T. Schneider (Editor)/*Acidification and its Policy Implications*
Elsevier Science Publishers B.V., Amsterdam - Printed in The Netherlands

THE NETHERLANDS POLICY AND RESEARCH PROGRAMME ON ACIDIFICATION

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INTRODUCTION

The main features of the acidification control policy were developed in the Indicative Multi-year Programme on Air Pollution 1985-1989 which was sent to Parliament by the Minister of Housing, Physical Planning and Environment in September 1984. Acidification was broadly interpreted in that programme. The influence of photochemical air pollution was also understood as acidification if it involved damage to forests and vegetation. The policy has been further elaborated in the subsequent Environmental Programme's of the Netherlands (1985-1989 and 1986-1990).

Situation

Although SO_2 control also took place before 1984, it has not prevented 90 percent of the Netherlands' fens from being damaged in the meantime. Injury to the Netherlands' forests could also be shown after the alarm was rung in Central Europe concerning forests. An inventory by our Forestry commission shows that 50 percent of our forests are now less vital, 13 percent have been damaged to such an extent that, although the possibility of recovery has not been excluded, it must be assumed that a great deal will have to be replaced in the medium term, and 2 percent of our forests have been irrevocably lost and will have to be cut down in the short term.

POLICY

Inventory of forest damage

	1984	1985
Healthy	51%	50%
Slightly damaged	40%	35%
Damaged	8%	13%
Dead or dying	1%	2%

FIGURE 1

The soil is sensitive to acidification in large parts of the Netherlands. It is precisely in these areas that, due to historical and social-economic reasons, large scale intensive livestock raising is carried out. Because of the

Areas in the Netherlands with soils sensitive to acidification.

FIGURE 2 Source: STIBOKA 1970

intensive livestock raising industry, we in the Netherlands have both the problem of surplus manure and the problem of acidification from ammonia. It also means that the soil in the Netherlands is burdened not only by deposition of SO_2 and NO_x - as is the case everywhere in Europe - but also by NH_3, produced chiefly in our own country.

All in all, our estimate is that the input in our soil of acidifying substances originating in our country and elsewhere is too high by a factor of two to four.

Damage

We estimate the damage from acidification and the effects of photochemical air pollution at an annual amount of US $ 250-350 million. This does not include effects which cannot - or can hardly - be expressed in monetary terms, such as the disappearance of plant and animal species, damage to our cultural property, and the often irreversible effects on soil. In the absence of control measures, the annual damage will increase to circa US $ 350-600 million.

As shown in the table (Figure 3), a significant share of the current damage is caused by the reduced harvest yield. The largest part of this reduced yield is due to ozone; a smaller share results from SO_2 and fluorine. This was calculated by two of our large agricultural institutes, namely the Institute for Plant Disease Research and the Agricultural Economics Institute. In the future, but also evident already, the financial consequences of forest damage will become increasingly more important.

ESTIMATE OF THE FINANCIAL DAMAGE FROM ACIDIFICATION (INCLUDING THE EFFECTS OF O_3) IN MILLIONS OF GUILDERS[1]) PER YEAR

	Current damage	Future damage[2])
Agriculture	565 - 655	565 - 655
Nature management	5 - 30	15 - 55
Forestry	pm	170 - 550
Recreation	pm	pm
Cultural goods	55 - 100	55 - 100
Users goods	40	40
Drinking and industrial water recovery	pm	20 - 50
TOTAL	**700 - 800**	**900 -1500**

1) 1 dutch guilder is equivalent to about 0.40 US $
2) if policy is not changed
FIGURE 3

Origin

On average in the Netherlands, the total deposition of substances contributing to soil acidification amounts to circa 6000 mol H^+ per hectare per year (Figure 4). This deposition is composed of:

- SO_2 and sulfates originating in our own country and far over our borders (Figure 5),
- NO_x and nitrates that are deposited on the soil over large areas less pointedly than SO_2 (Figure 6), and finally
- NH_3 and ammonium that are created primarily as a result of the livestock industry in our own country (Figure 7).

