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Volume V

FINAL ANALYSIS

BENEFITS ANALYSIS OF ALTERNATIVE SECONDARY NATIONAL AMBIENT AIR QUALITY STANDARDS FOR SULFUR DIOXIDE AND TOTAL SUSPENDED PARTICULATES

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By:

Ernest H. Manuel, Jr.
Robert L. Horst, Jr.
Kathleen M. Brennan
William N. Lanen
Marcus C. Duff
Judith K. Tapiero

With the Assistance of:

Richard M. Adams
David S. Brookshire
Thomas D. Crocker
Ralph C. d'Arge
A. Myrick Freeman, III
Shelby D. Gerking
Edwin S. Mills
William D. Schulze

MATHTECH, Inc.
P.O. Box 2392
Princeton, New Jersey 08540

EPA Contract Number 68-02-3392

Project Officer:
Allen C. Basala
Economic Analysis Branch
Strategies and Air Standards Division
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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PREFACE

This report was prepared for the U.S. Environmental Protection Agency by MATHTECH, Inc. The report is organized into six volumes containing a total of 14 sections as follows:

Volume I

- Section 1: Executive Summary
- Section 2: Theory, Methods and Organization
- Section 3: Air Quality and Meteorological Data

Volume II

- Section 4: Household Sector
- Section 5: Residential Property Market
- Section 6: Labor Services Market

Volume III

- Section 7: Manufacturing Sector
- Section 8: Electric Utility Sector

Volume IV

- Section 9: Agricultural Sector

Volume V

- Section 10: Extrapolations
- Section 11: Bibliography

Volume VI

- Section 12: Summary of the Public Meeting
- Section 13: Analysis of Pollutant Correlations
- Section 14: Summary of Manufacturing Sector Review

The analysis and conclusions presented in this report are those of the authors and should not be interpreted as necessarily reflecting the official policies of the U.S. Environmental Protection Agency.

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SECTION 10

EXTRAPOLATIONS

SECTION 10

EXTRAPOLATIONS*

INTRODUCTION

The previous sections of this report have estimated the economic benefits of alternative secondary ambient air quality standards for the household, manufacturing, electric utility, and agricultural sectors. However, the estimates obtained in each of the sectors represent only a partial accounting of total benefits. In each of the analyses, data limitations or methodological considerations prevented the enumeration of a complete set of national benefits. For example, in the household sector, the geographic coverage was limited to 24 SMSAs and economic data were available for only about 40 percent of current consumption expenditures. Similarly, the analysis in the manufacturing sector covered only six industries, with these industries accounting for about 8 percent of the value added in that sector. In order to broaden the scope of the analysis, this section provides a limited extrapolation of the results of the basic analysis.

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* Sections 1 and 2 of the report should be read before this section. An understanding of Sections 3, 4, 7 and 8 would also be desirable, but it is not as essential.

Table 10-1 summarizes the basic scope of the study. Note that in addition to limited coverage of the sectors analyzed in this study, there are several sectors which were not covered at all. Furthermore, consideration of benefit types is restricted to vegetation and materials damage and soiling. Since the extrapolations reported in this section are limited to extended coverage of the sectors and benefit types analyzed in the basic study, the benefits reported represent conservative estimates of the benefits associated with attainment of the secondary ambient air quality standards.

The remaining subsections review the extrapolation procedures and report extrapolated benefits for the household, manufacturing, and electric utility sectors. For reasons given in Section 9, no extrapolations were attempted in the agricultural sector.

HOUSEHOLD SECTOR EXTRAPOLATIONS

The basic analysis in the household sector is limited to 24 SMSAs, with these SMSAs accounting for approximately 30 percent of the total U.S. population in 1976. This subsection estimates the benefits that would be realized by other areas of the country, given attainment of the secondary standards for TSP and SO_2.

TABLE 10-1. COVERAGE OF ECONOMIC ACTIVITY IN EACH SECTOR

Final demand sector	Percent of final demand	Percent coverage	
		Basic analysis	Basic plus extrapolation
Households*	63.5	17	45-55
Government	20.5	0	0
Other	16.0	0	0
Totals	100.0	11**	29-35**

Producing sector	Percent of GNP	Percent coverage	
		Basic analysis	Basic plus extrapolation
Agriculture, forestry and fisheries	3.1	2-15	2-15
Mining and construction	7.1	0	0
Manufacturing	23.9	4-8	25-30
Transportation, communication and utilities	9.0	8-11	15-20
Commercial and services	43.6	0	0
Government and other	13.3	0	0
Totals	100.0	2-3**	7-9**

* Goods and services consumed by individuals and certain nonprofit institutions. Includes rental of dwellings but not purchases of dwellings. The latter are included with "other".

