SO_2 and NO_x from LCPs in Europe by "end-of-pipe" technical measures only – such as retrofitting almost all large boilers in Europe for FGD and SCR plus very large investments in refinery up-grading – would no doubt be very expensive.

In an alternative framework of lower capital and energy intensity, driven by a tax shift, reductions of emissions would not only be possible but could be brought about while creating wealth and employment in traditional GDP terms and at the same time halting the steady impoverishment of natural capital.

With decreasing demand for energy, cost of closing down worst plants almost nil.

Furthermore, with the demand for energy decreasing as outlined above, it will cost next to nothing to close down the worst-polluting plants.

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APPENDIX: TABLES AND FIGURES

Table 1. (Annex I) Ceilings and reduction targets for emissions of SO_2 from existing plants.[a b]

Member state	Emissions ktons 1980	Emission ceiling ktons/year 1993	1998	2003	% reduction over 1980 emissions 1993	1998	2003	% reduction over 1980 adjusted emissions 1993	1998	2003
Belgium	530	318	212	159	-40	-60	-70	-40	-60	-70
Denmark	323	213	141	106	-34	-56	-67	-40	-60	-70
Germany[1]	2225	1335	890	668	-40	-60	-70	-40	-60	-70
Germany[2]	5000	3000	2000	1500	-40	-60	-70	–	–	–
Greece	303	320	320	320	+6	+6	+6	-45	-45	-45
Spain	2290	2290	1730	1440	0	-24	-37	-21	-40	-50
France	1910	1146	764	573	-40	-60	-70	-40	-60	-70
Ireland	99	124	124	124	+25	+25	+25	-29	-29	-29
Italy	2450	1800	1500	900	-27	-39	-63	-40	-50	-70
Luxembourg	3	1.8	1.5	1.5	-40	-50	-60	-40	-50	-50
Netherlands	299	180	120	90	-40	-60	-70	-40	-60	-70
Portugal	115	232	270	206	+102	+135	+79	-25	-13	-34
United Kingdom	3883	3106	2330	1553	-20	-40	-60	-20	-40	-60

[a] Additional emissions may arise from capacity authorized on or after July 1, 1987.

[b] Emissions coming from combustion plants authorized before July 1, 1987 but not yet in operation before that date and which have not been taken into account in establishing the emission ceilings fixed by this annex shall either comply with the requirements established by this directive for new plants or be accounted for in the overall emissions from existing plants that must not exceed the ceilings fixed in this annex.

[1] Figures for former West Germany according to Annex I of directive 88/609/EEC.

[2] Figures for Germany (as after the unification) according to Article 15 of directive 90/656/EEC. Note that for Germany, values set for 1993 in the tables must be complied with by 1996.

Table 2. (Annex II) Ceilings and reduction targets for emissions of NOx from existing plants.[a b]

Member state	Emissions ktons 1980	Emission ceiling ktons/year 1993[c]	1998	% reduction over 1980 emissions 1993	1998	% reduction over 1980 adjusted emissions 1993	1998
Belgium	110	88	66	-20	-40	-20	-40
Denmark	124	121	81	-3	-35	-10	-40
Germany[1]	870	696	522	-20	-40	-20	-40
Germany[2]	1090	872	654	-20	-40	–	–
Greece	36	70	70	+94	+94	0	0
Spain	366	368	277	+1	-24	-20	-40
France	400	320	240	-20	-40	-20	-40
Ireland	28	50	50	+79	+79	0	0
Italy	580	570	428	-2	-26	-20	-40
Luxembourg	3	2.4	1.8	-20	-40	-20	-40
Netherlands	122	98	73	-20	-40	-20	-40
Portugal	23	59	64	+157	+178	-8	0
United Kingdom	1016	864	711	-15	-30	-15	-30

[a] Additional emissions may arise from capacity authorized on or after July 1, 1987.

[b] Emissions coming from combustion plants authorized before July 1, 1987 but not yet in operation before that date and which have not been taken into account in establishing the emission ceilings fixed by this annex shall either comply with the requirements established by this directive for new plants or be accounted for in the overall emissions from existing plants that must not exceed the ceilings fixed in this annex.