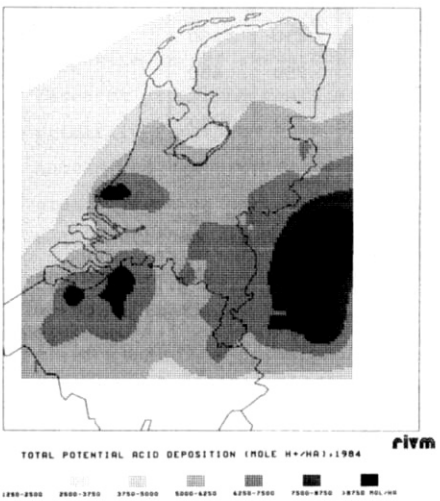

FIGURE 4

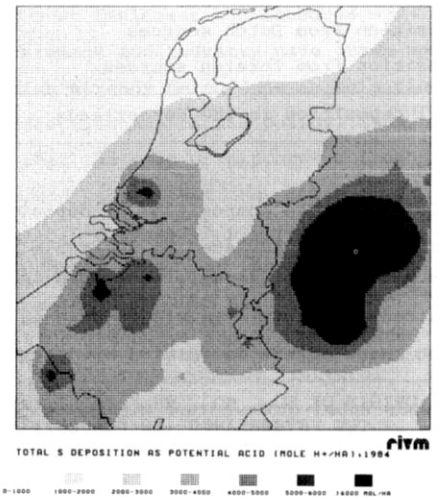

FIGURE 5

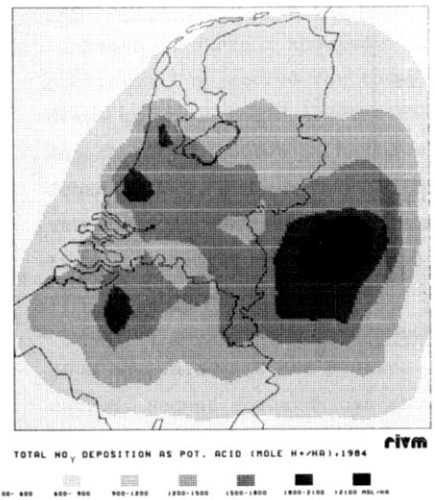

FIGURE 6

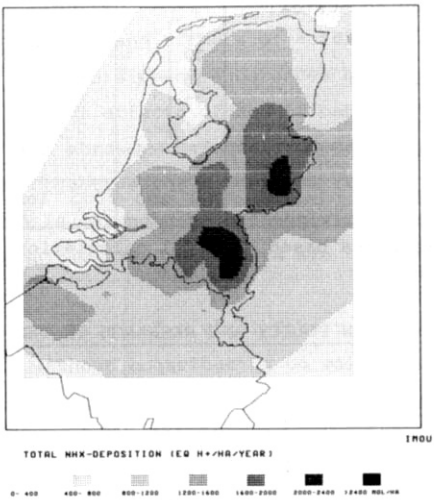

FIGURE 7

We have recently learned that ammonia does not have to be an exclusively Dutch problem. A recent inventory of the NH_3 emission pattern in Europe by an institute of our university in Utrecht gives cause to believe that NH_3 could also play a role elsewhere. It is, therefore, possibly also important for other countries to combat ammonia in certain regions.

AVERAGE DEPOSITION AND ORIGIN OF POTENTIALLY ACIDIFYING SUBSTANCES (ACID EQUIVALENT/HECTARE/ANNUM) IN THE NETHERLANDS.

	SO_2	NO_x	NH_3
Deposition from natural sources (rough estimate)	280	130	190
Deposition from Dutch sources	570	430	1350
Deposition from foreign sources	1900	750	400
Total deposition in the Netherlands	2750	1310	1940

FIGURE 8

All in all, the composition of deposition in the Netherlands is approximately as indicated in the table (Figure 8). The level of circa 6000 mol H^+ per hectare per year is higher than we think acceptable by a factor of two to four. The table in Figure 9 shows that, with the exception of NH_3, the largest share of the deposition originates in nearby countries.

