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PRELIMINARY REPORT ON EXISTING KNOWLEDGE WITH REGARD TO SO_2 EMISSION SOURCES

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This report was first presented at the meeting of the Working Party on Air Pollution Problems in ECE, 13-17th January 1975. The OECD reports "Oil Statistics, Supply and Disposal" and "Statistics of Energy" for 1973 have now been published and new calculations have been performed, based on the consumption figures for 1973.

There are still some discrepancies between the emissions calculated here, and the emissions given in the LRTAP emission survey. Table 7 illustrates this.

For some countries, the emissions from industrial processes (not included in the survey based on energy statistics) may explain this, but not in all cases. In order to obtain comments from each country as to the reason for these discrepancies, we now send this report to each of the OECD-member country participating in the LRTAP-project.

PRELIMINARY REPORT ON EXISTING KNOWLEDGE WITH REGARD TO SO_2 EMISSION SOURCES

PREFACE

At the last meeting of the Senior Advisers Group, ECE, it was decided to work out a European emission survey for sulphur dioxide. As a first step it was agreed that a scientist to be appointed by the USSR together with Dr. B Ottar, Norway, as representatives of respectively the Eastern and Western European countries, should work out a report based on available information on this subject. In July 1974, Dr. J Brodsky was appointed by the USSR, and the first meeting took place in Moscow on 20-22 November 1974. At this meeting, it was agreed that a first report should be presented at the meeting of the Working Party on Air Pollution on 13-17 January, 1975.

In the present report, first the need for an emission survey and its possible applications are briefly pointed out. In a second chapter, available data for the total energy consumption and total emissions of sulphur dioxide in the countries are presented for various types of sources, and finally a list is given of the literature on which the report is based.

The emission of sulphur dioxide has been calculated in two ways. In the first calculation, the OECD statistics of fuel consumption and emission factors estimated in an earlier OECD report (1) have been used to estimate the emissions for 1973. The second and more correct set of emission data also applies to 1973 and was worked out by the countries for the OECD project "Long Range Transport of Air Pollutants" (LRTAP) (2).

The two sets of data are not directly comparable. The LRTAP emission survey also includes emission from chemical processes. For some countries, the difference is, however, much larger than this. It is believed that the LRTAP data are the more correct ones because these data were collected by the countries for an emission survey, while the other set of data for 1973 are based on simple energy statistics. These discrepancies may become less when the countries have had an opportunity to adjust the primary data.

1 INTRODUCTION

The present report represents a first step in the construction of a European emission survey for sulphur dioxide, for use in connection with a cooperative programme for monitoring and evaluation of the long range transmission of air pollutants in Europe. The main objective of this programme, which was recently discussed at a meeting in Oslo 3-5 December 1974, is to provide information on the quantity and significance of the large scale geographical dispersion and deposition of air pollutants in Europe, in order to enable evaluations of specific air pollution problems and trends in Europe.

At present the selection of effective solutions to the management of the air pollution problem is limited by lack of sufficient information on the emissions of pollutants from various sources, their long range transmission and effect. Infor-

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mation on the relative importance of local and distant sources would assist governments in developing national abatement strategies, and promote international cooperation in this field.

It is generally recognized that the first problem requiring further investigation on a large geographical scale would be the acidification of the precipitation and other effects arising from the long range transmission of sulphur compounds, primarily due to the emission of sulphur dioxide from antropogenic sources.

Monitoring and evaluation of the long range dispersion and deposition of sulphur dioxide requires that observed concentrations and deposition data can be compared with estimated values calculated from atmospheric dispersion models, using an appropriate emission survey. Experience shows that in order to be able to account for the influence of changes in wind direction, atmospheric stability, etc, this requires the use of atmospheric dispersion models based on 6-hourly evaluations of the weather parameters in a grid system of 100-150 kilometer grid length. Data from the WMO network are satisfactory for this purpose. The time and space resolution of other data used in the calculation, i.e. the observed air concentrations and the emission data, must be selected to fit in with this requirement.

In order to limit the observational effort, concentration data observed as 24 hour averages and with a space resolution of about 250 kilometers may be sufficient, provided some consideration is given to geographical and topographical features. For the emission survey a grid distance of about half the grid distance used for the atmospheric dispersion model, should be used, as this will improve the representativity of the model calculation appreciably without adding much work to the collection of the emission data.

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For the emission of sulphur dioxide a space resolution of $\frac{1}{2}^{O}$ latitude x 1^{O} longitude (55 x 55 km^2 at $60^{O}N$) will be suitable. From a practical point of view this coordinate system is easily identifiable, and the fact that the size of the grid element becomes a function of the latitude, is of little consequence, as this grid system is easily transformed into any other system by the use of suitable computer programmes.

In this survey the emissions have to be split in a constant and a time variable part. Also a distinction should be made between sources with effective chimney height above and below 100 m, for use in two-layer atmospheric dispersion models. The diurnal variation of the emissions is important if associated with significant diurnal variations of the vertical dispersion. Day to day variations (weekends, etc), and seasonal variations, are particularly important and should be included.

At present, several dispersion models are available and these can be operated on the basis of an emission survey of the type described and available data from the WMO network. These include statistical models based on trajectory calculations, as well as budget-type models (Eulerian and Lagrangian), which are based on numerical solutions of the continuity equation. The two types are used to evaluate the transport and deposition of air pollutants, statistically and on a day to day basis.