[c] Member states may for technical reasons delay for up to two years the phase 1 date for reduction in NOx emissions by notifying the Commission within one month of the notification of this directive.

[1] Figures for former West Germany according to Annex II of directive 88/609/EEC.

[2] Figures for Germany (as after the unification) according to Article 15 of directive 90/656/EEC. Note that for Germany, values set for 1993 in the tables must be complied with by 1996.

Table 3. (annex V) Emission limit values for SO_2 for new plants: gaseous fuels.

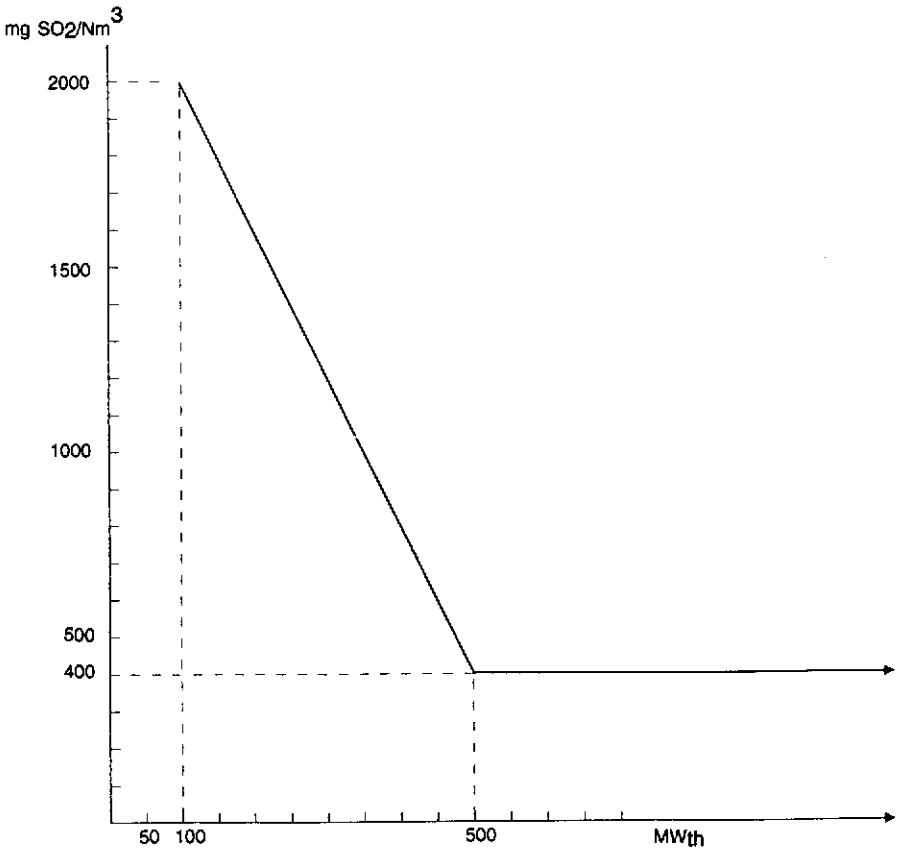
Type of fuel	Limit values (mg/Nm^3)
Gaseous fuels in general	35
Liquefied gas	5
Low calorific gases from gasification of refinery residues, coke oven gas, blast-furnace gas	800
Gas from gasification of coal	(1)

(1) The Council will fix the emission limit values applicable to such gas at a later stage on the basis of proposals from the Commission to be made in the light of further technical experience.

Table 4. (annex VI) Emission limit values for NO_x for new plants.

Type of fuel	Limit values (mg/Nm^3)
Solid in general	650
Solid with less than 10% volatile compounds	1300
Liquid	450
Gaseous	350

Figure 1. (Annex III) Emission limit values for sulphur dioxide for new plants[1] Solid fuels.



[1] In 1990, on the basis of a Commission report on the availability of low-sulphur fuel and a relevant Commission proposal, the Council will decide on emission limit values for plants between 50 and 100 MW_{th}.

Figure 2. (Annex IV) Emission limit values for sulphur dioxide for new plants: Liquid fuels.