** Weighted average coverage.

Source: Estimates of final demand and GNP shares are from U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. July 1979. Tables 1.1 and 6.1.

Overview

In the basic household sector analysis (see Section 4), benefits are calculated in a two-stage procedure. In the first stage, price data for marketed goods such as laundry and cleaning supplies, together with data on air quality, climate, and household demographics, are used to calculate the implicit prices for "final" goods and services such as "household operations." In the second stage, the implicit prices are used to calculate the allocation of household expenditures among the various final goods and services. In this formulation, the effect of an air quality improvement is to reduce some of the implicit prices and therefore induce a reallocation of household expenditures. Benefits are then estimated by calculating the compensating variation (CV) associated with the expenditure reallocation.*

In extrapolating beyond the original 24 SMSAs, the same procedure as described above is used. However, some of the required demographic, climate, and market price data are not available for the counties outside of the original SMSAs. Thus, approximate data are used instead, together with actual air quality data. For the demographic and climate data, regional averages are used. For the

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* The compensating variation (CV) is a measure of the compensation required such that the consumer is indifferent between the original price set and the new price set.

price data, two alternative approaches are used since benefits are especially sensitive to price: regional average prices, and the highest and lowest price sets from among the original SMSAs (where high and low are measured in terms of effect on benefits). The specific data development procedures are described more fully below.

Note that this extrapolation procedure assumes that the implicit price and expenditure models developed in the basic analysis are also appropriate for other parts of the country. This does not seem unreasonable since the original 24 SMSAs were quite varied. Note also, however, that by using the models developed in the basic analysis, the scope of the extrapolation is limited to those benefit types included in that analysis. Consequently, since such benefits as visibility improvement and ecosystem protection were neglected there, the extrapolated benefits in the household sector continue to represent conservative estimates of the benefits associated with attainment of the secondary standards.

Data Development Procedures

The geographic extrapolations reported here are done on a county-by-county basis. Counties included within the boundaries of the original 24 SMSAs were excluded from the extrapolation procedures. The specific assumptions made in performing the extrapolation include:

- Certain data are assigned to counties based on the region in which the county is located. In particular, the following steps were taken:

  -- The country is divided into two major areas -- Northeast plus North Central and South plus West.

  -- Averages by region are computed from the SMSA-specific data for the following items:

     a) 30-year average temperature.

     b) family size

     c) average annual percent change in the all-item consumer price index.

     d) average percent of total consumption expenditures in the SMSA data.

     e) disaggregate and aggregate price sets developed for the basic analysis.

- Certain data are assigned to counties based on county- or state-level data. These data include:

  -- Air quality data obtained from the SAROAD data base (1978 statistics) on a site-by-site basis and aggregated to the county-level by the procedures described in Section 3.

  -- Baseline county population numbers obtained from the County and City Data Book, 1977 (1). These are 1975 statistics. Conversions to household data are made by dividing by the regional family size values.

  -- Population projections by county developed by calculating the annual percent change in population by county between 1970 and 1975. These data are obtained from the County and City Data Book, 1977 (1). The annual changes are assumed to be maintained at the same rate into the future.

  -- State income projections for 1985 and 1990 (current 1972 dollars) obtained from the Department of Commerce News, December 9, 1980 (2).

  -- The annual percent changes in income implied by the data described above are computed for each state. These annual changes are assumed to hold into the future.

- Certain data or assumptions are pertinent to all counties. These include:
  - The parameters of the various demand equations estimated in Section 4.
  - The air quality scenario developed for the benefits calculations remains the same as before.
  - Benefits are calculated as discounted present values in 1980, in 1980 dollars. A social rate of discount of 10 percent and an infinite time horizon are assumed.

Estimated Household Sector Benefits

Given the extrapolation scenario described above, household sector benefits were calculated on a county-by-county basis for each pollutant and then aggregated to Census Divisions.

Table 10-2 presents the benefits obtained in the household sector for attainment of the current 3-hour secondary standard for SO_2. As described in Section 3, it is not possible to calculate directly the incremental benefits for the 3-hour standard since there is no primary standard defined for the same averaging time. Consequently, for each county, we have calculated the equivalent 24-hour concentration level that would be expected to occur when the 3-hour standard is just met. This 24-hour concentration level is then used as an "equivalent" secondary standard and comparisons can be made directly with the current 24-hour second-high primary standard.

TABLE 10-2. HOUSEHOLD SECTOR EXTRAPOLATION FOR CURRENT 3-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Census Division	Benefit estimates with average price set
1. New England	--
2. Mid-Atlantic	--
3. East North Central	1.81
4. West North Central	--
5. South Atlantic	--
6. East South Central	0.02
7. West South Central	--
8. Mountain	0.19
9. Pacific	--
U.S. total	2.02

* Current SO_2 secondary standard is 1,300 $\mu g/m^3$, based on a 3-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

-- Equals zero.