Once established, a proven dispersion model has many applications. The statistical trajectory analysis may be used to evaluate the amounts deposited in a given area and where they come from. The budget-type models can be used to calculate the contribution from selected source areas to other parts of the region in a given weather situation. The models can be used to forecast concentration levels and the distribution of pollutants in the atmosphere 1-2 days in advance.

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By altering the emission data, the effects of improved abatement or a further increase of the emissions of sulphur dioxide may be studied. Thus, the effect of assumed trends in energy consumption and development on the concentration of the air pollutants may be studied.

Finally, it should be pointed out that an emission survey of the type described here, is constructed for large scale dispersion calculations only. As the resolution required in the concentration field is of the order 100-200 kilometer, various approximation methods can be used to estimate the emissions from the grid elements with sufficient accuracy.

2 DESCRIPTION OF SULPHUR DIOXIDE EMISSION SOURCES FROM THE POLLUTION POINT OF VIEW

In this first survey it was agreed to give figures for the total emission of sulphur dioxide in each country for the following main categories of sources:

A) Heat and power stations, including cases when power production is combined with heating purposes.

B) Industrial emission data including industrial heating and specified on major industrial categories.

C) Heating of houses including offices and regional heating plants if these do not at the same time produce electricity.

For each of these categories the total consumption of the various types of fuels (coal, heavy oil, light oil etc) is given together with their emission factors. These emission factors give the percent sulphur emitted per ton oil equivalent (T.o.e.). In this way it is taken into account that a part of the sulphur in the fuel is retained in the ash of solid fuels. For fuel oils the emission factor is equal to the sulphur content.

By multiplying the consumption figures and the emission factors together a first estimate for the emissions of sulphur dioxide can be obtained. However, a more detailed emission survey has been constructed for the OECD-countries in connection with the OECD-project "Long Range Transport of Air Pollutants". This survey also includes the emissions of SO_2 from industrial processes.

The type of industrial branches for which the data are given may differ from one country to another, depending on the data available.

Much of the data given in this report were collected in connection with the two OECD-projects "Study on Air Pollution from Fuel Combustion in Stationary Sources" (1) and "Long Range Transport of Air Pollutants" (LRTAP) (2).

For most of the countries in Western Europe reference (1) gives the consumption of fuels in 1968 for the following groups: "Power Stations", "Refineries", " Iron and Steel Works", "Coking plants and Gasworks", "Other Industries" and "Domestic and Commercial heating". Some of the countries did not give consumption figures for the different industrial branches. In these cases total figures for the industry have been given under the title "Other Industry".

In table 1 a survey of the consumption of gas, oil and coal for the mentioned groups of users is given for 1968. The designation "coal" covers all types of solid fuel, and by "fuel oil" is meant all types of fuel oil. All the figures have been converted to T.o.e.

Table 2 gives the emission factors for all the fuels used in 1968. These factors were provided by the different countries (1) and give the percentage of sulphur emitted

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per t.o.e. that is burnt. Minor changes in these factors may have taken place during the later years. This has, however, not been taken into account. In cases where the emission factors were not given, values have been estimated.

Consumption figures for 1973 are given in table 3 and table 4. Data for the consumption of fuel oils are taken from the annual OECD report "Oil Statistics - Supply and Disposal" (3). Reference (3) did not give the consumption by the refineries, these figures are taken from the OECD report "Statistics of Energy" (4). Reference (4) also gives the consumption of gas and solid fuel for the different groups of consumers. The emissions calculated from the fuel consumption are also given in table 3 and 4.

A comparison between the figures given in table 1 and those given in table 3 and 4 indicates how the consumption pattern has changed from 1968 to 1973. The consumption of gas has increased considerably, and in most cases at the expense of the coal consumption. This particularly applies to the countries situated around the North Sea, because of the findings of gas and oil in the region.

As mentioned, an emission survey has been constructed for the OECD countries, giving the emissions in a grid system with individual grid areas of $\frac{1}{2}^{\circ}$ latitude times 1° longitude. This survey is to a great extent based on detailed studies carried out by the countries themselves. For countries that did not give information, the emissions were estimated by the use of population statistics, information on the economic and industrial structure and other data available.

In table 5, values from this survey are given for the emissions from the different groups of consumers within each country. Some of the countries gave the emissions for the groups

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mentioned, while others gave the slightly different split up. For these countries only the totals are given in table 5.

Reference (2) also gives the emissions separated in a continuous and a variable part (the variable part includes all seasonal heating), and the corresponding emission per inhabitant was calculated for each square in the different countries. In table 6, these emission factors are given together with the total emissions for each country.

In table 7, the values given in table 5 are compared with emissions of sulphur dioxide calculated from the figures given in tables 2, 3 and 4. Considerable differences will be noticed. One reason for this is that the data in table 5 include emissions of sulphur dioxide directly from the industrial processes.

For several countries, these factors alone can not explain the differences. Generally, the LRTAP emission survey (2) is believed to be the more accurate, as these data were collected by the countries for the purpose of constructing an emission survey. The calculated emission data in this document are based on emission factors estimated for 1968 and statistics of energy consumption for 1973. All consumption figures for solid fuels were given in metric tons. In converting those values to tons of oil equivalents, the conversion factors given in "World Energy Supplies "(5) were applied. It is uncertain whether the conversion from metric tons to oil equivalents is in accordance with the emission factors used. This will have to be controlled by each country.