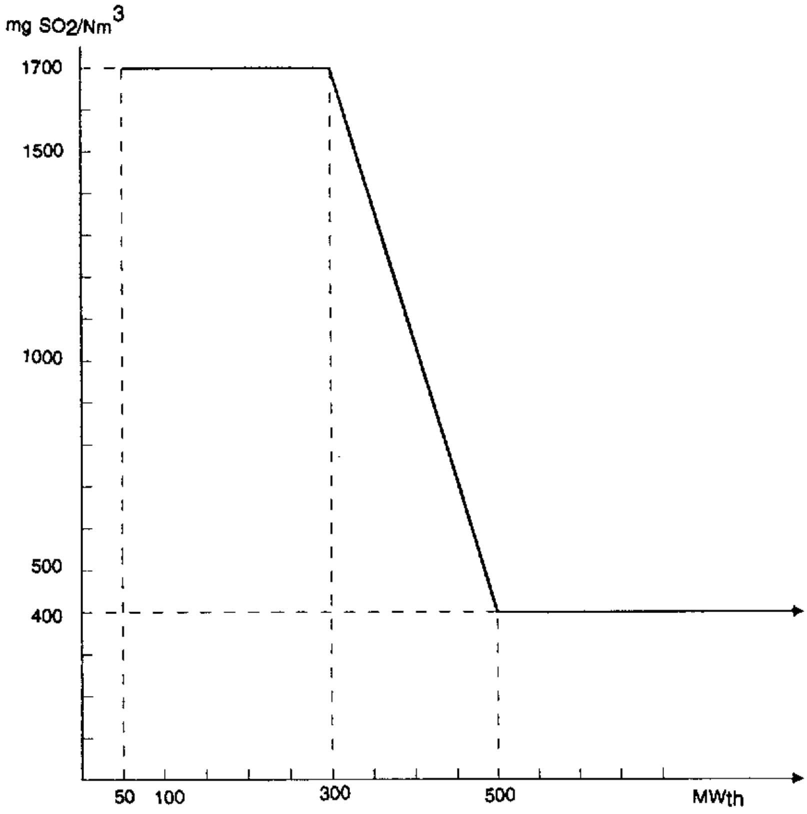
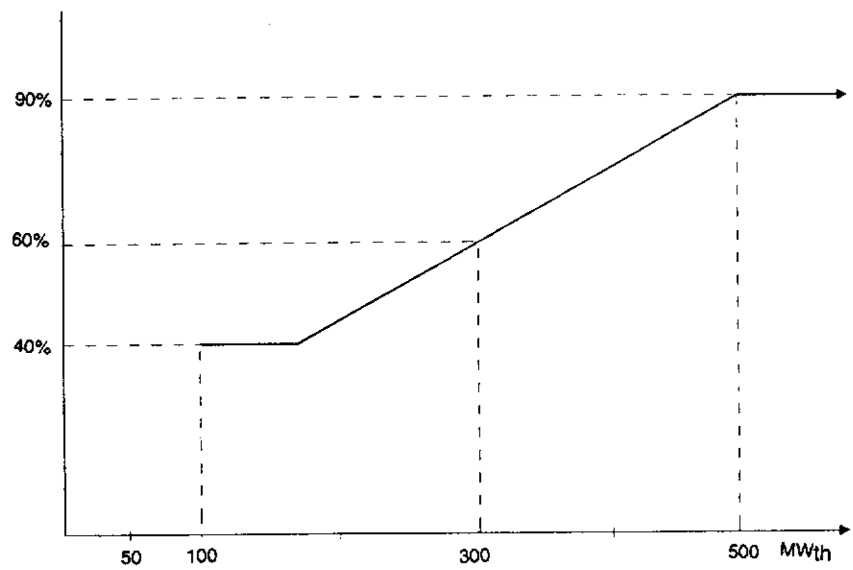


Figure 3. (Annex VIII) Rates of desulphurization.



Sweden's lakes and forests

BECAUSE OF AIR POLLUTION, close on 14,000 lakes are now distinctly acidified in Sweden – and about 4000 of them very badly so. And rapid further deterioration will ensue if acid deposition continues at the same rate as today – it being estimated that after only a few decades the number of acidified lakes will have risen to 34,000. In total, the country has something like 85,000 lakes with a surface area of more than one hectare.