ORIGIN OF SO_x, NO_x, NH_x DEPOSITION IN THE NETHERLANDS (IN PERCENT)[1])

Country	SO_x(%)	NO_x(%)	NH_x(%)
The Netherlands	23	33	72
Nearby countries:			
FRG	25	30	6
U.K.	19	14	5
Belgium	16 > 71	10 > 61	7 > 26
France	7	6	6
GDR	4	1	1
other countries	6	6	3
Total	100	100	100

1) Estimate based on model calculations.
FIGURE 9

ACIDIFICATION POLICY AND RESEARCH IN THE NETHERLANDS

Policy

General

The kernel of the Netherlands' acidification policy is determined by two factors. In the first place, there is the fact that we have first established a provisional objective for the deposition of acidifying substances. The

technological and economic possibilities have been weighed in establishing the tempo with which it will be attempted to achieve the objective, namely the year 2000, and to a certain extent in the stringency of the objective itself. Based on this deposition objective, a package of control measures has been drawn up and a time path has been set out for the phased introduction of the measures.

The second factor is the role of research. We did not think it responsible to wait with measures until all research was exhausted. Therefore, the measures have already been set out. Research does have an important function in the supervision of the effectiveness and efficiency of the control measures. Government and industry - who must implement the measures - cooperate in the research. Together government and industry have drawn up a research programme that, added to research already being done in this field, primarily functions as a check on the effectiveness of the policy. Thus, should the research show, for example, that the role of nitrogen compounds is greater than is currently assumed, it could happen that the emphasis of the policy will shift to NO_x and NH_3 control. This research programme, financed and steered jointly by government and industry, runs for three years. It is expected that the research will deliver results in 1988 that will play a role in the planned evaluation of the deposition objective and the associated measures. A central place has been made in the research for "integral monitoring" of forests. This has been made central because knowledge about the mechanism of damage from acidification is crucial for instituting or, if necessary, adapting measures.

Provisional objective for acidifying substances

Based on current knowledge about the causes and effects of acidification, a provisional objective for the deposition of acidifying substances has been drawn up which could prevent the most serious effects of acidification. This deposition objective is based on data from abroad - especially Sweden and Canada - and from our own country. This objective for deposition is 1400 equivalents acid per hectare per year, which is intended to protect vital vegetation. Less vital vegetation and very sensitive surface waters are not, however, protected by this.

In the past it was assumed that the ecosystem of a vital forest can absorb 1600 equivalents N per hectare per year without contributing to soil acidification. Recent research has shown that this threshold value of 1600 equivalents N per hectare per year only applies for the short term; with prolonged exposure, the ecosystem will become saturated and the deposition will have an acidifying effect.

At the April workshop on "Critical loads for Sulphur and Nitrogen" held in Oslo at the initiative of the Nordic Council of Ministers, the consensus of expert opinion was that in the long term deposition will have to be reduced considerably more than the objective currently adhered to by the Netherlands.

Emission reduction of acidifying substances

If this deposition objective were applied to all of Europe, it would mean a 70 percent reduction in SO_2 emissions and a 30 percent reduction in NO_x emissions in Europe compared to the level in 1980. Acid deposition in the Netherlands exceeds the average in Europe. This is so because NH_3 emissions are much larger in the Netherlands (by approximately a factor of three) than on average in Europe. In order to attain the provisional objective in the Netherlands, NH_3 emissions in the Netherlands must also be reduced by 50 percent.

The problem, of course, is to achieve a balanced approach, in which a reasonably distributed effort is realized for the different sources and substances that contribute to acidification. Such a package of measures has been drawn up for the Netherlands. The package of measures that was drawn up will lead to the attainment of emission reductions of circa 60 percent for SO_2, circa 30 percent for NO_x and circa 50 percent for NH_3 in the year 2000 compared to 1980 in the Netherlands.