As no emission factors for gas have been provided by the countries, a factor of 59 kg/Tcal has been used in all calculations. This may be wrong in some cases. However,

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a different emission factor for gas will hardly change the overall picture.

If these problems should have been studied in detail, much more time would have been required to complete the present report. Also, it is felt that these problems are more easily dealt with by each country in question.

In a Concawe report (6) from November 1974, the limits on sulphur contents of fuel oils are given for most of the countries in Western Europe. For some countries, the values seem to be a little higher than the emission factors given in table 2. New calculations have not been performed, but the differences are not likely to change the overall picture.

In the following, some comments are given to the background material used for each of the countries.

AUSTRIA

Austria did not take part in the "Study on Air Pollution from Fuel Combustion in Stationary Sources" (1). The figures in table 1 are taken from the OECD report "Statistics of Energy" (7). A comparison between table 1, 3 and 4 shows that from 1968 to 1973, the consumption of gas doubled, while the oil consumption increased by 60 %. The consumption of solid fuels decreased by 30 % during the same period. The emissions given in table 5 are given by Austria.

BELGIUM

The consumption figures for 1968 were given in tons. In this report, these values are converted to t.o.e.. From 1968 to 1973, the consumption of gas almost doubled, while the coal consumption decreased by 10 %. The oil consumption increased by 15 %. The emissions given in tables 5 and 6 are estimates.

DENMARK

For Denmark, the 1968 consumption figures and emission factors were given on a t.o.e. basis. All the industrial consumption was given in one group: "Other industries". The tables 1 - 4 show no significant increase in the gas consumption, but the consumption of fuel oil has increased by 40 %, while the coal consumption of fuel oil has decreased by 45 %. The emission data for "Power Stations", "Industry" and "Domestic and Commercial Heating" were provided by Denmark.

FINLAND

Consumption figures for 1968 were not available in reference (1). The figures in table 1 were taken from the OECD-report "Statistics of Energy" (7). A definite increase in the comsumption of oil has taken

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place between 1968 and 1973 (approximately 60%), while minor changes appear in the consumption of gas and coal. Emissions for the LRTAP emission survey were provided by Finland.

FRANCE

The consumption figures and emission factors for 1968 were given in tons and have been converted to t.o.e. basis. From 1968 to 1973, the consumption of coal has been reduced to 50 % of the 1968 level. The consumption of gas and fuel oil has almost doubled during the same period.

Emission figures for the LRTAP emission survey were provided and distributed by France on the groups given in table 5. The emission from the refineries may seem high, but this also includes emissions from the Lacq district.

GERMANY

All consumption figures and emission factors were given on a t.o.e. basis. The consumption of fuel oil doubled during the period 1968/1973, while the gas consumption increased with 37 %. The coal consumption remained almost constant. For the LRTAP emission survey, the emissions from house-heating, power stations and industry have been provided by Germany.

GREECE

All the consumption figures and the emission factors for 1968 were given on a t.o.e. basis. The figures for 1973 show that 65 % of the consumption of fuel oil is heavy fuel oil, and the consumption of liquid fuels doubled from 1968 to 1973. The emission data are estimates.

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IRELAND

The consumption figures and emission factors for 1968 were given on a t.o.e. basis. For 1973, only total consumption figures were available. The emission data are estimates.

ITALY

The consumption figures for 1968 were taken from the OECD Energy Statistics (7). From 1968 to 1973 both the oil consumption and the gas consumption have increased by 60 %. The emission data were estimates.

LUXEMBOURG

All consumption figures and emission factors for 1968 were given on a t.o.e. basis. The emission data are estimates.

THE NETHERLANDS

The consumption figures and emission factors for 1968 were given on a t.o.e. basis. The consumption figures for 1973 show a definite change in the consumption pattern. The consumption of gas has increased by more than 300 %, while the coal consumption has been reduced to 1/3 of the 1968 level. The oil consumption has decreased by 20 %. In 1973, 60 % of the energy consumption was covered by natural gas (8) and after 1972, the consumption of coal is expected to be insignificant.

The emissions given in table 5 were provided by the Netherlands.

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NORWAY

The consumption figures and emission factors for 1968 were given on a t.o.e. basis. A comparison between table 1 and table 3 and 5 indicates no particular changes in the consumption pattern. The oil consumption increased by 30 %. The emission data were provided by Norway.

PORTUGAL

All consumption figures and emission factors for 1968 were given on a t.o.e. basis. The consumption of oil increased by 300 % from 1968 to 1973, while there was no definite change in the consumption of gas and coal. The emission data are estimates.

SPAIN

All consumption figures and emission factors for 1968 were given on a t.o.e. basis. Table 3 shows that the consumption of fuel oil more than doubled from 1968 to 1973. A definite increase in the coal consumption has also taken place. The emission data are estimates.

SWEDEN

The consumption figures for 1968 were taken from Sweden's national report (9). No definit changes in the consumption pattern have taken place from 1968 to 1973. The oil consumption increased with 27 %. The emission data given in table 5 were provided by Sweden.