As Table 10-2 shows, the estimated benefits of the current 3-hour SO_2 standard are small. This is in part because only soiling and materials effects are captured by the model. It also occurs because very few counties in the United States are out of compliance with the equivalent secondary standard, given that the primary standard is

attained. In fact, benefits for attainment of the secondary standard are predicted to be realized in only five counties, with total benefits of $2.02 million dollars.

In Section 3, it was noted that air pollution measures based on longer averaging times were likely to be more appropriate for the types of damaging effects included in our analysis. Because of this, benefits were analyzed for an alternative secondary standard for SO_2 based on a 24-hour averaging time. For this alternative standard of 260 $\mu g/m^3$ the SO_2 benefits are as shown in Table 10-3.

The top part of Table 10-3 reports benefits only for counties not included in the original analysis. The range of estimates denoted by low, average, and high price sets gives some idea of the sensitivity of the results to assumptions concerning the assignment of prices to counties.

The average price set is defined on a regional basis. That is, from the original group of 24 SMSAs, average prices are calculated for all those SMSAs in the Northeast or North Central regions to obtain an index of prices for all counties located in these two regions. A similar average is calculated for counties in the South and West.

The low and high price sets are obtained by finding the SMSAs, from our group of 24, that yield the low and high marginal valuations of air quality improvements. For example, in order to identify the

TABLE 10-3. HOUSEHOLD SECTOR EXTRAPOLATION FOR ALTERNATIVE 24-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Census Division	Low price set	Average price set	High price set
1. New England	6	6	8
2. Mid-Atlantic	24	26	33
3. East North Central	64	69	87
4. West North Central	1	1	1
5. South Atlantic	43	41	62
6. East South Central	21	20	31
7. West South Central	--	--	--
8. Mountain	19	18	28
9. Pacific	--	--	--
Extrapolated U.S. total	178	181	250
24 SMSA total		920	
Total U.S. benefits		1,101	

* Alternate SO_2 secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

-- Equals zero.

"high price set" SMSA, we evaluate the predicted level of benefits per unit change in air quality (TSP and SO_2) for each SMSA. This evaluation is performed at a variety of air quality levels in order to

account for changes in the marginal valuations across concentration levels. When this analysis is performed, New York City households are found to have the highest per-unit valuation. Thus, the price set for New York City is assigned to each of the counties in the extrapolation, and the benefits calculations performed. These results are reported under the high price set column. Similar steps are carried out to identify the low price set SMSA. In this case, Atlanta is found to be the SMSA with the lowest marginal valuations.

On a regional basis, the largest benefits are realized in the eastern part of the country, with the East North Central Region accounting for almost 40 percent of extrapolated U.S. benefits.

The bottom part of Table 10-3 lists the total benefits estimated for the original SMSAs. Because of the different types of sensitivity checks carried out in the two sets of benefits calculations, only the "most reasonable" values are reported from the analysis phase. These are listed under the average price set column, and the estimate of total U.S. benefits for SO_2 is recorded on the last line of the table. The best estimate of total household sector benefits (soiling and materials benefits) for attainment of a 24-hour averaging time secondary standard for SO_2 is approximately $1.1 billion.

Table 10-4 presents extrapolations for TSP. The low, average, and high price sets are as defined above. Since primary and secondary air quality standards for TSP exist with the same averaging time, no

TABLE 10-4. HOUSEHOLD SECTOR EXTRAPOLATION FOR CURRENT 24-HOUR SECONDARY TSP STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Census Division	Low price set	Average price set	High price set
1. New England	64	72	86
2. Mid-Atlantic	119	133	160
3. East North Central	220	245	294
4. West North Central	60	68	80
5. South Atlantic	58	63	73
6. East South Central	64	69	79
7. West South Central	60	67	77
8. Mountain	244	270	308
9. Pacific	297	344	392
Extrapolated U.S. total	1,186	1,331	1,549
24 SMSA total		2,299	
Total U.S. benefits		3,630	

* Current TSP secondary standard is 150 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

additional transformations were required to account for alternate averaging times.

The regional dispersion of TSP benefits is different from that observed for SO_2. In this case, the largest benefits occur in the

East North Central, Mountain, and Pacific regions. Note, however, that the other six regions realize nontrivial benefits.

As with SO_2, the bottom part of Table 10-4 records the benefits calculated from the original 24 SMSAs. In this case, the best estimate of total household sector benefits (soiling and materials benefits) for attainment of a 24-hour averaging time secondary standard for TSP is about $3.63 billion.