The measures for SO_2 amount to flue gas desulphurization, fluidized bed combustion and use of low sulfur fuels at coal and oil fired combustion installations, reduction of process emissions in industry and at refineries, and reduction of the allowed sulphur content of diesel fuel and bunker oil. The measures for NO_x are directed partly at mobile sources, for which strict standards will apply that can only be achieved through use of three way

POLICY

Abatement measures

SO_2 - Flue gas desulphurisation
- process emissions
- % S in fuel oil

NO_x - stricter standards for motor vehicles
- Low-NO_x combustion for stationary sources

NH_3 - limiting amount of manure spread per ha
- manure injection into the soil

FIGURE 10

REDUCTION OF EMISSIONS IN 2000 (MILLION KG/ANNUM)			
	SO_2	NO_x	NH_3
Agriculture	-	25	65
Power plants	260	25	-
Refineries	60	-	-
Traffic	20	70	-
Others	40	50	5
TOTAL	380	170	70

FIGURE 11

catalytic converters or lean-burn motors, and partly at stationary sources, where low NO_x combustion systems for furnaces and process integrated control technologies for industrial sources will be obligatory. The (intensive) livestock raising industry is the chief NH_3 source that will be controlled, particularly through the introduction of norms for the quantity of manure that may be spread per hectare and through promotion of more favourable kinds of stalls. We will also promote the spreading of manure in a way that generates less ammonia (manure injection, rapid plowing under, etc.). This leads to a considerable emission reduction (Figure 11).

The measures are being carried out partly via the legislative instrument of general administrative orders (e.g. furnaces) and partly via instruments such as public information (e.g. NH_3 from agriculture) and economic incentives (e.g. traffic). Large costs accompany the programme (Figure 12).

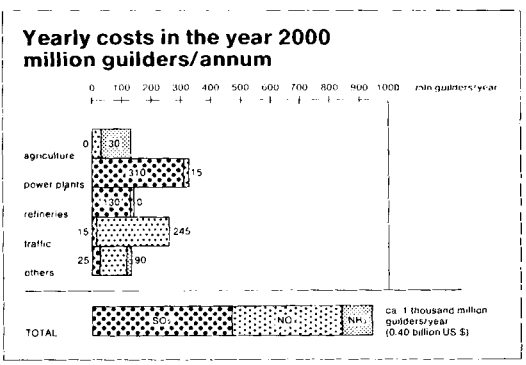

FIGURE 12

Development of emissions

We are trying to realize in the Netherlands the contribution to the reduction that we can deliver ourselves. The graph (Figure 13) presents how emissions in the Netherlands will progress if this policy is successful.

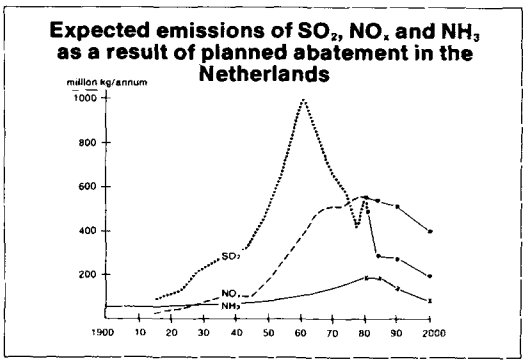

FIGURE 13

Whether or not the deposition objective is achieved also depends on agreement in the framework of the convention on Long Range Transboundary Air Pollution and particularly on the efforts of nearby countries. The Netherlands is aware that they cannot solve the acidification problem alone. The scenario to be followed internationally determines whether we will reach our goal.

As shown in the figure (Figure 14, next page), only one of the many conceivable options is sufficient to reduce current deposition to the level of 1400 mol H^+ per hectare per year.

In our opinion, only reducing SO_2 emissions by 30 percent, as was agreed to in the Helsinki Protocol, is not sufficient. More steps with respect to SO_2 will have to be taken. A reduction in the order of magnitude of 70 percent is necessary in our view.