SWITZERLAND

Consumption figures and emission factors for 1968 were given on a t.o.e. basis. From 1968 to 1973, the consumption of oil has increased by 45 %. The coal consumption is decreasing.

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The emission data for the LRTAP emission survey were provided by Switzerland.

UNITED KINGDOM

The consumption figures for 1968 were taken from the national report from the United Kingdom (10).

From 1968 to 1973, the coal consumption has decreased by 20 %, while the gas consumption has increased by 70 %. The consumption of oil has increased with 30 % during the same period. From 1972, the increase in energy consumption is expected to be covered by the increased use of gas. The emission data given in table 5 were provided by the United Kingdom.

LITERATURE

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Table 1: Energy consumption in Western Europe, 1968 figures (1).

Unit: 10^6 T.o.e.

COUNTRY	Power stations			Refineries		Iron & Steel Works			Other industry			Coking plants & gaswork		Domestic & Commercial Heating			TOTALS		
	Gas	Fuel oil	Coal	Gas	Fuel oil	Gas	Fuel oil	Coal	Gas	Fuel oil	Coal	Gas	Coal	Gas	Fuel oil	Coal	Gas	Fuel oil	Coal
Austria	0.45	0.44	0.93	-	0.10	0.36	0.45	0.73	0.76	1.82	0.94	0.18	-	0.41	1.57	1.40	2.16	4.38	4.0
Belgium	0.92	3.14	2.72	0.09	1.0	1.91	0.88	2.98	1.02	4.28	0.80	0.67	-	0.70	5.79	3.91	5.30	15.1	10.4
Denmark	-	1.40	3.5	-	0.4	-	-	-	-	1.90	0.90	-	-	-	5.30	0.7	-	9.0	5.1
Finland	0.08	0.33	0.6		0.35	0.07	0.09	0.37	-	2.15	0.87	-	-	-	2.83	0.14	0.15	5.75	1.98
France	-	2.31	13.63	-	5.62	-	-	9.67	-	19.52	6.17	-	11.55	-	15.24	10.06	-	42.69	51.08
Germany	3.3	4.8	36.5	-	2.6	5.9	3.3	8.4	9.9	18.4	12.2	3.4	0.1	3.0	27.1	12.6	25.5	56.2	69.8
Greece	-	1.03	0.38	-	0.22	0.04	0.1	0.12	-	0.83	0.20	-	-	-	0.80		0.04	2.98	0.70
Ireland	-	0.58	0.04	-	0.10	-	0.03	-	-	0.75	0.53	-	-	0.07	0.46	0.38	0.07	1.92	0.95
Italy (69)	2.0	9.12	3.30		4.05	1.94	1.6	2.23	5.8	14.3	0.8	-	-	1.98	9.56	1.66	11.72	38.63	7.99
Luxembourg	0.4	-	-	-	-	-	-	-	0.8	0.7	1.0	-	-	-	0.3	-	1.2	1.0	1.0
Netherlands	1.19	2.67	2.98	1.04	2.10	0.35	0.45	1.28	3.20	5.63	0.50	0.31	0.01	2.74	4.69	1.68	8.83	15.54	6.45
Norway	-	-	-	0.10	0.02	-	-	-	0.14	1.93	0.26	-	-	0.01	1.11	0.14	0.25	3.06	0.40
Portugal	-	0.09	0.22	-	0.11	-	0.03	0.07	0.03	0.60	0.17	-	-	0.04	0.11	0.16	0.07	0.94	0.62
Spain	0.08	2.82	2.98	0.59	1.25	-	-	-	1.20	5.30	2.10	-	-	0.18	1.35	0.82	2.05	10.72	5.90
Sweden		1.4	-	-	0.14		0.7	1.05	-	5.23					8.6		-	16.07	1.05
Switzerland	-	0.21	-	-	0.19	-	-	-	-	1.73	0.32	-	-	0.16	4.67	0.36	0.16	6.84	0.68
United Kingdom	0.02	6.53	52.3	1.99	3.86	4.29	5.33	10.1	2.45	23.96	18.4	1.66	0.70	3.85	8.47	22.5	19.26	45.15	104.0

Table 2: Emission factors per 1968 (1).

(% S emitted/T.o.e.)

Country	Power Stations			Refineries		Iron & Steel			Coking Plants		Other Industry			Domestic	
	Fuel oil	Coal	Lignite	Gas	Fuel Oil	Coke	Fuel oil	Coal	Coke	Coal	Coke	Oil	Coal	Oil	Coal
Belgium	3.4	1.4	-		2.75	1.6	2.5	-	1.6	-	1.1	2.5	1.4	0.6-2.2	1.4-1.6
Denmark	2.0	1.0	1.0		2.7	-	-	-				0.6-2.2	1.0	0.6-2.5	1.0
Finland	-	-	-		-	-	-	-						-	-
France	2.3	1.0	-		0.7	1.0	-	-	0.05	1.0		0.5-2.0	1.0	0.5-2.0	1.0
Germany	1.9	1.8	-		1.6	1.25	1.9	1.75				0.5-1.9	1.75	0.5-1.9	1.4
Greece	3.5	-	3.8		3.5	-	3.5	-				3.5	0.8-1.3	1.0-3.5	0.8-1.3
Ireland	2.2	1.89	-		2.6	-	-	-			1.35	2.6	1.17	2.6	1.04-1.2
Italy	2.5	-	-		2.5	-	-	-				0.8-2.5	0.9-6.0	-	-
Luxembourg	-	-	-		-	-	-	-				2.5	1.3	2.2	-
Netherlands	2.4	1.4	-		2.4	0.25	1.4	0.25				2.4	1.3	0.7	1.07
Norway	-	-	-		2.2	-	-	-			1.3	0.4-2.2	1.2	0.4-2.2	1.3
Portugal	3.0	1.7	-		2.6	1.7	3.0	1.7				3.0	1.2	2.0	1.2-4.0
Spain	3.0	1.7	Ca 5		2.6	-	-	-				3.0	1.2	2.0	1.2-4.0
Sweden	1.9	-	-		2.5	-	0.3-2.0	-				0.6-2.5	-	0.6-2.0	-
Switzerland	1.5	-	-		0.3	-	2.0	-			1.35	1.5	1.5	0.36	1.1-1.3
United Kingdom	2.2	1.89	-		2.6	1.04	2.6	1.17			1.04	2.6	1.17	2.6	1.04-1.28