MANUFACTURING SECTOR EXTRAPOLATIONS

Overview

The basic analysis in the manufacturing sector (see Section 7) is limited to six 3-digit SIC industries comprising about 8.3 percent of the value added in the manufacturing sector. The analysis is done on a county-by-county basis in each industry. The unavailability of air quality data and economic data for those industries in many counties of the U.S. further reduces the coverage to about 3.6 percent (i.e., data sets were available for counties containing about one-half the economic value in the six industries). The possibilities for extrapolation of the basic analysis thus included: (1) extending the geographic coverage of the original six industries to other areas of the country; and (2) extending coverage to other manufacturing industries.

Geographic Extrapolation--

It was decided not to undertake the geographic extrapolation for two reasons. First, although counties containing only half of the economic value (on average) in the six industries were included in the basic analysis, these counties are the more industrialized counties in the U.S. Since air pollution is likely to be more severe in these counties, and less severe in the other counties, the probability of identifying large additional benefits in the other counties was judged to be small.

Second, the basic analysis already included all counties for which economic data were available. Thus, to extend the geographic coverage to other areas, the analysis would have to be done at the more aggregate SMSA (metropolitan area) level. A review of this situation indicated the following: (1) single-county SMSAs would be of no interest because those for which economic data were available were already included in the basis analysis; and (2) for many of the multi-county SMSAs, air quality data were not available for all of the member counties, and thus air quality for the SMSA was not well defined.

In view of the two reasons above -- the expectation of small benefits, and the limitations of the air quality data -- no geographic extrapolation for the original six industries was undertaken.

Industry Extrapolation--

The alternative possibility was to extrapolate the results for the original six industries to some of the other closely related manufacturing industries. For example, two of the industries included in the basic analysis were SIC 344 (fabricated structural metal products) and SIC 346 (metal forgings and stampings). Both of these 3-digit SIC industries are part of the broader 2-digit industry, SIC 34 (fabricated metal products). One might therefore take the view that the air pollution effects identified in the two subindustries are representative of the effects likely to be present in the broader industry group.

The extrapolation to other industries, of course, raises two questions. First, can the effects identified in the subindustries be viewed as representative of the effects in the broader industry group? Second, if so, how should the extrapolation be carried out? The first question cannot be answered definitively without actually conducting a specific analysis of the other subindustries in each group. Clearly, there are similarities among the various 3-digit industries within a 2-digit group. The similarities can include the use of common raw materials, similar processing techniques, and most importantly, the production of related end products. However, the industries can also be different in important ways, and it is the latter fact which guided the selection of an extrapolation procedure.

One possible extrapolation procedure would be to apply the estimated models for the six industries, developed in Section 7, to data for the corresponding 2-digit industries. The models in that section are designed to estimate the savings in production cost (e.g., maintenance cost) due to an improvement in air quality. However, direct application of the models was viewed as unattractive for two reasons. First, it requires two specific assumptions: (1) that the underlying production technology is the same at both the 2-digit and 3-digit levels; and (2) that the effect of air pollution on that technology is similar at both the 2-digit and 3-digit levels. Comparisons in Section 7 between the 3-digit SIC models developed in this study and the 2-digit SIC models developed in another study suggest that at least the first of these assumptions may not always be valid.

A second problem with applying the models directly is that the models incorporate specially developed price indexes for raw materials inputs used by the 3-digit industries. New price indexes would be required corresponding to the different mix of input materials used by the 2-digit industries.

In view of the above, a less formal extrapolation procedure was adopted. It basically involves answering the following question: If the benefits of improved air quality at the 2-digit level were the same as at the 3-digit level in terms of the percentage savings in production cost for a given change in air quality, how large would the

benefits be? Note that this approach does not necessarily require that the underlying production technologies be the same -- only that air quality benefits, on a percentage basis, be the same. The remainder of this subsection addresses the above question. Three features of the extrapolation are worth noting:

- Actual economic data on each 2-digit industry are used, on a county-by-county basis.
- Actual air quality data are used on a county-by-county basis.
- The sensitivity of the results to variations in the benefits observed within each 3-digit industry are examined.

The extrapolations are carried out for the 2-digit SIC industries listed in Table 10-5.

Extrapolation Procedure

In the basic analysis, benefits are calculated by estimating the savings in production costs that would result from attainment of the secondary ambient air quality standards, as compared to attainment of the primary standards only. This savings (benefit) is calculated for each industry and county. It is calculated as the discounted present value (DPV) in 1980 dollars, of all future cost savings due to the secondary standards.