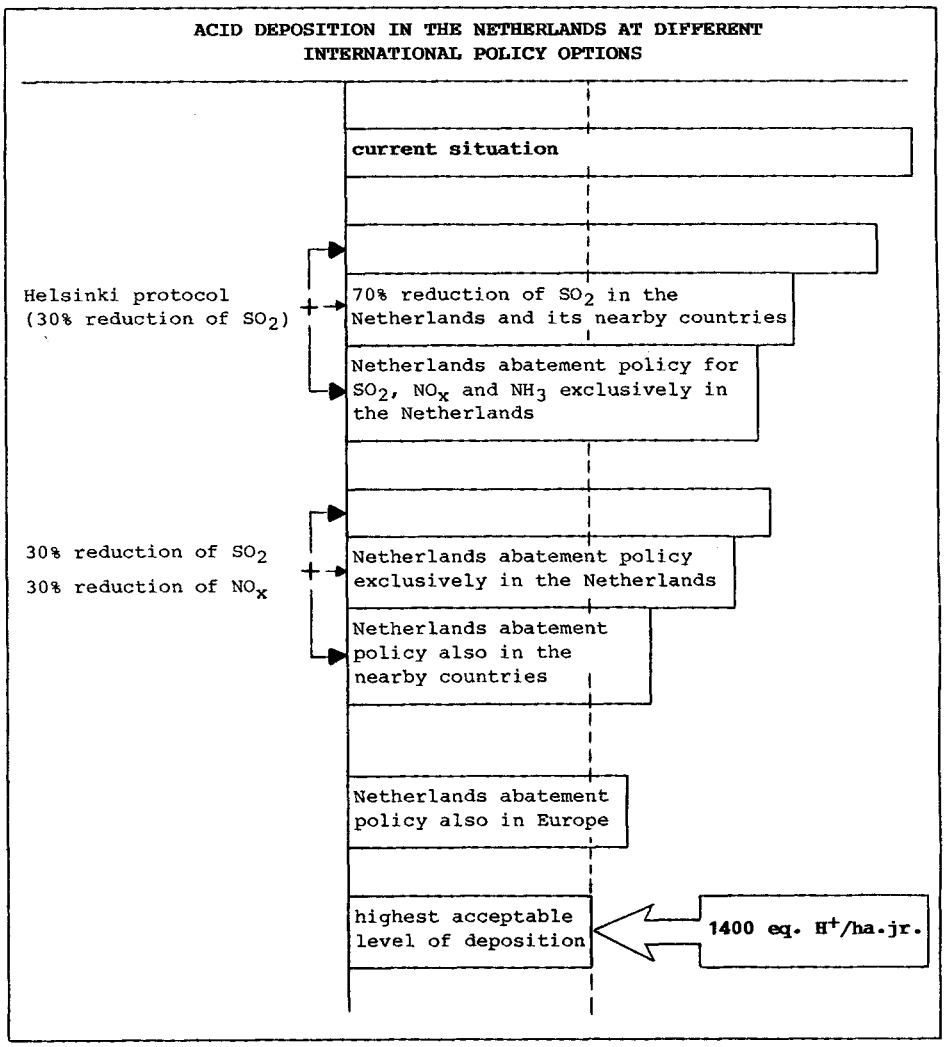

FIGURE 14

But no matter how seriously SO_2 is dealt with, a problem will remain if NO_x emissions are not also dealt with. The second cluster of options shows how important additional NO_x reduction - for example, by circa 30 percent - is for the Netherlands.

We must take into account that no matter how energetically policy is developed nationally or internationally, more effects of acidification are going to appear during the coming decades. The measures currently planned are

insufficient to prevent that. Moreover, there are effects for which the seed has already been planted and which are now unavoidable. In that connection it is essential to devote timely attention to temporary management measures on the effects side. Possibly in this way can the dying off of forests be temporarily delayed.

Research

General

In 1983 Parliament requested information from the government about the effects of acid deposition and how government would tackle acidification. In response to this, a brief but very thorough survey was held that same year on the effects on soil, groundwater, vegetation, surface waters and animals living in the soil or water. Both the effects that were observed and those that might be anticipated were investigated. The Ministers of Environment and Agriculture presented their findings to Parliament in January 1984. It contained, among other things, the main outline of the research that was regarded as necessary.