Table 3: Consumption of fuel oil and emission of SO_2 from stationary sources, 1973 figures.

Unit: 10^6 T.o.e.

COUNTRY	Power Stations		Refineries	Iron & Steel Works		Chemical Industry		Petrochemical Industry		Other Industry		Domestic & Commercial Heating		Other Users		TOTALS	
	L	H	R	L	H	L	H	L	H	L	H	L	H	L	H	L	H
AUSTRIA	-	0.84	0.13	-	0.57	0.01	0.23	-	-	0.13	2.35	0.97	1.50	0.48	-	1.58	5.62
%S		2.0	2.5		2.5	0.6	2.5			0.6	2.5	0.6	2.5	0.6			
10^3 tons SO_2		34	7		29	0.1	12			2	117	12	75	6		20	274
BELGIUM	0.03	4.99	1.50	0.14	0.65	0.07	0.73	-		1.10	2.05	5.93	0.68	0.43	0.57	7.70	9.67
%S	0.6	3.4	2.75	0.6	2.5	0.6	2.5			0.6	2.5	0.6	2.2	0.6	2.2		
10^3 tons SO_2	0.4	339	83	2	33	0.8	37			13	103	71	30	5	25	92	650
DENMARK	0.01	2.92	0.24							0.84	1.69	3.89	1.94	0.76	0.28	5.50	7.1
%S	0.6	2.0	2.7							0.6	2.2	0.6	2.5	0.6	2.2		
10^3 tons SO_2	0.1	117	13							10	74	47	97	9	12	66	313
FINLAND	0.08	0.9	0.69	0.10	0.56	0.03	0.25	-	0.11	0.14	2.74	2.85	1.10	0.37	-	3.57	5.53
%S	0.6	2.0	2.5	0.6	2.0	0.6	2.3		2.3	0.6	2.3	0.6	2.2	0.6			
10^3 tons SO_2	1	36	35	1	22	1	12		5	2	126	34	48	4		43	284
FRANCE	0.12	13.99	7.32	0.21	2.45	0.58	2.70			5.49	12.30	29.55	2.47	2.42	0.17	38.37	41.4
%S	0.5	2.3	0.7	0.5	2.0	0.5	2.0			0.5	2.0	0.5	2.0	0.5	2.0		
10^3 tons SO_2	1	644	102	2	98	6	108			55	492	296	99	24	7	384	1550
GERMANY	-	6.50	8.33	0.27	4.24	0.50	4.59			6.66	14.27	44.52		2.53	0.24	54.48	38.17
%S		1.9	1.6	0.5	1.9	0.5	1.9			0.5	1.9	0.5		0.5	1.9		
10^3 tons SO_2		247	267	3	151	5	174			67	542	445		25	9	545	1400
GREECE			0.30											2.26	3.84	2.26	4.14
%S			3.5											1.0	3.5		
10^3 tons SO_2			21											45	269	45	290
IRELAND		1.11	0.06		0.03					0.07	1.00	0.45	0.13	0.32	0.02	0.84	2.35
%S		2.2	2.6		2.6					0.7	2.6	0.7	2.6	0.6	2.6		
10^3 tons SO_2		48	3		2					1	52	6	7	4	1	11	113

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Table 3 continued.

Unit: 10^6 T.o.e.

