



Project Summary



Estimates of Sulfur Oxide Emissions from the Electric Utility Industry: Volume 1 and Volume II

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The report that this summary describes was prepared as part of the Electric Utility Analysis Project, a research project supported by the U.S. Environmental Protection Agency (EPA). The objective of the report is to provide detailed information on atmospheric emissions of sulfur oxides (SO_x) from electric generation plants from 1976 to 1980. Annual emissions estimates for all generating plants were calculated using fuel use, fuel quality and plant configuration data from several sources.

The analysis of yearly emissions from 1976 to 1980 shows a gradual reduction of about 7.7 percent in emissions from the utility industry. The reductions are attributed to use of cleaner coals and increased use of SO₂ scrubbers. Analysis also shows that a subset of plants with high emissions accounts for a substantial share of industry capacity and coal use. Approximately 10 percent of the plants produced roughly 85 percent of the SO_x emissions and account for 50 percent of total capacity.

Volume I presents a summary of fuel use and emissions information as well as results of analyses of the data. Volume II presents selected statistics for the 237 plants which were the largest emitters of SO_x during the 1976-1980 period.

This Project Summary was developed by EPA's Office of Environmental Engineering and Technology, Washington, DC, to announce key findings of the research project that is fully documented in a separate report of the same

title (see Project Report ordering information at back).

Introduction

Purpose

The purpose of the full two volume report is to provide detailed and definitive information on atmospheric emissions of sulfur oxides from generating plants operated by the electric utility industry from 1976 through 1980. To provide the needed information, a detailed database at the individual plant level of detail was used. Analyses based on this database are presented at the plant level. These analyses are also aggregated to state or national totals. The database and the analyses are the major products of this study. In addition to sulfur oxide emissions, the database contains power generation statistics and information on quantity and quality of fuels used. Appendix A of the full report describes the contents of this database.

In Volume I, summary information and analytical results are presented. The companion volume, Volume II, contains selected statistics for the 237 plants that emitted the most sulfur oxides over the period 1976 through 1980. An example of the information contained in Volume II is presented in Appendix B of the full report.

Background

Sulfur dioxide (SO₂) is one of the seven pollutants for which national ambient air quality standards have been promulgated. These standards are designed to limit

ground level concentrations of SO₂. More recently, a number of studies have linked emissions of sulfur oxides to elevated levels of acid deposition, thus increasing the interest in understanding emission quantities and distribution patterns of sulfur oxides. In the United States, the electric utility industry is responsible for approximately two-thirds of sulfur oxide emissions.¹

Two research needs have been identified in this context. The first concerns emissions of SO₂ and other possible precursors of acidic deposition from the electric utility industry. The second concerns the need to quantify the effects on the industry of possible actions to alter emission quantities and/or patterns. Thus, the EPA has initiated the Electric Utility Analysis Project (EUAP). The EUAP is a cooperative agreement between EPA and the University of Illinois at Urbana-Champaign, with E.H. Pechan and Associates, Inc. (EHPA) as the principle subcontractor.

This summary announces the first of a series of reports to be produced as part of the EUAP. One major project activity is the development of a comprehensive Electric Utility Analysis Database. The information presented here is derived from the Utility Fuel Quality and Use Database, a major component of this system.

Scope of Analysis

The analysis encompassed the following three interrelated tasks:

1. Develop as accurate an estimate as possible of emissions from the electric utility industry for the base year of 1980.
2. Analyze the emission estimates for the years 1976 through 1979 to permit further comparison with the 1980 data.
3. Compare the results from task 1 with other available estimates. Included among these other estimates are the "AIRTEST 80" estimate developed by Teknekron Research, Inc., and modified by EHPA, estimates reported to the

¹Throughout this report, what we refer to as sulfur dioxide or SO₂ emissions are actually total sulfur emissions expressed as SO₂. While the vast majority of sulfur emitted to the atmosphere from utility plants is emitted as SO₂, small amounts are emitted as sulfate (SO₄) or other sulfur compounds. The relative share of sulfur emitted as sulfate differs by source. Additional research is under way to better characterize these emissions

Department of Energy (DOE), by the utilities themselves, and estimates maintained by the EPA as part of the National Emissions Data System (NEDS). The AIRTEST estimate generally has been considered to be the best available base case utility emissions estimate. It has been used as part of the "unified inventory" developed by the U.S. and Canadian working groups that have been examining transboundary air pollution issues, including acid rain, since August, 1980 under a Memorandum of Intent between the two governments.

