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ACIDIFICATION POLICY AND RESEARCH IN FINLAND

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ABSTRACT

Acidification is one of the top priorities for the air pollution administration in Finland. A sulphur commission has been set up to define an optimal sulphur emission abatement policy, whereby sulphur emissions could be reduced by at least 50 percent by the early 1990´ies from the level of 1980. The optimization has two dimensions: costs and air quality. The Finnish Acidification Project established in 1985 will with its annual budget of some 10 million FIM establish the knowledge basis for future emission reduction needs. In the project the extent of damage, especially on forests and waters, is surveyed and effect mechanisms are studied as well as abatement measures.

1. INTRODUCTION

The long range transport of air pollution has been followed in Finland since the early 1970´s, and the effects of acidification have been studied extensively since the beginning of the 1980´s. Small lakes have been observed to have undergone acidification in Southern Finland. The pH of the lakes has clearly decreased, and seasonal changes in pH have intensified. The influence of acid deposition on the pH of groundwater has not yet been clearly demonstrated.

The possibility of forests being damaged, which is suggested by some researchers, is regarded as a serious matter in Finland. Even though the amount of acid deposition in Finland is considerably less than in Central Europe, both the nature of the bedrock and the climate are factors which may make the ecosystems in this country particularly susceptible to damages caused by air pollution. The effects of pollutants which have accumulated in the ecosystems in small amounts may suddenly exhibit effects after a long period of time.

2. THE MEANS

The Air Pollution Control Act came into force in Finland in October of 1982. At the same time a statutory order was issued which regulated more precisely the manner in which the law was to be implemented. This law served as the basis for two decisions issued by the Council of State concerning the lead and benzene content of petrol and the guidelines on air quality.

The decision on the guidelines, issued in June 1984, also includes the goal that, with respect to extensive areas important to forestry or agriculture or which are significant from the standpoint of nature conservation, the annual sulphur dioxide concentration should not exceed 25 $\mu g/m^3$, nor should the deposition of sulphur in areas of the aforementioned types exceed 0.5 grams of sulphur per square meter annually.

The Ministry of the Environment was established in October of 1983. With it was created the Division for air pollution control and noise abatement. The act, the Ministry and the division created a structure to tackle air pollution problems in a much more efficient way.

Measures to reduce sulphur emissions in Finland have long been under preparation. In December of 1983 a memorandum was left to the Ministry of the Environment by a task force on sulphur surveys. This task force drew up a programme to investigate alternatives for reducing the amount of sulphur emitted in Finland and study the relevant issues of commercial, energy, and industrial policy. The task force also recommended that when the technical and economic surveys had been completed a commission should be established to formulate the actual emission reduction policy. The ten surveys included in the programme compiled by the task force were, for the most part, completed during 1984.

3. THE SULPHUR EMISSION POLICY

The sulphur commission began its work in February of 1985. The commission is to draw up a proposal concerning the measures which would allow a 30 percent reduction in emissions by the year 1993, as well as a proposal on how the goal of reducing emission by 50 percent of the level which prevailed in 1980 could be realized during the early 1990´s. The work of the commission involves comparing options with different concrete measures and combinations

thereof. The effects of the measures will be studied especially in two dimensions: costs and air quality. The criteria for costs is the prize of reduced ton of sulphur dioxide emissions and for air quality sulphur dioxide levels in cities and sulphur deposition. The commission will deliver its final report in September this year.

In its first interim report in May 1985 the commission clarified the manner in which emissions of sulphur developed at the beginning of the 1980´s and assessed the level of sulphur emissions in 1993. Additionally, the possibilities of instituting various measures to further decrease these emissions were clarified, and a determination was made of the costs involved. The commission has made a study of the prevailing quality of the air as well as of the manner in which changes in the emissions influence it.

By 1993 emissions of sulphur dioxide in Finland will have undergone a considerable reduction from the level which prevailed in 1980 (see table 1). Many factors will influence this development. The structure of energy production continues to develop. The use of heavy fuel oil with a high sulphur content continues to decrease. Oil is being replaced primarily by coal and peat, both of which have a relatively low sulphur content, as well as by natural gas, which contains no sulphur at all. It is possible to further reduce the sulphur content of the light fuel oil which is refined in Finland. The use of energy is being intensified so that its total consumption is increasing more slowly than the production of the national economy. Even the structure of the wood-processing industry is changing. The use of the calcium sulphite method in the production of chemical pulp is becoming increasingly rare. Production plants in other processing industries are also being renovated and then sulphur emissions can also be reduced. Fulfilling the obligations contained in the Air Pollution Control Act contributes considerably to achieving these goals.