COUNTRY	Power Stations		Refineries	Iron & Steel Works		Chemical Industry		Petrochemical Industry		Other Industry		Domestic & Commercial Heating		Other Users		TOTALS	
	L	H	R	L	H	L	H	L	H	L	H	L	H	L	H	L	H
ITALY	0.15	15.45	6.0	0.05	1.30	0.03	3.10	0.53	3.0	0.21	13.69	11.45	6.05	1.16	0.40	13.58	48.99
%S	0.8	2.5	2.5	0.8	2.5	0.8	2.5	0.8	2.5	0.8	2.5	0.8	2.5	0.8	2.5		
10^3 tons SO_2	2	773	300	1	65	0.5	155	8	150	3	685	183	303	19	20	217	2451
LUXEMBOURG				0.06	0.68	0.04	0.05	-	-	0.04	0.03	0.39	0.01			0.53	0.77
%S				2.2	2.5	2.2	2.5			2.2	2.5	2.2	2.5				
10^3 tons SO_2				3	34	2	3			2	2	17	0.5			24	40
NETHERLANDS	0.03	1.70	3.22	0.04	0.48	0.02	0.12	-	0.18	0.33	1.22	3.15	0.27	1.28	0.72	4.87	7.91
%S	0.7	2.4	2.4	0.7	1.4	0.7	2.4		2.4	0.7	2.40	0.7	2.4	0.7	2.4		
10^3 tons SO_2	0.4	82	155	0.6	13	0.3	6		9	5	59	44	13	18	35	68	372
NORWAY	-	-	0.19					-	-	0.46	1.60	0.92	0.10	0.53	0.09	1.91	1.98
%S			2.2							0.4	2.2	0.4	2.2	0.4	2.2		
10^3 tons SO_2			8.0							4	70	7	4	4	4	15	86
PORTUGAL	0.02	0.32	0.30		0.03		0.14		-	0.05	1.02	0.03	0.03	0.40	0.22	0.68	2.06
%S	1	3.0	2.6		3		3			1.0	3.0	1.0	3.0	1.0	3.0		
10^3 tons SO_2	0.4	19	16		2		8			1	61	1	2	8	13	10	121
SPAIN			1.6											6.44	17.71	6.44	19.31
%S			2.6											1.0	3.0		
10^3 tons SO_2			83											129	1063	129	1146
SWEDEN	0.05	2.39	0.28	0.13	0.82	0.07	0.42	-	0.05	0.84	4.57	6.28	3.89	0.67	0.14	7.97	12.56
%S	0.6	1.9	2.5	0.3	2.0	0.6	2.5		2.5	0.6	2.5	0.6	2.0	0.6	2.5		
10^3 tons SO_2	1	91	14	1	33	1	21		3	10	229	75	156	8	7	96	554
SWITZERLAND	-	0.41	0.28							1.38	1.89	5.90	0.27	0.06	-	7.04	2.85
%S		1.5	0.3							0.4	2.0	0.4	2.0	0.4			
10^3 tons SO_2		12	2							3	76	47	11	0.5		57	101
UNITED KINGDOM	0.87	16.14	7.05	0.51	4.42	-	-	0.29	3.59	5.31	11.60	2.35	0.74	3.82	2.50	13.35	46.04
%S	0.7	2.2	2.6	0.7	2.6			0.7	2.6	0.7	2.6	0.7	2.6	0.7	2.6		
10^3 tons SO_2	12	710	367	7	230			4	187	77	603	33	33	53	130	186	2265

L = Gas/Diesel oil
H = Residual fuel oil
R = Refinery fuel

Table 4: Consumption of gas and solid fuels and emissions of SO_2, 1973.

Units: 10^6 T.o.e.

COUNTRY	Power Stations		Coking Plants and Gas Works		Iron and Steel Works		Other Industry		Domestic and Commercial		TOTALS		
	Gas	Solid	Gas	Solid	Gas	Solid	Gas	Solid	Gas	Solid	Gas	Solid	Sum
AUSTRIA 10^6 T.o.e.	0.96	1.01	0.17	-	0.83	0.70	1.66	0.23	0.66	0.86	4.28	2.8	
%S	0.06	1.4-1.6	0.06		0.06	1.35-1.6	0.06	1.35-1.6	0.06	1.35-1.6			
10^3 tons SO_2	1.2	32.2	0.2	-	1.0	19.1	2.0	7.8	0.8	29.4	5.2	88.5	93.7
BELGIUM	3.38	1.9	0.74	0.01	2.36	3.47	3.16	0.4	1.61	2.36	11.25	8.14	
%S	0.06	1.4	0.06	1.1	0.06	1.4 -1.6	0.06	1.4 -1.6	0.06	1.4 -1.6			
10^3 tons SO_2	4.1	49.5	0.9	0.2	2.8	95.8	3.8	11.3	1.9	61.2	13.5	218.0	231.5
DENMARK	-	2.1	-	-	-	0.02	0.08	0.27	0.08	0.11	0.16	2.5	
%S		1.0				1.0	0.06	1.0	0.06	1.0			
10^3 tons SO_2		41.4				0.4	0.1	5.5	0.1	2.2	0.2	49.5	49.7
FINLAND	0.06	1.16	-	-	0.05	0.82	-	0.43	-	0.15	0.11	2.56	
%S	0.06	1.3			0.06	1.1 -1.3		1.3		1.1 -1.3			
10^3 tons SO_2	0.07	30.2			0.06	19.6		11.3		3.9	0.1	65.0	65.1
FRANCE	4.08	9.66	1.25	0.29	3.67	5.29	5.61	2.7	5.99	6.0	20.61	24.94	
%S	0.06	1.0-1.7	0.05	1.1	0.06	1.0 -1.1	0.06	1.0 -1.7	0.06	1.0 -1.7			
10^3 tons SO_2	4.9	206.8	1.5	6.4	4.4	44.4	6.7	57.5	7.2	81.2	24.7	396.3	421.0
GERMANY	11.2	47.2	2.95	0.08	10.96	9.62	1.29	8.66	8.49	8.62	34.89	74.18	
%S	0.06	0.85-1.89	0.05	1.35	0.06	1.35-1.89	0.06	0.85-1.89	0.06	0.85-1.5			
10^3 tons SO_2	13.4	1668.4	3.5	2.2	13.2	272.4	1.5	303.3	10.2	207.1	41.8	2453.4	2495.2
GREECE	-	2.53	0.04	-	0.04	0.23	0.1	0.28	-	0.1	0.18	3.14	
%S		3.8	0.05		0.06	1.1	0.06	1.1 -3.8		0.8 -3.8			
10^3 tons SO_2		192.3	0.04		0.04	5.1	0.1	16.6		4.6	0.2	218.6	218.8
IRELAND	-	0.04	-	-	-	-	0.03	0.06	0.09	0.44	0.12	0.54	
%S		1.89					0.06	1.17	0.06	1.04			
10^3 tons SO_2		1.3					0.04	1.3	0.11	9.2	0.2	11.8	12.0

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Table 4 continued.