Results

The analyses of yearly SO₂ emissions from 1976 to 1980 show a gradual reduction of about 7.7 percent in emissions from the utility industry. As shown in Table 1, this reduction was due both to reductions in the sulfur content of coals used by the industry and to the increased use of flue gas desulfurization ("scrubber") systems. These reductions amounted to 1.1 million tons from the levels that would have occurred had coal sulfur contents not changed from 1976, and 1.0 million tons due to operation of more SO₂ scrubber systems. Growth in

quantities of coal use accounted for an increase of 0.9 million tons, almost as much as either of the two decreasing factors. Oil-related emissions showed a net decrease due to a significant decline in oil use. The decline (430,000 tons) overshadowed the increase (185,000 tons) that occurred due to the use, on the average, of higher sulfur oils. The increase in natural gas use by the industry had no noticeable effect on SO₂ emissions, since natural gas combustion produces almost no SO₂.

Another illustration of these trends is presented in Table 2, which compares total utility fossil fuel use by fuel type and SO₂ emissions from these fuels by totals and per million Btu heat input. Again, the dominance of coal as a source of utility SO₂ emissions is apparent. Average sulfur content of coal and oil used by the industry is presented in Table 3.

Almost all of the reductions indicated in Table 1 occurred in the states with the highest SO₂ emissions. As Table 4 indicates, essentially all of the net reduction for the nation occurred in the 15 states with the highest utility emissions in 1980. The set of major SO₂ emitting states, however, remained fairly constant between 1976 and 1980. For example, 8 of the 10 highest emitting states in 1980 were also among the

Table 1. Summary of Changes in Utility SO₂ Emissions from 1976 to 1980 (1,000 Tons)

	Coal-Related Emissions	Oil-Related Emissions
1976 Emissions	17,065	1,755
Difference Due to Change in Quantity of Fuel Used	929	-430
Difference Due to Change in Fuel Sulfur Content	-1,113	185
Difference Due to Increased SO ₂ Scrubbing	-1,013	0
1980 Emissions	15,868	1,510

Table 2. National Utility SO₂ Emissions and Heat Value of Fuels Used

	1976	1980	% Change 1976-1980
Total SO ₂ Emissions (million tons)	18.8	17.4	-7.7
Total Heat Value Used (quads)	16.3	18.8	15
Coal	9.7	12.2	26
Oil	3.4	2.6	-24
Gas	3.1	4.0	29
Net SO ₂ Emissions as Pounds/Million Btu			
All Fuels	2.3	1.9	-17
Coal	3.5	2.6	-26
Oil	1.0	1.2	20
Gas	<.01	<.01	0

Table 3. National Average Sulfur Content of Fuels Used by the Utility Industry

Year	Coal Sulfur (%)	Coal SO ₂ Content (lb/MMBtu)	Oil Sulfur (%)
1976	2.12	3.91	.96
1977	2.01	3.74	.91
1978	1.86	3.50	.96
1979	1.80	3.36	1.02
1980	1.68	3.15	1.04

highest emitting states in 1976. Michigan and Alabama, ranked ninth and tenth in 1976, were replaced by Georgia and Florida in 1980. The set of states comprising the 15 highest emitting states did not change from 1976 to 1980. The share of total emissions contributed by the 15 highest states declined slightly over the period, falling from 86 percent in 1976 to 83 percent in 1980.

Table 4 also shows utility emissions for a 31-state eastern U.S. region which includes all of the states east of the Mississippi River plus the first tier of states west of the Mississippi (Minnesota, Iowa, Missouri, Arkansas, and Louisiana). This region, which has been used in a variety of acid rain-related studies, accounted for 95 percent of national utility SO₂ emissions in 1976 and 92 percent in 1980.