TABLE 10-5. INDUSTRIES INCLUDED IN THE EXTRAPOLATIONS

Industry			Basis for the extrapolation		
SIC code	Name	Value added*	SIC code	Name	Value added*
20	Food and kindred products	35.6	201	Meat products	5.0
			202	Dairy products	4.1
26	Paper and allied products	13.1	265	Paperboard containers and boxes	3.6
34	Fabricated metal products	26.9	344	Fabricated structural metal products	6.7
			346	Metal forgings and stampings	5.1
35	Machinery, except electrical	37.6	354	Metalworking machinery	4.9

* Billions of 1972 dollars.

Source: U.S. Bureau of the Census. Census of Manufactures - 1972. 1976.

The benefits calculated in the basic analysis are used in the extrapolations as follows. First, the following quantities are calculated for each county included in the basic analysis for each 3-digit SIC:

- The dollar benefits, per dollar of value added, per unit change in air quality.
- The dollar benefits, per dollar of value shipped, per unit change in air quality.

For convenience, the first quantity above will be denoted by BVA_{ij}, where i indexes industries and j indexes counties. The second quantity will be denoted as BVS_{ij}. The above ratios are calculated for each county where there are non-zero benefits; i.e., where air quality is assumed to change as a result of the standard.

As an example, suppose the 1980 discounted present value of all future benefits in industry i and county j is $1 million, the 1972 (base year) value added in the corresponding industry and county is $10 million, and the air quality change due to the secondary standard is 50 $\mu g/m^3$ measured as a 24-hour average. In this case

$$BVA_{ij} = (1)/(10)/(50) = 0.002$$

Calculations are made for both value added and value of shipments since both are alternative measures of economic activity, and thus alternative bases for extrapolation.

As a result of the above calculations, six ratios are developed for each 3-digit industry: the minimum, maximum, and average values of BVA_{ij}, over all counties, and the corresponding ratios for BVS_{ij}. The minimums and maximums are calculated, as well as the averages, in order to assess the sensitivity of the estimates.

The second step in the extrapolation procedure was to assemble data on the value added and value of shipments in each county for each of the four 2-digit industries. Data for 1972 were used in order to provide consistent scaling with the ratios above. Note that with the use of the more aggregate 2-digit industries, data are available for more counties than in the basic analysis based on 3-digit industries. Hence, the industry extrapolation also accomplishes some geographic extrapolation of the basic analysis.

Also collected for each county was the air quality data for SO_2 and TSP in 1978. As in the basic analysis, data for 1978 were used as the base year in describing the scenario for attainment of the secondary standard (see Section 7).

The third step in the calculation was to multiply the ratios by the appropriate measures of economic value and air quality change in each county. This leads to six county-by-county estimates of the discounted present value of benefits in each industry -- six corresponding to the six different ratios.

In the two 2-digit industries where more than one 3-digit industry was available as the basis for extrapolation (SICs 20 and 34), a weighted average of the benefits for each 3-digit industry was used in estimating the benefits for the corresponding 2-digit industry. The weights used were value added or value of shipments, depending on which ratio was under consideration. In SIC 201, air pollution effects were not statistically significant at the 10 percent level (see Section 7). Thus, in SIC 20, a weighted average of zero and SIC 202 benefits was used. In SIC 344, air pollution effects were occasionally significant but not in the final model (nor at all in SIC 346). The calculation for SIC 34 is based on a weighted average of zero and SIC 344 benefits, but in intended to be primarily illustrative.

Manufacturing Sector Estimated Benefits

When the county-by-county benefits, calculated as described above, are added up, the national estimates shown in Tables 10-6 through 10-8 result. Table 10-6 presents estimates for the current 3-hour SO_2 secondary standard. Table 10-7 contains estimates for the alternative 24-hour SO_2 secondary standard. Estimates for the current 24-hour TSP secondary standard are in Table 10-8. In each table, estimates are shown for each of the six ratios -- the minimum, maximum, and average ratio based on value added, and similarly for value of shipments. All estimates are 1980 discounted present values, in 1980 dollars, using a 10 percent discount rate. Note that the

TABLE 10-6. MANUFACTURING SECTOR EXTRAPOLATION FOR CURRENT 3-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in million of 1980 dollars)**

SIC	Basis for extrapolation					
	Value added			Value of shipments		
	Minimum ratio	Average ratio	Maximum ratio	Minimum ratio	Average ratio	Maximum ratio
20	7.3	11.1	25.6	6.1	6.4	6.7
26	—	—	—	—	—	—
34	—	—	—	—	—	—
35	—	—	—	—	—	—

* Current SO_2 secondary standard is 1,300 $\mu g/m^3$, based on a 3-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

— Equals zero.