At Parliament's request the report on the problem of acidification of 8 January 1984, was followed by a report which dealt specifically with the organization of acidification research. The latter, submitted on 27 June 1984, was debated in Parliament on 13 February 1985. The report contains a rough survey of current research, priorities set with regard to the content of future research and the organizational structure of research.

Research already underway

Research into different aspects of the acidification problem has been going on for many years in the Netherlands. Much of this research takes place as part of air pollution research: the main topics are emissions, abatement technologies, atmospheric processes, transport and dispersion models, wet and dry deposition research and monitoring of air concentrations.

Partly in another context, research into effects has also been underway for many years: changes in the natural environment (terrestrial and aquatic) and the effects of air pollution on crops, natural vegetation, forests and heathland, materials and cultural goods.

The quality of forests and groundwater have also been monitored for several years now. For some time, too, damage to plants from oxidants (O_3 and NO_2) and at prevailing oxidant levels has been the subject of investigation. In the past such research involved mainly fumigation tests in which the plants were exposed to much higher concentrations.

Moreover, as part of the joint German-Dutch project (PHOXA), photochemical air pollution in Western Europe is a subject of study. A model is being used in an attempt to gain insight into the relationship between European emissions of nitrogen oxides and hydrocarbons on the one hand and high ozone concentrations on the other.

The research budget in 1985 was approximately 70 million guilders (circa US $ 25 million). It contained 215 projects and was carried out by about 30 institutes (Figure 12). The research is commissioned mainly by the Ministries of Housing, Physical Planning and Environment, of Agriculture and Fisheries and of Economic Affairs (Figure 13). But it may also be commissioned by provincial and municipal authorities and industry.

Approach

In the report to Parliament concerning the organization of research was consciously decided not to re-organize or give central guidance to research already underway. Instead we determined to set up a supplementary research programme. We were satisfied with the results of research already underway. Re-organization would be detrimental to scarce research capacity rather than providing an increase in yield.

It was considered efficient to charge a small group of directly interested parties (government and industry) with designing the supplementary programme. Under the direction of a steering committee in which government and industry (Co-operative Electricity Producers and refineries) co-operate and whose members provide joint financing (circa 15 million), this supplementary programme has been drawn up for three years. The starting point of the programme is to guard that the policy already implemented and the measures associated with it are in fact an effective and efficient answer to acidification, or in other words, to guard that the optimal yield is being attained.

Main features of the supplementary research programme

General

The additional programme of research was drawn up from the assumption that the major blindspots in the acidification problem should be remedied first. The main ones in the Netherlands were:

- the relationship between exposure and effect (particularly for forests and crops)
- abatement technology for ammonia
- effectiveness of the package of measures (system model)

These three themes have been incorporated into the programme with heavy emphasis on the first, of which "integrated monitoring" is an essential part.

A programme was drawn up consisting of separate projects for the priority research themes. The programme has been running since 1 January 1985. 27 institutes are participating. All of the institutes receive a contribution from the supplementary acidification research budget, but also provide partial financing themselves.

Relationship between exposure and effect

For the Netherlands - which has big problems with manure production in the intensive livestock and poultry raising industry - the NH_3 emitted by manure is a research priority. Further, we want to institute cost-effective measures which is why system analysis via the development of an integral acidification model is another priority. Among the research priorities, however, the theme 'relationship between exposure and effect' springs to the fore. This theme is being approached from several angles, namely field and laboratory research into trees and natural vegetation, inventories and crop research.

The field research concerns two Douglas stands - a thriving one and a less thriving one - where integral measurements will be carried out over a three year period. The objective is to investigate the effect of air pollution and deposition on the physiological processes of trees in the field. The processes being researched are photosynthesis, respiration and water management. The field experiments are being supported by laboratory research, which concerns:

- soil processes
- mineral intake
- growth study with varying loads of air pollution and different soils
- effects of fungi on growth
- effects of changes in soils on root fungi
- effect of PH on the take up of ions in the root zone.

Inventorying research will be carried out on a limited scale into the relationships among air pollution, soil parameters and the viability of forests by way of a first step to extrapolating the research results from the two previous parts. This study will link up with the viability research in Dutch forests which has already been underway for two years.