A subset of plants with high emissions accounts for a substantial share of industry capacity and coal use. To illustrate this, a subset of plants was developed consisting of the 200 highest SO₂ emitting plants during 1980. As Table 5 shows, these plants, about 10 percent of plants included in the study,² accounted for slightly less than 50 percent of all generating capacity, over 75 percent of all coal used, and over 85 percent of all SO₂ emissions. The coal plants constructed in the last three decades are generally more economically efficient because of their larger size. These plants are used to generate power a larger fraction of the time, and, without sulfur emission controls, emit a relatively larger amount of SO₂ than comparable oil- and gas-fired plants.

Appendix C of the full report contains summary SO₂ estimates for the 200 highest SO₂ emitting plants from three sources: (1) AIRTEST, (2) Form 67 (for

²All utility generating plants burning at least some coal, oil, or natural gas between 1976 and 1980.

Table 4. Trends in Utility SO₂ Emissions 1976-1980 for the 15 Highest Emitting States (1980) and the Nation (Emissions in 1000 Tons per Year)

1980 Rank	State	1976 Rank	1976 Emissions	1977 Emissions	1978 Emissions	1979 Emissions	1980 Emissions
1	Ohio	1	2,750	2,686	2,463	2,515	2,172
2	Indiana	3	1,443	1,458	1,351	1,537	1,540
3	Pennsylvania	4	1,432	1,381	1,323	1,415	1,466
4	Missouri	7	1,179	1,202	1,014	1,076	1,141
5	Illinois	5	1,429	1,367	1,293	1,168	1,126
6	Kentucky	2	1,512	1,357	1,210	1,130	1,008
7	West Virginia	8	1,010	1,001	896	956	944
8	Tennessee	6	1,228	1,258	1,033	893	934
9	Georgia	13	499	581	616	666	737
10	Florida	11	673	658	595	659	726
11	Michigan	9	888	905	807	741	565
12	Alabama	10	705	735	531	521	543
13	Wisconsin	14	470	515	472	496	486
14	New York	12	513	549	520	508	480
15	North Carolina	15	410	427	396	380	435
<i>Total of 15 Highest</i>			16,141	16,080	14,520	14,661	14,303
<i>Eastern U.S. Total</i>			17,853	17,945	16,472	16,459	16,068
<i>National Total</i>			18,821	19,071	17,593	17,685	17,379

Table 5. Shares of 1980 Emissions and Other Variables Attributed to Large Plants

	All Plants (N=1,878)	200 Highest SO ₂ Emitting Plants (N=200)	% of Total in 200 Highest
<i>Total SO₂ Emissions (thousand tons)</i>	17,379	14,984	86
<i>Total Generating Capacity (gigawatts)</i>	477	227	48
<i>Total Generation (terawatt-hours)</i>	1,754	1,027	59
<i>Average Capacity Factor</i>	.42	.52	
<i>Total Coal Used (million tons)</i>	569	438	77
<i>Total Oil Used (million barrels)</i>	420	162	39
<i>Total Gas Used (billion cubic feet)</i>	3,682	1,282	35

1979), and (3) our own work (for 1976 through 1980).

Table 6 further emphasizes the dominance of coal plants (plants consuming at least some coal) among the set of all plants as well as those in the set of the 200 highest SO₂ emitting plants. The 24 percent of plants burning at least some coal account for over half of all

generating capacity and over two-thirds of actual generation. Of the 200 highest emitters, 183 use at least some coal.

In developing the information presented here, we conducted extensive comparisons with other recent estimates of SO₂ emissions. Extensive comparisons were made with EPA's National Emissions Data System (NEDS) as well as