TABLE 1
Summary of the emissions for 1980 and 1983, and estimated emissions for 1993 without measures on the fuel side

SOURCE OF EMISSION	EMISSION OF SO_2		
	1980	1983	1993
FUELS	329,000	171,000	164,500...270,000
Oil	246,000	119,000	55,500... 78,500
Coal	80,000	46,000	96,000...178,500
Peat	3,000	6,000	13,000
MANUFACTURE OF CHEMICAL PULP	104,000	75,000	38,000... 51 000
Sulphate pulp	43,000	41,000	26,000... 33,000
Sulphite pulp	52,500	24,000	6,000... 7,000
Semichemical pulp	8,500	10,000	6,000... 11,000
OTHER PROCESSING INDUSTRY	151,000	111,000	72,500
Oil refining	60,000	34,000	30,000
Basic chemical and metal industry	87,000	73,000	38,500
Other industry	4,000	4,000	4,000
Total	584,000	357,000	275,000...393,500
Reduction compared to 1980	39 %		53... 33 %

The goal of the first phase, that is to say, a permanent thirty percent reduction in sulphur dioxide emissions by 1993 imposes requirements on both energy production and the processing industry.

With respect to energy production a thirty percent reduction presupposes the following:

1. A maximum of 8.5 million tonnes of coal will be used annually, and its level of sulphur content will not increase from the present level of 0.8 percent to anything higher than 1.2 percent.
2. The total amount of sulphur dioxide emissions annually caused by the use of heavy fuel oil will not exceed the figure caused by a consumption of 1.6 million tonnes of oil with a 3.0 percent sulphur content.
3. The proportion assumed by natural gas as a source of energy will increase so that it corresponds to at least 1.6 million tonnes of oil equivalents annually.
4. The sulphur content of middle distillates (light fuel oil and diesel oil) is not higher than 0.25 percent.
5. Use of domestic fuels (wood, peat and refuse) increases to the level of 6.3 million tonnes of oil equivalents.

With respect to the processing industry a thirty percent reduction presupposes the following:

1. The calcium sulphite method will be used to manufacture chemical pulp at no more than one factory (already achieved).
2. When factories producing chemical pulp have to be renovated the direct evaporation of black liquor with combustion gases will be replaced by other techniques, and the collection and treatment of all strongly odorous gases as well as, to a considerable degree, of weakly odorous gases, will be implemented.
3. In the manufacture of sulphuric acid, transition to new technology will be realized in such a manner that at least two thirds of the sulphuric acid used will be produced by the double contact method.
4. At oil refineries heavy fuel oil will be partly replaced by refinery gases.
5. The sulphur content of the ores used in the iron and steel industries will decrease.
6. Sulphur emissions from other processing industries will be decreased making use of new process technology.

These prerequisites to a reduction of sulphur emissions involve, for the most part, a continuation of structural developments which have already been implemented in energy production and industrial processes, and for this reason they do not require large separate investments for what could be regarded as expenses for air pollution prevention. At the beginning of the 1980's more than FIM 5 billion were invested in measures which led to structural changes, the result of which was partly a decrease in sulphur emissions.

Decreasing emissions of sulphur dioxide to half of the level which prevailed in 1980 presupposes that further measures be taken. A decrease of 50 percent will be obtained when:

- the total amount of sulphur dioxide emissions from the use of coal is not greater than emissions which correspond to amounts of coals and their sulphur content as follows:

consumption of coal millions of tonnes per annum	sulphur content of the coal percent
5.6	1.0
7.0	0.8
9.3	0.6

- the consumption of heavy fuel oil will decrease so that its annual use will lead to emissions corresponding to 1.2 million tonnes of oil with a 3.0 percent sulphur content, or to 1.4 million tonnes of oil with a 2.5 percent sulphur content. No further use will be made of ores with a high sulphur content in the production of iron and steel
- the gaseous emissions from the chemical wood processing industry will be effectively treated.