Units: 10^6 T.o.e.

COUNTRY	Power Stations		Coking Plants and Gas Works		Iron and Steel Works		Other Industry		Domestic and Commercial		TOTALS		
	Gas	Solid	Gas	Solid	Gas	Solid	Gas	Solid	Gas	Solid	Gas	Solid	Sum
ITALY	1.99	0.86	0.77	0.04	2.86	2.7	8.61	0.49	4.45	0.55	18.68	4.64	
%S	0.06	1.4-1.6	0.06	1.35	0.06	1.35-1.6	0.06	1.35-1.4	0.06	1.0 -1.4			
10^3 tons SO_2	2.4	25.7	0.9	1.1	3.4	73.8	10.3	13.2	5.3	14.3	22.3	128.1	150.4
LUXEMBOURG	0.33	-	-	-	0.92	1.23	0.02	-	0.03	0.03	1.3	1.26	
%S	0.06				0.06	1.1 -1.3	0.6		0.06	1.0 -1.3			
10^3 tons SO_2	0.4				1.1	28.0	0.02		0.04	0.7	1.6	28.7	30.3
NETHERLANDS	10.4	0.48	0.24	-	1.07	0.96	8.41	0.21	12.4	0.37	32.5	2.02	
%S	0.06	1.35	0.06		0.06	0.25	0.06	1.3	0.06	1.07			
10^3 tons SO_2	12.5	13.0	0.3		1.3	4.8	10.1	5.4	14.9	7.9	39.1	31.1	70.2
NORWAY	-	-	0.03	-	0.05	0.39	0.03	0.15	0.01	0.09	0.12	0.63	
%S			0.06		0.06	1.7 -1.9	0.06	1.7 -1.9	0.06	1.7 -1.9			
10^3 tons SO_2			0.04		0.06	14.6	0.04	5.7	0.01	3.6	0.2	23.9	24.1
PORTUGAL	0.02	0.22	0.02	-	0.02	0.09	-	0.09	0.05	0.03	0.11	0.43	
%S	0.06	1.2	0.06		0.06	1.1		1.1 -1.4	0.06	1.1 -1.2			
10^3 tons SO_2	0.02	5.4	0.02		0.02	1.9		2.0	0.06	0.7	0.1	10	10.1
SPAIN	0.20	3.8	0.48	-	1.13	2.16	0.42	2.5	0.33	0.26	2.56	8.72	
%S	0.06	1.2-4.0	0.06		0.06	1.1 -1.2	0.06	1.1 -4.0	0.06	1.2 -1.4			
10^3 tons SO_2	0.24	142.8	0.58		1.36	48.3	0.5	67.3	0.40	6.4	3.1	264.8	267.9
SWEDEN	-	0.04	0.24	-	0.16	0.68	0.09	0.34	0.02	0.05	0.51	1.11	
%S		1.3	0.06		0.06	1.1 -1.3	0.06	1.1 -1.3	0.06	1.1 -1.3			
10^3 tons SO_2		1.0	0.20		0.20	3.3	0.11	8.5	0.02	1.3	0.6	14.1	14.7
SWITZERLAND	-	-	0.02	-	-	0.02	0.05	0.15	0.22	0.17	0.29	0.34	
%S			0.06			1.35	0.06	1.35-1.5	0.08	1.1 -1.3			
10^3 tons SO_2			0.02			0.5	0.06	1.7	0.25	4.2	0.3	6.4	6.7
UNITED KINGDOM	1.62	55.74	1.52	0.14	3.74	5.97	11.97	8.46	14.85	14.45	33.7	84.76	
%S	0.06	1.89	0.06	1.04	0.06	1.04-1.17	0.06	1.04-1.17	0.05	1.04-1.28			
10^3 tons SO_2	1.94	2107.0	1.82	2.9	4.49	125.0	14.36	196.6	17.83	305.1	40.4	2736.6	2777.0

Table 5: Total emission of SO_2 from the LRTAP emission survey, 1973.

Unit: Tons SO_2/year

	Country	Power Stations	Refineries	Industry	Domestic and Commercial Heating	TOTAL
Data given by each country	Austria	98 400		222 500	40 400	441 300[1]
	Denmark	235 400		108 400	279 750	623 400
	Finland					548 970
	France	785 600[2]	465 400	1.335 900	597 700	3.234 600
	Germany (F.R.)	782 000		2.310 500	755 550	3.928 050[3]
	Netherlands	155 200	195 700	310 600[4]	111 550	782 050
	Norway	0	7 900	144 600	29 000	181 500
	Sweden					829 300
	Switzerland					150 980
	United Kingdom	2.441 500	266 000	1.624 500	1.273 000	5.605 000
Estimated	Belgium	321 560	123 480	360 150	192 940	998 130
	Ireland					330 500
	Italy	750 000	175 000	1.344 000	400 000	3.169 000
	Luxembourg	-	-	40 300	6 100	46 400
	Spain	589 500	187 700	371 000	149 100	1.297 300

[1] The total also includes emissions from traffic and other not specified groups.