TABLE 10-7. MANUFACTURING SECTOR EXTRAPOLATION FOR ALTERNATIVE 24-HOUR SECONDARY SO_2 STANDARD* (discounted present values for 1980 in million of 1980 dollars)**

SIC	Basis for extrapolation					
	Value added			Value of shipments		
	Minimum ratio	Average ratio	Maximum ratio	Minimum ratio	Average ratio	Maximum ratio
20	1,860	2,820	6,537	1,479	1,558	1,622
26	307	343	393	314	354	393
34	--	--	--	--	--	--
35	--	--	--	--	--	--

* Alternate SO_2 secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

— Equals zero.

TABLE 10-8. MANUFACTURING SECTOR EXTRAPOLATION FOR CURRENT 24-HOUR SECONDARY TSP STANDARD* (discounted present values for 1980 in million of 1980 dollars)**

SIC	Basis for extrapolation					
	Value added			Value of shipments		
	Minimum ratio	Average ratio	Maximum ratio	Minimum ratio	Average ratio	Maximum ratio
20	--	--	--	--	--	--
26	--	--	--	--	--	--
34+	6,511	10,148	19,051	7,156	9,307	11,495
35	2,707	6,788	10,253	3,539	8,029	11,798

* Current TSP secondary standard is 150 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

+ Illustrative calculations based on SIC 344 benefits.

-- Equals zero.

estimates are inclusive of the benefits for the six 3-digit industries.

As shown in Table 10-6, benefits for the current 3-hour SO_2 secondary standard are predicted to arise in only one industry, SIC 20, and be very small. This is because so few counties are out of compliance with this standard. It is for this same reason that no benefits are predicted to arise in SIC 26. For SICs 34 and 35 the

effect of SO_2 was not found to be statistically significant in the basic analysis (for SICs 344, 346, and 354) and thus no benefits are estimated.

In Table 10-7, estimated benefits for the alternative 24-hour SO_2 standard are presented. In this case, because many more counties are out of compliance, benefits are considerably larger.

Estimated benefits for the current 24-hour TSP standard are shown in Table 10-8. In SICs 20 and 26, the effect of TSP was not found to be statistically significant in the basic analysis (for SICs 201, 202, and 265). Hence no benefits arise in these industries. Large benefits are estimated for SIC 34 and SIC 35, however. Recall that these are 1980 discounted present values over an infinite time horizon. For comparison purposes, the discounted present values of future shipments in these two industries are estimated to be approximately $1 trillion and $1.3 trillion, respectively. Thus, benefits are approximately 0.9 percent and 0.6 percent of value shipped, respectively, when estimated using the "average" ratio for value of shipments.

The geographic distribution of estimated benefits is shown in Table 10-9. Entries are included for those industries, pollutants and standards with non-zero benefits. Estimates are shown for the extrapolation based on the "average" ratio for value of shipments.

TABLE 10-9. GEOGRAPHIC DISTRIBUTION OF EXTRAPOLATED BENEFITS FOR THE MANUFACTURING SECTOR (discounted present values for 1980 in millions of 1980 dollars)*

Census division	Current 3-hour SO_2 standard	Alternate 24-hour SO_2 standard		Current 24-hour TSP standard	
	SIC 20	SIC 20	SIC 26	SIC 34**	SIC 35
New England	--	5	75	417	20
Mid-Atlantic	--	497	134	1,359	970
East North Central	6	808	134	4,654	3,755
West North Central	--	67	10	475	367
South Atlantic	--	15	--	144	15
East South Central	--	134	--	304	163
West South Central	--	--	--	452	120
Mountain	--	33	--	162	659
Pacific	--	--	--	1,341	1,959
U.S. totals	6	1,558	354	9,307	8,029

* Using a discount rate of 10 percent and the "average" ratio for value of shipments. Details may not add to totals due to independent round-off errors.

** Illustrative calculations based on SIC 344 benefits.

-- Equals zero.

ELECTRIC UTILITY SECTOR EXTRAPOLATIONS

Overview

The basic analysis for the electric utility sector (see Section 8) was concerned with the effects of air pollution (e.g., corrosion) on the maintenance and operating costs for privately-owned, fossil fuel-fired, steam-electric generating plants. Not considered in that analysis were the effects on other types of generating plants, or on transmission and distribution systems. These other effects are considered in this section.

Other Types of Power Plants

The basic analysis found that fossil steam-electric power plants in polluted areas experience higher maintenance costs than power plants in cleaner areas, after statistically controlling for other sources of cost variation. This effect was associated with SO_2 pollution but not TSP.

Based on the above finding, the benefits of attaining compliance with the alternative 24-hour SO_2 secondary standard were estimated.* Benefits totaling $55.8 million, in the form of cost savings for fossil steam-electric plants, were identified in 22 counties. This

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* No benefits were found for the current 3-hour SO_2 secondary standard.

figure is the 1980 discounted present value of all future benefits, at a 10 percent discount rate.