In order to ensure that the desired halving of emissions actually happens several decisions which will promote the reduction of sulphur emissions will be considered by the commission, such as limiting the sulphur content of fuels by the Air Pollution Control Act, removing the sulphur from the combustion gases of power and heating plants, establishing emission norms and specific decisions for the processing industry.

The costs arising in conjunction with these measures may be estimated on the basis of the surveys submitted to the commission. Depending on the nature of the measures taken, they range from FIM 3,000 to FIM 12,000 per tonne of sulphur removed. If it was necessary to reduce emissions of sulphur dioxide by 100,000 tonnes annually, for example, the annual expenses would range from 200 million FIM to 600 million FIM, depending on the means used.

4. THE RESEARCH

The Finnish Government initiated a five year research project on acidification and air pollution at the beginning of 1986. The budget for 1986 includes a total appropriation of some 10 million FIM annually for financing the project through two ministries: the Ministry of the Environment and the Ministry of Agriculture and Forestry. The research program has been entitled "Finnish Research Project on Acidification" (abbreviated from Finnish name of the project to HAPRO). The project is concerned with the development of acidification caused by sulphur and nitrogen emissions and, more generally, with the problems associated with air pollution. The aim of the HAPRO project is to study cause-and-effect relationships in air pollution and, on that basis:

- to determine the extent of regional effects of air pollutants in Finland
- to study whether the harmful effects of air pollutants are increasing
- to determine which areas and components of the environment are being especially threatened

- to assess what measures would most effectively, and at the lowest costs, reduce the harmful effects of air pollutants.

Most of the research work associated with this project is being carried out in the form of individual sub-projects at research institutes and universities.

The project is being directed by an executive working group with the assistance of a separate research division.

A full time secretariat has been appointed to the project within the Environmental Protection and Nature Conservation Department of the Ministry of the Environment.

The main part of the research in the project is carried out in the fields, of forest and water effects, which together get some two thirds of the annual budget. The first results also show a good reason for this priority.

Forest effects were evaluated using needle loss in coniferous trees as the indicator. 2500 plots, throughout Southern and Central Finland were studied, and also undergrowth and soil factors were included. The methods used are the same as in the other Nordic countries.

According to Nordic criteria a tree is damaged if it has lost over 20 percent of its needles. Slightly damaged (needle loss 21-40 percent) were 9 percent of the trees, damaged (41-60 percent) one percent and severely damaged (61-100 percent) also one percent. Thus in all, 11 percent of the trees surveyed were damaged.

As to the causes of the damages all scientists do not agree. Most consider air pollution as a major reason, which theory is supported by noted changes in the undergrowth in forest areas.

Most of the surface waters in Finland are low of electrolytes, brown colored humic waters. Clear water lakes in Southern Finland are in general weakly buffered. In Northern Finland (Lappland) the prevailing buffering capacity is clearly bigger. The total sulphur deposition is about 1.5-1.8 $g.S.m^{-2}.a^{-1}$ in Southern Finland and 0.6-0.3 $g.S.m^{-2}.a^{-1}$ in Northern Finland. The small lakes in Southern Finland have lost in average 50 $\mu mol.l^{-1}$, in the coastal area even 90 $\mu mol.l^{-1}$ of their original alkalinity on the basis of four different empirical and theoretical methods. The survey of about 8000 lakes has revealed about 500 lakes of minimun pH < 5.0, but in Southern Finland 20-40 percent of all small forest lakes are acidic. However, only 150 of these acidic

lakes are clearwater lakes. Completely fishless lakes have not been found in the preliminary survey of 171 small acidic forest lakes in Finland. Therefore, it seems that a qualitative age class analysis can indicate the effects of acidification on fish better than a simple presence/absence relationship.

Comparing to the old data sets collected in the 1920´s, almost all monitored rivers have lost part of their alkalinity, particularly in spring. Small lakes have a general decreasing alkalinity trend over the past 15 years. Sinking trends of diatom-inferred pH from sediment cores are fairly common in acidic lakes in Southern Finland, indicating recent anthropogenic acidification. The acidification project is continuing at least throughout 1989, probably with a slightly increased budget. The thrust of research will be transferred from effect surveys to cause-effect relationships. Intense international contacts are also foreseen.