Table 6. Shares of 1980 Emissions and Other Variables Attributed to Coal Plants

	All Plants (N=1,878)	All Coal Plants (N=457)	Coal Plants Among 200 Highest Emitters (N=183)	Percent of 200 Highest Emitters
Total SO ₂ Emissions (thousand tons)	17,379	16,153	14,355	89
Total Generating Capacity (gigawatts)	477	278	209	75
Total Generation (terawatt hours)	1,754	1,223	959	78
Average Capacity Factor	.42	.50	.52	
Total Coal Used (million tons)	569	569	438	77
Total Oil Used (million barrels)	420	70	57	81
Total Gas Used (billion cubic feet)	3,682	239	101	42

with the AIRTEST system recently used in the EPA-DOE Acid Rain Mitigation Study. In addition, selected comparisons were made with utility-reported data contained in the DOE's Form 67. Finally, we subjected our draft results to detailed review by the utilities that own the major SO₂ emitting plants. We compared NEDS data with our 1978 estimates because the weighted average year of record on the NEDS data type was closest to 1978. The national differences are relatively small, but the state differences are much larger. This may be due at least in part to

different years of record for NEDS data by state, since the NEDS system is dependent upon state data. AIRTEST data were compared with our 1980 figures. Again, the relatively small national differences mask somewhat larger state differences. A summary of the comparison of our estimates with NEDS and AIRTEST is presented in Table 7. State- and plant-level comparisons are presented later in the full report.

We conducted sensitivity analyses on two key elements of our analyses, coal sulfur ash retention and capacity

utilization of large plants (see Table 8). These sensitivity analyses, intended to be illustrative rather than comprehensive, show that operating practice has a major effect on emissions, while the range of conventional assumptions concerning how much sulfur is retained in ash rather than emitted from the stack is relatively unimportant to overall emissions estimates. The significance of capacity utilization of large plants is further illustrated in Table 9. An increase in minimum capacity utilization of the 200 highest emitting plants in 1980 from the current average of .53 to a minimum of .70 could increase SO₂ emissions by approximately 5.7 million tons. On the other hand, a decrease in capacity utilization (to a maximum of .40) in the same plants could reduce SO₂ emissions by about 3.6 million tons. Of course, such changes would also affect quantities of fuels used as well as other aspects of utility operations.

Table 7. Summary Comparison of Utility SO₂ Emissions from this Report with Other Estimates

	1978	NEDS	1980	AIRTEST
National Emissions (thousand tons)	17,593	18,255	17,379	17,465
Difference (thousand tons)		662		86
Percent Difference		4		0.5
Maximum State Difference (thousand tons)		251.2		266.3
Average Absolute State Difference (thousand tons)		47.8		35.0
Average Absolute Difference (percent)		29.1		24.2

Table 8. Summary of Sensitivity Analyses Related to Coal Sulfur Ash Retention and Changes in Capacity Factors

	1980 SO ₂ Emissions (1000 tons)	% of Base 1980 SO ₂ Emissions
Base Case	17,379	100
AP-42 Sulfur Retention	17,583	101
Low Capacity Utilization of 200 Highest Emitting Plants (.40 maximum)	13,761	79
High Capacity Utilization of 200 Highest Emitting Plants (.70 minimum)	23,128	133

Table 9. Emissions from the 200 Highest SO₂ Emitting Plants under 1980 Conditions and if Capacity Utilization Were Changed (Emissions in 1000 Tons)

State	Emissions Under 1980 Operating Conditions	Potential Emissions Assuming Maximum 40% Capacity Factor	% of 1980 Actual	Potential Emissions Assuming Minimum 70% Capacity Factor	% of 1980 Actual
Ohio	2,100	1,600	75	2,900	140
Indiana	1,400	1,100	80	2,000	140
Pennsylvania	1,400	900	65	1,700	120
Missouri	1,000	800	80	1,500	150
Illinois	900	700	80	1,300	145
Kentucky	900	700	80	1,300	145
West Virginia	900	600	65	1,100	120
Tennessee	900	700	80	1,400	155
Georgia	700	500	70	900	130
Florida	600	500	85	1,000	165
Total of 10 Highest States	10,800	8,100	75	15,100	140
National Total	15,000	11,400	75	20,700	140

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The complete report consists of two volumes, entitled "Estimates of Sulfur Oxide Emissions from the Electric Utility Industry,"

"Volume I. Summary and Analysis," (Order No. PB 83-130 229; Cost: \$14.50, subject to change)

"Volume II. Databook," (Order No. PB 83-130 237; Cost: \$23.50, subject to change)

The above reports will be available only from:

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