In the above counties, fossil steam-electric power plants accounted for 79 percent of the installed generating capacity. Within these counties there were also gas turbine, hydroelectric, and gas/steam turbine plants. A detailed analysis of the maintenance costs of these other plants was not undertaken, in view of the fact that the additional benefits to these plants were likely to be small. Instead, the following rough calculation was made.

If we assume that the total benefits in these counties are proportional to installed capacity (i.e., benefits to other generating plants are comparable to those for fossil steam plants), then the additional benefits to the other plants can be calculated as

$$55.8/0.8 - 55.8 = \$14.0 \text{ million.}$$

Note that this is based on a rather strong assumption, but in view of the small magnitude, a more specific analysis did not seem warranted.

Transmission and Distribution Systems

As noted in Sections 2 and 8, data limitations make a statistical analysis of air pollution effects on transmission and distribution systems difficult. Individual system components, such as transmission

towers, can and have been studied statistically (see Section 8 for references). However, the overall systems are for the most part so geographically dispersed that the appropriate matching with air quality data is not well-defined.

As an alternative basis for estimating benefits, an updated version of the approach and data developed by Perl (3) was used. The approach involves the following steps:

i) Estimate the inventory for key elements of the transmission and distribution system in some base year.

ii) Adjust the baseline inventory to account for growth after the base year.

iii) Allocate the adjusted inventory among counties based on the distribution of population.

iv) Estimate the additional unit maintenance cost as a function of air pollution conditions.

v) Calculate benefits as the savings in maintenance cost in each county, based on the change in air quality as a result of achieving the secondary standard.

Each of these steps is described below.

Baseline Inventory--

Among the items considered in the study by Perl were three of interest for the electric utility sector analysis. These included: (1) externally mounted power transformers, (2) galvanized steel power line transmission towers, and (3) pole line hardware. Note that the

latter are also used jointly by the telephone utilities so an adjustment for this fact is made later in the analysis. Note also that some electricity customers may own substation equipment, and thus external power transformers. However, utility ownership is far more common, so the possibility of customer ownership is neglected in the analysis.

The baseline inventory for the above items in 1970 were estimated by Fink et al. (4) to have been as follows:

- Transformers -- $556.63 \cdot 10^6$ ft^2
- Towers -- 194,000 towers $\cdot$ 2,500 ft^2/tower
  $= 485 \cdot 10^6$ ft^2
- Hardware -- $3.04 \cdot 10^6$ tons $\cdot$ 450 ft^2/ton
  $= 1,368 \cdot 10^6$ ft^2

Growth Adjusted Inventory--

In the Perl study, benefits were calculated for 1978 and the growth in inventory between 1970 and 1978 was assumed to be at the same rate as the growth in GNP. In this study, an estimate for 1985 is required, and the inventory growth is taken to be at the same rate as the growth in installed electric generating capacity as forecasted by the Department of Energy (5). The latter should be a better indicator of the requirements for transmission and distribution facilities. This assumption leads to adjusted inventory estimates (in ft^2) of $1,120 \cdot 10^6$, $976 \cdot 10^6$, and $2,752 \cdot 10^6$, respectively.

Geographic Allocation--

As in the Perl study, we assumed that the inventory was distributed in the same manner as the population distribution. The population distribution by county in 1975 was used, as reported in the County and City Data Book (1).

Incremental Maintenance Cost--

As in the Perl study, estimates of the additional maintenance cost due to pollution were taken from Fink et al. (4). In 1970 dollars, these were

- Transformers -- \$0.0167 per ft^2 per year.
- Towers -- \$0.0233 per ft^2 per year.
- Hardware — \$1.20 per pole per year/4 ft^2 per pole = \$0.30 per ft^2 per year.

Since poles are often jointly used by both telephone and electric utilities, we assume that half of the pole line hardware maintenance cost is incurred by each, thus yielding \$0.15 per ft^2 per year. To be consistent with other parts of this study, the above costs were then adjusted to 1980 dollars using the implicit price deflator for GNP.

The estimates above represent the difference in maintenance cost between "clean" and "polluted" environments, neither of which was defined in the original study by Fink. Perl converted the estimates to cost per unit of SO_4 pollution. In this study, the conversion is made to costs per unit of SO_2 pollution. As the definition of

"polluted", we used the population weighted average SO_2 concentration in all of the counties which exceeded the primary 24-hour SO_2 standard in 1978. The weighted average was 555.64 $\mu g/m^3$. As the definition for "clean", we used the alternative 24-hour SO_2 secondary standard of 260 $\mu g/m^3$.

Incorporating all of the above adjustments leads to the following estimates of incremental unit maintenance costs for electric utilities in 1980 dollars (expressed in mills):

- Transformers — 0.10966 per ft^2 per year per $\mu g/m^3$.
- Towers — 0.15299 per ft^2 per year per $\mu g/m^3$.
- Hardware — 0.98498 per ft^2 per year per $\mu g/m^3$.