Acidification has extensive biological effects in lakes. For one thing the diversity and number of aquatic species diminishes, resulting in a greatly changed ecosystem. Such effects occur already when the pH-level of the water drops below 6. Among the sensitive animal species are snails, mussels, crustaceans, and certain species of insects and fish.

As regards the effects on forest soils, the pH value of the soil on some 650,000 hectares of forest land in South Sweden is now under 4.4, which is thought to be a critical level at which release of potentially toxic metals to the soil water will start. On a further 700,000 hectares in that part of the country the pH values range between 4.4 and 4.7, and unless there is a dramatic reduction of the acid deposition, the acidification of these soils too will go below the critical level within a couple of decades.

Areas where the forest soils are so acidified that there is a risk of extensive damage to trees and other vegetation.

One effect of acidification is the greatly increased leaching of plant nutrients from the soil. Since 1950, in some areas more than half of the available magnesium, potassium, and calcium has become lost in this way.

National inventories of the scale and distribution of forest damage have been carried out since the mid 1980s. In 1993 eleven per cent of the trees were classed as moderately to severely damaged, i.e. they had lost more than a quarter of their foliation.

Other negative effects caused by the sulphur and nitrogen pollution are changes in the flora and fauna, acidification of the groundwater, reduced crop yields, damage to materials and cultural monuments, and direct impact on human health.

The cause of acidification is to be found in man-made emissions to the atmosphere, primarily of sulphur dioxide and nitrogen compounds. As shown by data from the European monitoring program, between 80 and 90 per cent of the sulphur and oxidized nitrogen compounds that are deposited over Sweden comes from abroad, the countries contributing the most being Germany, Britain, and Poland.

The discovery of the acidification problem in Sweden, in the mid-1960s, led to the adoption of measures to reduce the emissions of sulphur dioxide, starting in 1969. In 1970 Swedish emissions of sulphur dioxide amounted to about 900,000 tons. By 1980 they had been nearly halved, and by 1993 thay had fallen to 101,000 tons – a reduction of 80 per cent as compared to the level of 1980. Parliament has decided that the aim will be to reduce emissions by 80 per cent between 1980 and 2000.

Swedish emissions of nitrogen oxides amounted in 1980 to 454,000 tons, and by 1993 they had been reduced by 12 per cent, to 399,000 tons. The target for reductions as decided by the Swedish parliament is to reach a 30-per-cent reduction by 1995. According to estimates by the Swedish Environment Protection Agency, this target is however not likely to be attained until around 2000.

The amount of acid deposition that that various types of soil will manage to neutralize in the long run – the so-called critical load – will depend primarily on the rate of mineral weathering. The critical load may be defined as the greatest superaddition of a certain pollutant that ecosystems can support without suffering damage in the long term. The additions of acid substances should therefore not take place at a rate exceeding that required to enable the weathering of the soil to neutralize them.

In Scandinavia, the critical loads for acid deposition are being exceeded on 80 per cent of the forest area. According to recent calculations done by the Swedish Environment Protection Agency, for Sweden the deposition will have to be reduced by at least 70 per cent between 1990 and 2010 if the acidification of the soil is not to go on increasing. To reverse acidification will naturally require still greater reductions. And the quicker the desired rate of recovery, the faster and greater they must be.

If continued harm to the environment is to be avoided, the emissions to the air of acidifying pollutants will have to be radically reduced. The steps so far taken to do so have by no means sufficed.

Much of this kind of pollution comes from large combustion plants, and just now an EC directive from 1988 for the control of their emissions is in course of revision. Here that directive is critically examined, and proposals made, on the basis of the best available technology, for stricter standards both for new and existing plants.

This report is published by the Swedish NGO Secretariat on Acid Rain as a contribution to discussion regarding the revision of the directive. It has been written by Christer Ågren, director of the secretariat, and Fredrik Lundberg, a journalist who has been reporting for many years on energy and the environment, has published books on this and associated subjects, and has recently been observer for the Swedish Society for Nature Conservation in Brussels.

The Swedish
NGO Secretariat
on Acid Rain