It emerged form earlier research that, in addition to HF, SO_2 and O_3 cause considerable damage to crops in the Netherlands (on the order of 600 million guilders per year or about 5% of the revenue). It is thought that each of these substances enhances the effects of the other. The research is moving from detailed study of processes in and on parts of plants (leaf curves) via separate plants (assimilation chambers) and groups of plants (fumigation chambers and open-top-chambers) to crops in field conditions and entire stands of vegetation (field fumigation systems).

Photosynthesis and respiration are being examined as well as growth rate, leaf weight and nutrient intake as a function of the exposure to air pollution by substances separately (SO_2, O_3 and NH_3) or in combination. The research is being backed by model studies so that an explanatory model can be developed.

EXPECTATIONS FOR ACIDIFICATION RESEARCH AND POLICY

Research

One year after the start of the supplementary research programme, a pronounced role in water and soil acidification is already being assigned to N. Based on current data, it can be expected that the threshold value of 1600 equivalents H^+ for N - as part of the provisional deposition objective for acidifying substances - will be shown to be untenable. Depending on the kind of soil or water to be protected and for what period, deposition limits are being named which are on the order of magnitude of 5-20 kg $N/ha^{-1}\ yr^{-1}$. These values are in line with the results of the Oslo workshop concerning deposition guide values for sulphur and nitrogen compounds.

It is expected that the PHOXA results will present a clearer picture of ozone formation on a European scale. This can possibly provide inducement for diverting the emphasis of acidification research somewhat to nitrogenoxides and hydrocarbons. In any case, it is expected that NO_x's central place in the research will be strengthened.

Policy

If the expectations of the research have a positive result, this will mean that pressure for the control of nitrogenoxides and hydrocarbons will become even greater. On 1 April 1986, fiscal measures entered into force that should stimulate the use of unleaded petrol and the sale of clean automobiles. Based on presently foreseen measures for mobile sources, anthropogenic emissions will decrease by 27 percent in 2000 (Figure 15).

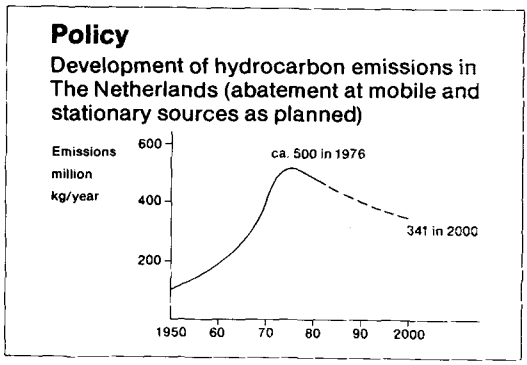

FIGURE 15

The wish to control NO_x emissions further could mean that pressure will be created to go further than the application of low-NO_x combustion systems for stationary sources.

It is possible that an adjustment in the provisional deposition objective will have to be decided upon in 1988. This has been requested in a parliamentary motion.

CONCLUSIONS AND RECOMMENDATIONS

The Netherlands has formulated a provisional deposition objective which is intended to protect vital vegetation against the effects of acidification. In order to reach the level of the objective, SO_2 and NO_x will have to be reduced to a significant extent on an international scale. Moreover, NH_3 emissions will have to be controlled in the Netherlands itself.

The Netherlands has drawn up a package of measures to achieve the goal of a circa 70 percent reduction in SO_2, 30 percent in NO_x, and 50 percent in NH_3 emissions around the year 2000.

The Netherlands considers the SO_2 protocol providing for a 30 percent SO_2 reduction in 1993 a positive first step, but not a conclusive one. The Netherlands believes that it is essential to also realize a substantial reduction in NO_x. Mobile and stationary sources require separate approaches in achieving this.

In view of the large scale character of photochemical air pollution and the extensive damage to vegetation, among other things, caused by ozone, it is also important to include hydrocarbons in the control of air pollution on a European scale.

The Netherlands considers it essential that conferences such as this one in support of international control of acidification take place regularly - for example once every two or three years - in the framework of the ECE.