Estimated Benefits--

Using the above information, and actual air quality data for the individual counties, an estimate of benefits was calculated. For the 24-hour equivalent of the current 3-hour SO_2 secondary standard, the estimated benefits were $0.057 million, all in one county in the Mountain Census Division. For the alternative 24-hour SO_2 secondary standard, the estimated benefits were $54.2 million. Both of these estimates are the 1980 discounted present values of all future savings, in 1980 dollars, using a 10 percent discount rate and the attainment scenario described in earlier sections.

The above figures are conservative estimates because they assume no additional growth in the inventory after 1985. If, instead, the inventory is assumed to continue to grow at the post-1985 forecasted rate of growth in installed generating capacity reported in Reference (5), benefits for the alternative 24-hour standard would be about 40 to 50 percent higher.

The geographic distribution of benefits is shown in Table 10-10. As in the other sectors, benefits for SO_2 are heavily concentrated in the Mid-Atlantic and East North Central Divisions. This reflects both the distribution of air pollution and population.

TABLE 10-10. ESTIMATED BENEFITS TO ELECTRIC UTILITY TRANSMISSION AND DISTRIBUTION SYSTEMS FROM ATTAINMENT OF THE ALTERNATIVE 24-HOUR SO_2 SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

New England	1.4	East South Central	0.4
Mid-Atlantic	15.0	West South Central	--
East North Central	23.4	Mountain	4.9
West North Central	2.2	Pacific	—
South Atlantic	7.0	U.S. total	54.2

* Alternative SO_2 secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

— Equals zero.

SUMMARY OF EXTRAPOLATIONS

The purpose of this section has been to expand the coverage of the basic analysis. The basic analysis considered only four sectors -- households, agriculture, manufacturing, and electric utilities -- and provided only partial coverage of those sectors. In this section, the coverage was broadened by making limited extrapolations within the sectors included in the basic analysis.

In the household sector, the basic analysis covered 24 major metropolitan areas. The extrapolations extended these results to other areas of the country.

In the manufacturing sector, the basic analysis included six industries representing 8 percent of the manufacturing sector. Extrapolations were made to closely related industries, thus extending coverage to about 32 percent of the sector.

The electric utility sector basic analysis considered the effects on fossil steam-electric generation. These results were extended to other forms of generation. Additional data and procedures led to estimates for the transmission and distribution phases of the industry.

For reasons described in Section 9, no extrapolations were developed for the agricultural sector.

A summary of the results for the basic analysis and the extrapolations is provided in Tables 10-11 through 10-13. Table 10-11 includes benefits estimates for the 24-hour equivalent of the current 3-hour secondary SO_2 standard. Table 10-12 presents benefits for an alternative 24-hour secondary SO_2 standard. Table 10-13 provides the estimated benefits for the current 24-hour secondary TSP standard.

TABLE 10-11. ESTIMATED BENEFITS IN SECTORS ANALYZED FOR CURRENT SO_2 SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Sector	Basic analysis+	Basic analysis with extrapolation
Households	--	4.6
Agricultural	0.2	0.2
Manufacturing	—	6.4
Electric Utilities	—	0.1

* Current secondary standard for SO_2 is 1,300 $\mu g/m^3$, based on a 3-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

\+ Estimates shown are for effects which were statistically significant at the 10 percent level or less. Estimates would be larger if higher significance levels are used.

-- Equals zero.

TABLE 10-12. ESTIMATED BENEFITS IN SECTORS ANALYZED FOR ALTERNATIVE SO_2 SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Sector	Basic analysis+	Basic analysis with extrapolations
Household	733	1,140
Agricultural	22	22
Manufacturing	345	1,912
Electric utilities	56	124

* Alternate secondary standard is 260 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

+ Estimates shown are for effects which were statistically significant at the 10 percent level or less. Estimates would be larger if higher significance levels are used.

TABLE 10-13. ESTIMATED BENEFITS IN SECTORS ANALYZED FOR CURRENT TSP SECONDARY STANDARD* (discounted present values for 1980 in millions of 1980 dollars)**

Sector	Basic analysis+	Basic analysis with extrapolations
Household	1,144	2,930
Agricultural	--	--
Manufacturing	4,117	15,870
Electric utilities	--	--

* Current TSP secondary standard is 150 $\mu g/m^3$, based on a 24-hour averaging time. Standard not to be exceeded more than once per year.

** Discount rate of 10 percent is assumed.

+ Estimates shown are for effects which were statistically significant at the 10 percent level or less. Estimates would be larger if higher significance levels are used.

-- Equals zero.

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SECTION 11

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