[2] Includes emissions from "Centrales Charbonnages de France".

[3] In the total also emission from traffic is included.

[4] Emissions from agriculture is included here.

Table 6: Table of emissions by countries. LRTAP emission survey, 1973.

		Emission of sulphur dioxide per inhabitant, kg SO_2/inhabitant year 1973			Total emission of SO_2 per country, tons SO_2/year 1973		
Country	Population	Continuous comp. average	Variable comp. average	Sum cont. + variable average	Cont.	Variable	Sum
Switzerland	6.272.227	15.7	8.4	24.1	98.230	52.746	150.976
West-Germany	61.166.000	46.2	18.0	64.2	2.825.792	1.102.252	3.928.044
Norway	3.866.468	34.0	12.9	46.9	131.462	50.048	181.510
Sweden	7.975.880	74.0	29.9	104.0	590.466	238.847	829.313
England							
Scotland	54.236.601	57.3	46.0	103.3	3.111.345	2.493.655	5.605.000
North Ireland							
France	49.509.100	45.3	20.0	65.3	2.243.040	991.517	3.234.557
Denmark	5.009.548	56.9	67.6	124.4	284.842	338.537	623.379
Finland	4.710 674	86.9	29.7	116.5	409.160	139.810	548.970
Belgium	9.650.944	72.2	31.2	103.4	696.763	301.363	998.125
Netherlands	13.266.000	40.9	18.1	59.0	542.537	239.496	782.033
Austria	7.456.403	48.8	8.6	57.4	375.000	66.300	441.300
Spain	33.055.731	25.9	13.3	39.3	856.523	441.183	1.297.805
Italy	54.031.325	-	-	58.7	-	-	3.169.000
Luxembourg	339.848	82.0	54.6	136.6	27.352	18.568	45.420
Ireland	2.978.249	57.9	53.0	111.0	172.527	157.981	330.508

Table 7: Total emissions of SO_2.

COUNTRY	Power Stations		Refineries		Industry		Domestic and Commercial		Total		Emissions from the various fuels, I (1973)				
	I	II	I	II	I	II	I	II	I	II	Gas	Solid	Light oil	Heavy oil	Sum
Austria	67.4		7		190.2		123.2		387.8	441.3[5]	5.2	88.5	20	274	388
Denmark	158.5	235.4	13.0		90.0	108.4	167.3	279.8	428.8	623.4	0.2	49.5	66	313	429
Finland	67.3		35		200		89.9		392.2	549.0	0.1	65.0	43	284	392
France	856.7	785.6[1]	102	465.4	881.9	1.385.7	514.4	597.7	2.355.2	3.234.6	24.7	396.3	384	1.550	2.355
Germany	1.928.8	782.0	267		1.548.1	2.310.5	696.3	755.6	4.440.1	3.928.1[2]	41.8	2.453.4	545	1.400	4.440
Nether-lands	107.9	155.2	155	195.7	114.8	319.6[3]	132.8	111.6	510.5	782.1	39.1	31.1	69	372	511
Norway	0	0	8.0	7.9	94.4	144.6	22.6	29.0	125.0	181.5	0.2	23.9	15	86	125
Sweden	93		14		310.4		247.3		664.7	829.3	0.6	14.1	96	554	665
Switzer-land	12		2		87.3		63.0		164.3	151.0	0.3	6.4	57	101	165
United Kingdom	2.830.9	2.441.5	367	266	1.453.2	1.624.5	576.9	1.273.0	5.228.0	5.605.0	40.4	2.736.6	186	2.265	5.228
Belgium	393	321.6	83	123.6	303.6	360.2	194.1	192.9	973.8	998.1	13.5	218.0	92	650	974
Ireland	49.3	-	3	-	56.3	-	27.3	-	135.9	330.5	0.2	11.8	11	113	136
Italy	803.1	750.0	300	175.0	1.170.2	1.844.0	544.6	400.0	2.817.9	3.169.0	22.3	128.1	217	2.451	2.818
Luxem-bourg	0.4	-	-	-	75.9	40.3	18.2	6.1	94.5	46.4	1.6	28.7	24	40	94
Spain	143[4]	589.5	83	187.7	118.1[4]	371.0	6.8[4]	149.1	1.542.9	1.297.3	3.1	264.8	129	1.146	1.543
Greece	-	-	21	-	-	-	-	-	553.8	-	0.2	218.6	45	290	554
Portugal	24.8	-	16	-	75.9	-	24.8	-	141.5	-	0.1	10.0	10	121	141

1 Including emissions from "Centrales Charbonnages de France".

2 In the total emissions from traffic is included.

3 Emissions from agriculture is included here.

4 Represents the emission from gas and solid fuels only.

5 Includes emissions from traffic and other not specified groups.

I: Calculated from energy statistics, 1973.
II: The LRTAP emission survey, 1973.